Governing the Groundwater Economy:

Comparative Analysis of National Institutions and Policies in South Asia, China and Mexico

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Abstract

In many parts of the world, especially in South Asia, the size of the groundwater economy has rapidly grown during the past 5 decades, and is growing still. Elsewhere in Asia— Sri Lanka, Vietnam, Laos, Thailand — and in Maghreb countries, groundwater use in agriculture has begun to grow during the past decade and is likely to peak in the coming 10 years. Global concerns with growing groundwater use in agriculture have focused mostly on its sustainability, quality degradation and adverse impacts on environment and ecological flows. Direct regulation of groundwater draft through stringent laws, regulatory frameworks and aggressive water pricing has been strongly advocated. However, despite the consensus for need to move in these directions, many governments have dragged their feet in operationalizing direct regulation. Where governments have taken pro-active stance, as in Mexico and to lesser extent, China, the impacts are variable.

Governing groundwater economies is proving intractable; and responses to intensive groundwater use vary widely across nations. This paper attempts to understand why. It also argues that particularly in Asia, direct regulation of groundwater use may remain a pipe dream for a long time to come; and for effective governance of the groundwater economy, there is need to invent a wider toolkit – including direct and indirect instruments of management – that can be adapted to peculiar contexts of the groundwater economy in different countries.

I. The Common Challenge

Regions of Asia where food security and rural livelihoods have come to depend precariously on intensive use of groundwater in agriculture have expanded at a frightening pace, especially after 1970. Recent IWMI analyses suggest that 1970 was probably the watershed year: prior to that, steady rise in food production depended squarely on growth in surface irrigation. Since then, however, South Asia and North China have experienced a massive groundwater boom; and by the early 1990's, groundwater irrigation had overtaken all other sources in explaining the total area irrigated as well as in contribution to farm output and incomes (Debroy and Shah 2001). An extraordinary aspect of this boom is its quiet, furtive character: governments in many Asian countries remain unaware of this wildfire growth of wells and tubewells fueling right under their noses. As a result, by the time resource managers begin to size up the challenge facing them, they find they are fighting a losing battle. Many regions of Asia are now discovering that the groundwater boom comes with a price tag in the form of groundwater depletion, pollution and quality deterioration (because of fluoride, arsenic, nitrates, etc) raising serious concerns about the future sustainability of such intensive groundwater irrigation. What these need direly is a practical strategy of managing this runaway growth in the bubble of the groundwater economy before it bursts, causing misery all around. The phrase 'groundwater governance' has come into currency primarily in the wake of the recognition that managing groundwater has come to involve dealing with

not just physical and ecological processes but a complex of socio-economic and institutional relationships with far reaching impacts on society.

Drawing from the experience of Western US, Europe and Australia, international thinking on the ways forward on improving groundwater governance has veered towards a complex of stylized prescriptions: [a] countries should get an appropriate legal and regulatory framework for groundwater appropriation and use; [b] a new system of groundwater rights should replace the present open-access regime; [c] groundwater should be treated as an economic good and priced to reflect its scarcity value; [d] an institutional structure created for development of the resource should be transformed into one appropriate for resource management; and [e] policies should be redefined and adjusted to the new priority of sustainable management.

Against these stylized prescriptions, we find vast variations in the way nations actually respond to the problems of groundwater stress. In this paper, we try to understand why. We do this by developing a comparative analysis of institutions and policies for groundwater management in South Asia, China and Mexico. Our purpose is to explore to what extent the responses to groundwater overdevelopment in these regions conforms to these stylized prescriptions, and why. In section II, we draw a broad comparison between the South Asian and Chinese situations because we find marked similarities in these in several respects. In part III, we develop the Mexican case study. In part IV, we offer some general conclusions and argue for a more nuanced understanding of the context within which groundwater economies operate in different parts of the world and which shapes their strategies of governing its appropriation and use.

II. Comparing Groundwater Institutions and Policies in South Asia and North China

History and Context

South Asia and North China have important similarities in terms of very high population densities, small land holdings, and predominance of groundwater. While South Asia's irrigation history goes back to the millennia, North China's goes back to all of 50 years. However, when it comes to history of groundwater irrigation, unprecedented expansion in it after 1970 was spurred in both the regions by nearly the same compact of factors, viz., intensification of farming and the propagation of seed-fertiliser technologies, reduced and undependable surface water supplies, role of groundwater in mitigating the impacts of drought, and early encouragement from public policy makers to groundwater irrigation. In both the regions, well-densities increased in spurts during drought periods, and with active support from the state (Ronghan 2000: 83). Booming groundwater-based irrigated agriculture in both the regions is facing imminent threat of decline as a result of resource depletion or salinization caused by constant over-draft. Secondary salinization has yet not emerged as a critical problem in large areas of North China, especially in the Western Parts (Kendy et al 2002; Zhang and Zhang 2001) as it has in Pakistan Punjab and Sindh and Indian Punjab and Haryana. However, groundwater depletion and secular decline in water table, high fluoride content, rising energy costs of pumping, problems of land subsidence, falling well-yields and high rate of failure of wells are problems common to both the regions.

Organization of Village Groundwater Economies

However, there are notable differences in other respects, mostly in the institutional fabric of the two regions. First, it is the sheer numbers; China has an estimated 3.5 million agricultural tubewells, mostly in the North China plains that extract an estimated 75 km^3 of groundwater/year; in comparision, South Asia had 19 million agricultural wells and tubewells during mid 1990's, which may well have increased to 23-25 million now, extracting some 210-230 km^3 of groundwater. Then, the structure of land and water rights and groundwater institutions are different. Throughout South Asia, overwhelming majority of groundwater wells and pumps are privately owned by farmers. Rights to groundwater are not separately specified, and are treated as an easement attached to land; as such, land owners act as if they have unrestricted ownership rights on groundwater. However, exercising this right requires a well and a pump; and many small farmers' holdings are too small to make a mechanized well viable.

Moreover, because of high level of land fragmentation, even those who own wells can not irrigate all their fragments by their own wells. A major institutional response to this problem is the emergence of pervasive, local, fragmented pump irrigation markets which have helped smooth out these rough edges of the groundwater economy in a South Asian village and have expanded access to groundwater irrigation to the resource poor.

This institution of South Asian groundwater markets—or, to be precise, pump rental markets—has been extensively studied in South Asia during recent years (Shah 1993; Saleth 1994; Palmer-Jones 1994; Janakarajan 1992; Kolawali and Chicoine 1989; Meinzen-Dick and Sullins 1994; Strosser and Kuper 1994). Like markets in general, these create new wealth and help alleviate rural poverty; but these also make the organization of the groundwater economy a chaotic maze of intense, criss-crossing interaction amongst pump owners and water buyers without any mediating influence. In many regions of South Asia, farmers invest in tubewells and pumps primarily for selling water for profit; even when the primary motive is irrigating own land, pump owners can still earn significant supplemental income from selling water as a side activity (Kolawali and Chicoine 1989). As water markets mature, intense competition amongst water sellers confers benefits to buyers in terms of lower price and better service; but it also encourages huge overlap in command areas of private tubewells and excess pumping capacity.

In a typical South Asian village, the groundwater economy is completely untrammeled by any regulatory authority or mediating agency. It permits no role for even the village level governance structures (such as India's Gram Panchayats or Pakistan's *numberdars*). No norms are effectively in place for siting and licensing of groundwater wells. The only government agency the pump owners have any interaction with is the electricity utility, and some times public sector banking institutions. India's National Bank for Agriculture and Rural Development, which refinances bank loans for groundwater structures, stipulated some siting norms; however, these are extensively violated (Shah 1993). In groundwater depletion areas such as North Gujarat region in western India, where capital investments as well as risks in making successful tubewells are high, farmers come together to form co-operative tubewell organizations (Shah and Bhattacharya 1998); however, their prime aim is to secure irrigation for their members, and play no role whatever in guiding or managing the overall groundwater socio-ecology of the village. All in all, in South Asia's chaotic village groundwater economies, all formal and informal institutions function with the sole aim of maximizing present wealth creation from groundwater irrigation.

In a typical North China village, however, nearly the opposite was the case until early 1980's. Before the sweeping agrarian reforms initiated by the Deng administration in 1983, irrigation organization in the Chinese country-side was uniform and orderly in comparison. Collectives were responsible for making and maintaining tubewells as well as pumps and distribution systems. This does not necessarily mean that they were efficient in techno-economic terms; however, it did mean the presence of an over-arching governance mechanism at the level of the collective and above that oversaw the working of the irrigation economy. With the onset of reforms and the household responsibility system, we find a wide variety of institutional arrangements have now come into play in the Chinese countryside (Xiang, Huang and Wang 2000). Table 1 outlines a range of institutional arrangements we came across for tubewell management in 9 villages of Hanan and Hebei province in course of fieldwork during 2002. Where water tables are high and the cost of making tubewells low—as, for example, in the lower Hanan province—it is common for pre-existing shallow tubewells to be owned and maintained by Village Committees from agricultural taxes[1]. Where new Shallow Tube Wells (STWs) need to be built, Village Committees still do so, especially if they have buoyant tax revenue; else, they invite private farmers to build and operate tubewells under formal contracts which vary from very

1 Chinese farmers pay several types of land tax—notably, crop tax, education tax, water use tax, electrician tax, etc. In Xiaotan Village, Yanjin county in Henan, for instance, half of the annual tax collection of Y 20,000 is turned in to the township government and half is retained by the village leader. Of the village share of Y 10,000, some 15% was earmarked for maintenance of tubewells.

Table 1: Variety of Institutional Arrangements for Groundwater Irrigation in 9 Villages of Henan and Hebei Provinces

Village, County, Province	Pumping Water Level	Shallow Tubewell	Motor Pump	Deep tubewell	Transformer	Collection of electricity fee
Xiaotan, Yanjin county, Henan	7-8 m	BOM by Village Committee	Farmers own & share pumps	Nil	O & M by Township Electricity Bureau	TEB's electrician collects based on meter reading on each motor pump
Guantun,Yanjin county, Henan	10 m	BOM by Village Committee	Farmers own & share pumps	Nil	O & M by Township Electricity Bureau	TEB's electrician collects based on meter reading on each motor pump
Xijie, Yanjin county, Henan	17 m	STW maintenance by Village Committee; but O & M of STW and pump by contractor who charges Y 1/kWh against Y 0.7/kWh to be paid to electrician		Nil	O & M by Township Electricity Bureau	TEB Electrician collects irrigation fee @ Y 1/kWh and pays the contractor Y 0.3/kWh as his margin.
Zhao Zhuang, Ci county, Hebei	26-30	12 contractors operate collective STWs; 12 private service providers; 5 share-holder service providers		Nil	4 managed by private contractors; 2 by Village Committee	STW operators collect Y 1/kWh from irrigators against electricity cost of Y 0.565/kWh
Dong wan gnu, Ci county, Hebei	5	Farmer-contractors operate STWs & maintain them,		Nil	Owned and Managed by Village Committee	Contractors charge Y 0.82/kWh from irrigators and pay Y 0.565/kWh to electrician
Shi cun Ying, Ci county, Hebei	220	Private and stake-holder group owned and managed deep tubewells with pumps and buried pipe networks			Collectively owned by Village Committee	Tubewell owners charge Y 10/hour from irrigators and pay 0.565/kWh
Yao Zhung Zi, Chang Zhou county, Hebei	220	15 STWs managed by Village Committee	Farmers use own or borrowed pumps	6 DTWs owned & managed by the Village Committee	Collectively owned by Village Committee	DTW operators employed by VC collect Y 16/hour from irrigators and pay Y 0.45/kWh to electrician
Xi Huayuan, Chang Zhao county, Hebei	250	VC owns and operates 6 DTWs and private farmers operate 4, all with 28kW pumps; the former operate as a utility, the latter as a business			Four private DTW owners own a transformer each	Private DTW owners charge Y 1.1/kWh and pay Y 0.48/kWh; VC DTW charges Y 0.65/kWh and pays Y 0.55/kWh to TEB
Xi Tun Zi, Chang Zhou county, Hebei	250	VC collected Y 200/mu to build 7 collective DTWs at a cost of Y 620,000; each has a 400 m deep DTW, 30 kW pump and 1200-1500 m of underground pipeline network			Collectively owned and managed by VC	VC employed DTW operators charge Y 15/hour and pay Y 0.48/kWh to electrician

simple to quite complex.

Regardless of whether STWs are collectively managed or contractor-managed, pumps and ground pipes are generally owned by farmers or borrowed from friends or relatives. Unlike in South Asia, where the ownership of a pump in many regions is not only a source of significant extra income but, as some social scientists claim, also of social status and political power (Wood 1995; Dubash 2002), in STW areas in North China, pump ownership yields the owner neither profit, nor power nor status. The chief reason is the relatively low real cost of machine capital in China in comparison to the rest of the developing world.

In deep tubewell areas of Hebei and Shandong provinces, the village irrigation organization undergoes a marked change; tubewells are bigger and fewer, each serving a larger command. Some Village Committees here also build and operate Deep Tubewells (DTWs) which are a much costlier affair compared to STWs. Here tubewells going to the depth of 350 meters or so, motor-pumps generally of 28 kW and 1000-1500 meters of buried pipeline network—which comprises a tubewell assembly may entail an investment of Y 250-300 thousand (US $ 31,000-38,000) apiece. Each tubewell here commands 600-1000 mu and is beyond the reach of any individual farmer unless he fancies himself as a water entrepreneur. It is common for deep tubewells to be established, funded, and owned by the Village Development Committee; but its

operation is commonly contracted out. A variety of contracting arrangements seem to be in vogue, each presenting interesting alternatives in the design of incentives. Regardless of whether they are privately or collectively managed, in deep tubewell areas of NCP, such as in most of Hebei province, irrigation is a far more expensive proposition than in the STW areas. In these villages, everyone is a water buyer and pays a water rate that is generally linked to energy use. In this increasingly complex maze of irrigation institutions in North China, private irrigation service providers are emerging as key players. Their margins vary and do not seem to show any particular pattern but did not seem to us to contain high monopoly premia, except in deep tubewell villages in Hebei.

Unlike in South Asia, where local water markets find their own prices, in North China, the Village Leaders or Party Leaders often fix or have a say in deciding the margins to be charged by contractors which hovered around Y 0.2-0.35/ kWh (US cents 2.5-4.4/kWh) in the villages where we worked. Even where private irrigation providers fixed prices, their gross margins tended to be in this range. There is hardly any competition in the sense it operates in South Asian groundwater markets mostly because there is little overlap in the command areas served by different tubewells; and it is common for contractors and private sellers to collude in setting a common price under the watchful guidance of the Village Committee. The net result is that the ratio of irrigation fee to energy cost—which in India may be as high as 2.5 or more—seldom exceeds 1.5 in China. In villages with alternative irrigation sources or in years of good rain fall, tubewell irrigation is sparingly used and contractors make little money. All in all, compared to South Asia, village governance institutions are stronger in China in that they enjoy and use greater authority in village affairs, and therefore have a pervasive influence not only on the irrigation organization but on the entire village economy and society. One aspect of this is the larger political system through which state authority percolates down; but another aspect—which must promote some measure of responsiveness in the governance structure to people's aspirations— has also to do with the fact that governance structures are supported from locally generated resources, an aspect completely absent in South Asian villages.

Compared to the South Asian farmer who virtually pays no direct taxes, the Chinese farmer is heavily taxed. A major reason for the heavy taxation is the burden of the salary of the local government officials. Every village has a Village Leader and a Village Communist Party Leader. The former is elected by a Village Committee of 7 elected members. The Party Leader for each village is selected by the Township level party leadership from all party members in the village. The party leader is all powerful in village affairs; if there is a dispute between the Village Committee and the Party, there are negotiations to settle the differences but ultimately what the party leader says goes. Party members, and particularly the party leader are selected supposedly for their social concern and awareness and a strong 'extension motive' (McClelland 1985). This helps somewhat in keeping the institution from becoming oppressive and hegemonic. The party leader as well as the village leader and members of the village committee are salaried officials. In Henan villages we covered, the party leader gets Y 140 (US $ 17.50)/month; while others get Y 120 (US $ 15)/month. These salaries have to come from land tax. Land tax is also used to sustain the Township government which lays claim to upto 50% of all land tax collections at the village level. Considering there is hardly any subsidization of agriculture, there is probably a heavy transfer of wealth from agriculture to industry in China, a situation akin to Japan's under Meiji restoration period (Mellor 1995).

This parallel structure of local government and party organization may not be perfect or even ideal; however, it ensures the presence in the average Chinese village of state authority which is largely or completely absent in the South Asian village. In an Indian village, farmers can chase away an Electricity Board meter reader with impunity; and in Pakistan, Water and Power Development Authority has to use the military to take meter readings on electric tubewells (Sunday Times of 7/4/2002); but in China, many rules of the game get formulated as well as enforced by the village level governance structures. The

Table 2: Comparing Features of Village Groundwater Economies in South Asia and North China

	South Asia	North China
Ownership of tubewells	*Private*	*Collective, contracted*
Ownership of pumps	Overwhelmingly private	Mostly private; some collective
Do all farmers own pumps	No	No
Do tubewell command areas overlap	Yes, extensively	No, rarely
Do pump owners compete to increase water sales	*Yes because of active markets in pump irrigation service with powerful productivity and equity impacts*	*No because tubewells are sited to serve specified command areas*
Are water prices fixed by the operation of the market?	Yes, entirely; there is no regulation whatever of the way fragmented, local pump irrigation markets function	No, it is guided by Village Committee and Village leader; usually it is fixed on energy-cost plus basis
Is water selling viewed as a source of significant income?	Yes, especially in Eastern India, Nepal terai and Bangladesh	No except in DTW areas where farmers make heavy investments
Irrigation cost as a proportion of total value of output?	20-25% for water buyers	3-5% for water buyers

'soft state' is as evident in the South Asian village as the 'hard state' is in a Chinese village. This authority structure is at the heart of the way irrigation institutions function in China. This village level governance structure with an all-encompassing mandate in the village life can underpin a national and regional structure of water governance in ways that would be impossible in South Asian country side. (Table 2)

All in all, the organization of village groundwater economy in North China differs in several material ways from that in South Asia in that: [a] the Village Committee and the village leader play a significant mediating and regulatory role in shaping the irrigation economy in North China whereas throughout South Asia, the village groundwater economy operates in a laissez faire style; [b] monopoly premia are non-existent or marginal on pump rental markets in NCP where as they are significant in South Asia; in the NCP, monopoly rents emerge with the rise of private water sellers in DTW areas; [c] since STWs as well as DTWs in the NCP have no overlapping command areas, the opportunities for 'competitive deepening' and destructive chasing of falling water tables encountered in SA is absent in the NCP; this advantageous feature is likely to stay as long as the village committee and the village leader play an influential role; [d] finally, effective cost of groundwater irrigation tend to rise as one moves from STW areas to DTW areas in a manner that broadly reflects the social cost of groundwater.

Direct and indirect cost of groundwater irrigation

Neither in South Asia nor in North China is groundwater itself priced on the margin. Under the new Chinese Water Law, farmers are required to obtain a 'permit' for which they have to pay a fixed fee. This was nowhere in effect; even if it were, it would not determine the marginal cost of groundwater use. What does however affect the marginal cost of groundwater use is the cost of energy used for pumping. In this, there are major differences between South Asia and North China. Energy costs of groundwater in South Asia seldom fully reflect the scarcity value of groundwater or energy. For instance, the cost of m^3 of groundwater purchased by a small farmer is around INR 4 (US c 8) in Eastern Uttar Pradesh or North Bihar in India where it is abundantly available[2]; but it is less than INR 2 (US c 4)[3] in North Gujarat where it is mined from 800 feet or more. In Bangladesh, where groundwater is abundant and can be pumped from 10 feet below ground, irrigating a hectare of paddy with purchased groundwater costs a high Taka 6000 (approx US $ 100) (Mainuddin 2002, pers. comm) which drives many small holders to manual irrigation; but in Tamilnadu, where almost all groundwater presently being used is mined, irrigating a hectare of paddy with purchased groundwater costs less

2 Water purchased from 5 hp diesel pump with an hourly discharge of 12000 litres costs Rs 50 in most parts of Eastern India.

3 Water purchased from a 75 hp electric pump with an hourly discharge of 55000 litres costs Rs 90 in North Gujarat.

than INR 1500 (~US $ 30).

The main reason why groundwater irrigation costs do not reflect its scarcity in India is the distorted electricity pricing policies pursued by Indian state governments. Collecting electricity charges from millions of farmers scattered over a huge country side has been a nightmare for South Asian countries like India and Pakistan. The logistical difficulty and economic costs of metering electricity used by tubewells has been found so high that most Indian states have done away with metering and instead charge a flat tariff based on horse power rating of the pumps (see Shah 1993; Shah *et al.* 2002a). Pakistan too tried flat tariff for nearly a decade before reverting to metering in 2000. In India, there is growing opposition to flat tariff in part because it is believed to induce inefficient use of power and groundwater but in part also because flat tariff has been used by populist politicians to subsidize tubewell irrigation. Electricity subsidy is thought to be the prime reason why many State Electricity Boards in India are on the verge of bankruptcy. Despite this state of affairs, many still argue that reintroduction of metering may not be a practical idea in the Indian context unless innovative technologies and/or institutional arrangements for collecting electricity charges can be used to reduce the transaction costs of metering and charge collection (Shah *et al.* 2002a; Godbole 2002). All in all, the management of this 'energy-irrigation nexus' in South Asia is central to the governance of the region's groundwater as well as energy economies. Now that many Indian states are waking up to this stark reality, their attempts to go back to metered electricity are frustrated by two blocks: first, sustained opposition from electric tubewell owning class; and second, the formidable logistical problems and high transaction costs of managing metered electricity supply to farmers.

Surprisingly, the electricity-irrigation nexus in ways widely discussed in South Asia is not a subject of discussion in China at all. Indeed, researchers and technocrats with whom we raised the topic had difficulty in understanding why the two need to be co-managed at all. The Chinese electricity supply industry operates on two principles [a] of total cost-recovery in generation, transmission and distribution at each level with some minor cross-subsidization across user groups and areas; and [b] each user pays in proportion to his use. Unlike in much of South Asia where farmers pay either nothing or much less than domestic and industrial consumers, agricultural electricity use in many parts of North China attracts the highest charge per unit, followed by household users and then industries. Operation and maintenance of local power infrastructure is the responsibility of local units, the Village Committee at the village level, the Township Electricity Bureau at the township level, and the County Electricity Bureau at the county level. Equally, the responsibility of collecting electricity charges too is vested in local units in ways that ensures that the power used at each level is paid for in full. At the village level, this implies that the sum of power use recorded in the meters attached to all irrigation pumps has to tally with the power supply recorded at the transformer for any given period. The unit or person charged with the fee collection responsibility has to pay the Township Electricity Bureau for power use recorded at the transformer level. To allow for normal line losses, 10% allowance is given by the Township Electricity Bureau to the village unit.[4] Under a new Network Reform program initiated by the national government with the objective of improving power supply infrastructure, village electricians in many areas of NCP have organized to provide improved services to their customers. However, these too levy a service charge for attending each request for help to cover their cost or transport on motor cycle. The village electrician, who generally enjoys the support of the party leader, is feared; and the new service orientation is designed partly to project the electrician as the friend of

4 The village electrician's reward system encourages him to exert pressures to achieve greater efficiency by cutting line losses. In Dong Wang nu village in Ci county, the village committee's single large transformer which served both domestic and agricultural connections caused heavy line losses at 22-25%. Once the Network Reform Program began, he pressurized the VC to sell the old transformer to the Township Electricity Bureau and raise Y 10000 (partly by collecting a levy of Y 25/family and partly by a contribution from the Village Development Fund) to get two new transformers, one for domestic connections and the other for pumps. Since then, power losses have fallen to the permissible 12% here.

the people. The hypothesis that with better quality of power and support service, farmers would be willing to pay a high price for power is best exemplified in Henan where at Y 0.7/kWh (US c 8.5/ kWh, INR 4.27/kWh) farmers pay a higher electricity rate compared to all categories of users in India and Pakistan, as also compared to the local diesel price at Y 2.1 (US c 26)/l.

The village electrician, Network Reform Program, Township Electricity Bureau, the incentive payments, and new service organization—are all elements of the Chinese strategy that has turned the energy-irrigation nexus into a positive ratchet. In India, there has been some discussion about the level of incentive needed to make privatization of electricity retailing attractive at the village level. The village electrician in Hanan and Hebei is able to deliver on fairly modest reward of Y 200/month which is equivalent to half the value of wheat produced on a mu (or 1/30th of the value of output on a hectare of land). For this rather modest profit, the village electrician undertakes to make good to the Township Electricity Bureau full amount on line and commercial losses in excess of 10% of the power consumption recorded on the transformers; if he can manage to keep losses to less than 10%, he can keep 40% of the value of power saved.

All in all, the Chinese have all along had the solution to the energy-irrigation nexus that has befuddled South Asia for nearly two decades. In the way the Chinese collect metered electricity charges, it is well nigh impossible to make financial losses since these are firmly passed on downstream from one level to the level down below. Take for example the malpractice common in South Asia of end-users tampering with meters or bribing the meter-reader to under-report actual consumption. In the Chinese system, it is very unlikely that such mal-practices can occur on a large scale since the village electrician is faced with serious personal loss if he fails to collect from the farmers electricity charges for at least 90% of power consumed as reported at the transformer meter. And since malpractice by a farmer directly hits other farmers in the village, there is likely to exist strong peer control over such practices. There are similar incentive-control mechanisms at the level of the Township Electricity Bureau as well so that major malpractices at the transformer level would be likely to be detected and curbed early.

Would transposing the Chinese institutional design for consumption based pricing of electricity and water work in South Asia? After all it should be simple to put the meter reader of a state electricity board on a salary plus performance-linked incentive or disincentive; and equally, to put the canal guard too on a similar system of performance-linked reward system with minor adjustments in physical infrastructure. Our assessment is that it would not work because of the break-down of local authority structures in South Asia. The primary reason why the metering system works in China is that, in order to perform their tasks effectively, the electrician can invoke the authority of the State through the Village Committee, the Village Leader and, above all, the Village Party leader. And since the Chinese are used to taking this authority seriously, the electricians too invoke a measure of fear and compliance. The ease with which an electrician in a Chinese village can recover the difference between power fee deficit by levying a cess on all users is suggestive of the authority these vicariously enjoy.

The Organization and Reach of the Water Bureaucracy

Never in the 2500 year history of South Asia have ordinary citizens been subjected to a unified system of governance for a sustained period of time. A major reason probably is that except for brief periods—when regents like Asoka, Harshawardhan, Akbar unified vast territories— what are now India, Pakistan, Bangladesh, Sri Lanka and Nepal were ruled over by numerous kings through feudal chiefs and overlords constantly engaged in internecine strife. These regions came under unified administration only during the Colonial period which created a bureaucracy as an institution of governance. Until then, each South Asian village was pretty much a republic..

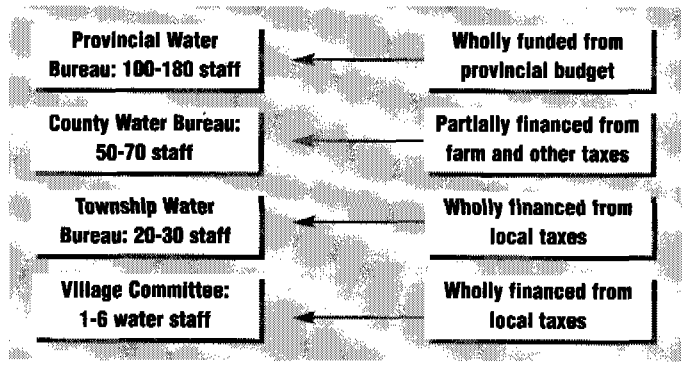
In contrast, for most parts of over 2000 years, right until 1911, China has been a unified, tightly-governed state that ensured respect for law and the authority of the state. Since the time of Qinshi Huangdi *circa* BC 250, China's first Emperor who unified numerous feuding kingdoms into an efficient and organized state, China's political system and governance institutions seem to have changed very little. The Chinese state Huangdi built has

survived, in its essentials, to date with a single currency, nationalized land and natural resources, standardized weights and measures, a single script with 3000 characters. In a brief reign of 11 years, Huangdi also produced homogeneity in people's thought by destroying all books apart from legalist works and rallied society around the common goal of creating a 'rich and powerful country'. Despite numerous efforts to recreate pre-Huangdi kingdoms, China retained, until well into the 20th century, the tradition of a unified state with, uniform penal code, the Legalist political system and a vast, centralized bureaucracy with a formidable reach and ambit, which are evident even today.

The organization of the south Asian water administration is thin, fragmented, top-heavy, bureaucratic and in general ill-equipped to manage a sector that is rapidly growing in size and complexity. Take for instance India; in a typical Indian block (or taluka or tehsil) that covers some 100 villages and a population of over 200,000 people, the total number of government officials (excluding the lowest rung, such as canal *chawkidaars* and public tubewell operators) working on water probably does not exceed 10; and for a district, which may have 18-30 such blocks and a population of 2-3 million, this number is probably around 100. Moreover, these are vertically organized into line departments—such as irrigation, groundwater, water supply and sanitation—which hardly interact with each other. Canal irrigation departments are commonly the largest; whereas groundwater departments are either absent (as, for instance in Gujarat, where the Gujarat Water Resources Development Corporation doubles up as one) or thinly staffed. Each department functions as a bureau, often pursuing a mandate that has long become irrelevant. For instance, the groundwater departments in most Indian states still believe further development of groundwater to be their key mandate; these are nowhere close to making a transition from the 'resource development mode' to 'resource management mode'. Likewise, once the construction of new projects gets over, canal irrigation bureaucracies too feel unable to move into the new role of system management and service delivery. Their ambit of operation is linked to administrative units—such as districts and talukas—rather than a river basin or sub-basin. Finally, the water bureaucracies in much of South Asia have increasingly become a drag on the society; over 90% of their budgets get used up by salaries and establishment costs; and the heavily subsidized water fees- of which only a small fraction is actually collected—can hardly meet even a part of this salary and establishment cost, leave alone contribute to infrastructure maintenance and improvement.

Chinese water administration differs from South Asian at least in two respects: it has much greater presence at the grass-roots; and increasingly, it is paying for itself through service fees. China has a nested hierarchy of water institutions at each level, controlled mostly by the government at that level but within an overall policy influence of the MWR (Wang and Huang 2002). Like South Asian bureaucrats, Chinese water bureaucrats too have a resource development rather than a resource management mindset. However, there are indications that water management concerns are increasingly coming to a head, especially in provinces like Hebei where groundwater scarcity, depletion and quality deterioration are emerging as paramount concerns.

Figure 1: Structure of Chinese Water Administration and its Funding Bureaus



Water Bureau's are substantial outfits even at the county level (equivalent to 2-3 taluks/ blocks/ tehsils/ thana in South Asia). In Ci county in Hebei province, which has 19 townships and 390 villages under it, the County Water Bureau staff is only 60 and a typical township water bureau employs 20-30 officials; however the entire hierarchy of water bureaus in the county employs some

560 people. Hebei province, for instance, has 9 city level water bureaus and 200 water bureaus of counties like Ci which manage water resources in 4000 small townships and villages. Thus, when all levels are taken together, the Water Bureau structure in a province may employ several thousand officials. Where as the Provincial Water Bureau is fully supported by the state budget, the county water bureau has to raise a portion of its own budget and the township water bureau is wholly self-financed. Thus, Ci county, for example, has an annual budget of Y 30 million; in this Y 10 m is contributed by the national government under drought mitigation program; however, the balance of Y 20 m has to be raised by the County Water Bureaus from farmers taxes and local incomes. Kendy et al. (2002) note, in their study of groundwater institutions and policies in Luancheng county near Beijing that 'fee revenues are sufficient to fund the County Water Affairs Bureau, but not to finance water conservation county-wide'. Changing incentives facing bureaucrats is an economy-wide phenomenon that seems designed to transform China's bureaucrats into entrepreneurs (Scott Rozelle et al, 2000)

The Water Bureau structure is apparently undergoing a strategic transformation under the 1998 reform; indeed, recently, in some provinces these are renamed Water Management and Service Bureaus and are strongly encouraged to adopt a business ethic rather than regulatory-bureaucratic approach, and generate resources locally by selling services. True, this may be easier said than done, especially since revenue yielding water infrastructural assets are commonly held by provincial bureaus or the national government. Even so, many researchers believe that unified water resources management under the overall leadership of the much-restructured MWR is gradually becoming a reality in China (Wang and Huang 2002). From the groundwater perspective, another major 1998 reform was to remove groundwater management from Ministry of Geological and Mineral Resources to MWR, a more logical home.

The Chinese bureaucracy—of the government as well as the party— in general has been a subject of much criticism by western scholars and researchers. However, the potentially powerful role of an effective bureaucracy in governance of scarce natural resources such as water has in general been underestimated. In India, for example, the Supreme Court announced two far-reaching environmental decisions in the span of a decade: in the first, it enjoined the Forest Department to bring illegal felling of trees in reserved forest areas forthwith; and the Forest Department which has a large bureaucracy with significant presence at the local levels effectively implemented the Supreme Courtt's injunction throughout Indian country-side; and deforestation of reserved forest was significantly reduced. In 1996, alarmed by widespread groundwater depletion, the Supreme Court, in an equally momentous judgment, empowered the Central Groundwater Board of India as the Central Groundwater Authority charged with the task of controlling groundwater depletion forthwith. Six years later, nothing has changed; beyond launching a limited regulatory program in the Union Territory of Delhi, the Central Groundwater Authority has been totally unequal to the task because it has no operational bureaucracy comparable to the Forest Department (See, also, Down to Earth 2002). The Groundwater Board has been used to its traditional role of groundwater monitoring, which it has been performing with the help of a thin force of scientific staff at the state level.

Groundwater Law, Policy and Their Implementation

In the context of growing scarcity, the task of managing water resources is becoming complex, entailing numerous tasks at the ground level such as, for instance, "1) the need to register users and control free riders, 2) [building] the technical capacity to deliver agreed upon discharges at different points on the network; 3) the establishment of a process of collective decision making where groups of users are federated in higher hierarchical levels, with corresponding representatives; 4) the definition of partnership between users and irrigation officials, where service fee contributes to payment of field staff; 5) a legal framework to support this new institutional setting; 6) a strong commitment from the administration and politicians." (Barker and Molle 2002: 21). Barker and Molle also argue that in the Asian context, 'the growing importance of common pool groundwater resources add greatly to the complexity of the problem." Doing this will require resource

management and regulatory institutions with wide reach.

South Asian countries are at ground zero in all these. None of them has in place a system of registering water users nor a law or a legal framework. In India as well as Pakistan, draft groundwater bills have been making rounds for several years; but there is no will to make them into a law because of doubts about their enforceability (Steenbergen and Oliemans 2002). China has more of the necessary conditions in place to make a beginning. Starting with the epoch-making 1988 National Water Law, which defined a new legal and policy framework for water management, China has enacted 3 more laws and issued some 30 water management regulations during the 1990's (Wang and Huang 2002). A slew of new laws is in the making. The 1998 reforms, which marked a further transition from a planned economy to a 'socialist market economy', pressures have been created for water bureaus at various levels to increase efficiency, reduce staff and generate resources through service provision. In 1992, when the Communist Party voted in favour of transition to a socialist market economy, the MWR proposed a strategic framework for water conservancy reform that focused on five key areas: water investment system, water asset management, water price and charge collection, water legislation and regulation; and water services provision (Wang and Huang 2002). Institutional reform in China's water sector has relentlessly pushed this five-point agenda in recent years.

As of now, however, there is little evidence that this is having much effect on the ground. Chinese as well as Western observers and researchers are critical of the ineffectual role of the Chinese water bureaucracy in managing groundwater depletion in North China. Several reasons explain this: first, the Chinese bureaucracy has for long been fed on the developmental rhetoric of 'protecting people against floods and droughts'(Boxer 2001: 337); moreover, rising from the farmers' ranks, the local bureaucracy empathizes more with farmers' needs to eke out a livelihood than the objective of long term environmental sustainability. Then, there are also informal kinship ties and networks—and cultural institutions such as 'quanxi'—which create a gulf between macro-level policy making and micro-level implementation. Finally, in their exhortations, even national and provincial leaders betray this ambivalence between protecting livelihoods and food security on the one hand and mitigating groundwater degradation. This ambivalence deepens as we move from national to provincial and county levels.

In course of our fieldwork, we found, however, that the water administration was more concerned about sustainability in water-stressed regions than where the water situation is more comfortable. For instance, in Hebei, regulating groundwater over-draft—and in general, managing scarce water efficiently— has become an important goal of administrative action, and initiatives are designed at all levels to focus on demand as well as supply side issues. It starts from the top; for example, the Ministry of Agriculture, Govt of PRC is working on a national policy to wean farmers away from wheat and rice and encourage them to grow water-saving high value crops. Water Affairs Bureaus came up in water scarce North China faster than elsewhere; for instance, in Fuoyang river basin, a sub-basin of Yellow, 49% of counties established water affairs bureaus by 1999 where as only 7% of the counties did so at the national level (Wang and Huang 2002). Similarly, although licensing is provided for all tubewells and water users by the National Water Law of 1988, it is enforced more vigorously and exhaustively in provinces like Hebei than in relatively less water-stressed provinces like Hanann[5]. Licensing of industrial and municipal tubewells is already in vogue in

5 Wang and Huang (2002) however cite a 1995 Report on Implementation Situation of Water Withdrawal Permit System by MWR which asserts that 95% of users (barring domestic water users who are exempt) had applied for permit by July 1995. If this is true, it is a major step forward in resource management since it automatically created a registry of water users, and brought these within the ambit of the resource management agency. Apparently, the performance of water resource fee by water affairs bureaus in urban areas too is quite satisfactory; however, in 1993, the farmers were specifically exempted from the fee for a period of 5 years by the Central Government to alleviate their burden; and the exemption continues to date. Wang and Huang (2002) suggested that water bureaus in Hebei were to begin collecting water fees from farmers irrigating with groundwater in 2000; however, in course of our fieldwork in Hebei in mid-2002, we found no sign of farmers paying any water resource fee in Hebei.

many provinces especially in North China. Farmers are to be licensed individually; however, in practice, only villages are licensed for irrigation tubewells; the next step is to issue tubewell license. In Luancheng county in Hebei, while existing tubewell owners are still outside the ambit of the permit system, farmers who drill new wells are obliged to obtain permits through which the spacing between wells is regulated (Kendy *et al.* 2002)[6].

Under the 1989 water law, borewell drilling contractors too are supposed to be licensed; but these are not covered by the permit system in most of the Hanan province. In Hebei, however, licensing of groundwater structures is taken far more seriously. In several villages we visited, we found that all the tubewells were individually licensed for 5 years. Drilling companies were licensed too; bigger ones were licensed by the Province Water Bureau and are allowed to operate anywhere in the province. Local contractors are licensed by Township Water Bureau and can operate only within the township area. There seemed to be no unlicensed drilling units in this township. Since 1999, the licensing drive has become more serious; besides domestic users, all other water diverters are to get a license which costs only Y 4 (US c 50). In some other counties of Hebei, we still found permits obtained at the village level; and the license drive is yet to begin with individual farmers in full earnest. But there were indications that this would gradually happen. Some county courts in Hebei have already constituted Water Law Teams whose job is to enforce the National Water Law. If a farmer has not obtained a license, the Bureau staff pursuade him to get one; however, they can not impose a penalty on him; they can merely lodge a court complaint; and only the court can punish unlicensed diversion of water.

In Chang Zhou county of Hanan, which exemplifies the groundwater crisis of North China plains somewhat in the manner of the Mehsana district in North Gujarat, the County Water Bureau is pursuing a 5 point strategy combining demand management as well as supply augmentation to counter it: a) Promoting water saving technologies; b) Discouraging water intensive crops and promoting water saving, high value ones: c) Water import; d) Limiting the number of tubewells; and e) Limiting the draft from each tubewell. There is some progress, especially on promoting water saving technologies. Buried pipes and over-ground pipes now cover 70% of the farm lands in the county. Little progress is made in encouraging a shift from food grain crops to high value water saving crops; however, rice which was once a significant crop is no longer permitted in Chang Zhou county or elsewhere in North China. On water imports, major progress will occur only when the mega water transfer project from Yangtzee to Yellow gets completed; but on a smaller scale, some water imports are already taking place from Shandong province. While little progress is seen in restricting the number of tubewells for agricultural use, industrial use of groundwater is much more tightly regulated in Chang Zhou county now than ever before. Each industrial unit is provided a licensed draft limit up to which groundwater withdrawn is charged @ Y 1 (US c 12)/m^3; beyond that, the rate goes up steeply to Y 5 (US c 62)/ m^3.

There is growing though scattered evidence of successes in groundwater demand management in North China. In Luancheng county in Hebei, Kendy *et al.* (2002) note that a cost-share program of water saving—in which the provincial, prefecture and county water bureaus share 30% each while the farmer contributes 10%—resulted in shift from flood irrigation to sprinkler sets serving 2900 ha, drip irrigation to 20 ha and buried pipe networks to 6700 ha. Similarly, a panel of UN experts studying basin management in Huiahe river basin east of Yellow noted that 'with the same irrigated area and water consumption, the grain output [in the basin] almost doubled from 1980 and 1993, increasing from 40.4 to 73.6 million tons. This may point to a significant improvement in agricultural and irrigation practices over a short space of time, but is probably due largely to the uncontrolled expansion of groundwater irrigation to supplement existing surface schemes" (UNDP 2000:8). And later, the report says, "While the predominant approach has been supply

6 However, a little later in the same paper, the authors suggest that even new tubewells easily escape the permit system because their owners use private drillers in preference to the Water Bureau since the former are cheaper, demand no labour contribution and evade the permit system. (Kendy *et al.* 2002:15).

oriented, demand management has made its mark. In irrigation, efficient water use is an important programme that is reported to have had significant impact during the past 15 years." (UNDP 2000:9).

In South Asia, such demand management initiatives by local governments or water bureaucracies are rarely to be found even in areas like Mehsana in North Gujarat, Ramnathapuram in Tamilnadu or Kolar in Karnataka, examples of Indian districts suffering extreme groundwater stress. Here, to start with there is no legal or regulatory framework under which groundwater use can be regulated; even if there were one, there is no administrative structure that might enforce it. In any case, there is no water administration at the district or taluka (block) level that might develop and implement anything like the strategy that the Chang Zhou water bureau has come up with. Above all, even at the higher levels of the bureaucracy and political leadership, there is no recognition of environmental sustainability as an important policy variable; the focus of attention is still on how best to protect livelihoods. It is not surprising that in most Indian states, electricity supplied to farmers by state-controlled power utilities tend to become cheaper, not costlier, as one moves from groundwater abundant to groundwater-depleted areas.

Larger Context: Political, Economic and Institutional

The strongest factor that may help China act decisively to manage its groundwater socio-ecology for environmental sustainability is that it has become a growth economy. Pressure on groundwater use in agriculture tends to decline as economies industrialize; no better example can be found to illustrate this than Hong Kong, where groundwater use—which was never very intensive— has almost stopped with the decline of agriculture and most of the workforce getting absorbed in secondary and tertiary sectors of the economy (Chen 2001). Hong Kong also exemplifies how water scarcity is seldom absolute; and as economies grow, public water systems are able to invest in multiple avenues of balancing water demand and supply. At a GNP of US $ 3600 per capita in PPP terms, the Chinese economy's capacity to absorb surplus rural labour is huge. Already, the work permit system which for long has kept China's rural labour force confined to the country-side is gradually relaxing; and migration to regions such as the Pearl River delta that are emerging as China's economic powerhouses is beginning to ease population pressure on land. The major agrarian challenge that China will face in the coming two decades is of producing enough food for its growing population so that its food deficits do not grow so large as to destabilize global food markets (Brown 1995). Long term forecasts made by China IWRH[7] suggest that by 2050, 60% of China's population of 1.55 billion will be urban (compared to 25% now); irrigation water use will increase moderately from 391 km^3 to 399.1 km^3 due to growing use of water saving technologies[8]; industrial water use will grow manifold but water use per unit (specific product) of GNP will fall drastically from 100 to 200 m^3 to 20. China will face an acutely negative water balance until 2020 but demand supply balance will be restored by 2050. In this scenario, China's industrial growth rate of 6-7%/year will play a pivotal role in ultimately overcoming the water scarcity. (Zhang and Zhang 2001).[9]

South Asian economies are lagging substantially behind China on the economic growth trajectory; India,

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8 According to Zhang and Zhang (2001:236), between 1980 and 1993, water use in agriculture in the four major provinces in Yellow, Huai and Hai river basins in China fell by up to 6 km^3.

9 That these projections are credible is indicated by the experience of Taiwan over the past 50 years. In most respects similar to mainland China, Taiwan has been an economic powerhouse and its economy has been transformed from a predominantly rural-agricultural to urban-industrial between 1960-90. Taiwan has history of advanced irrigation; even in 1895, 57% of its farm land was irrigated. Irrigated farming got a boost in Taiwan during the Japanese occupation during 1896-1947 when irrigated area increased to 570,00 ha. This trend continued upto early 1962 when irrigation peaked at 676,000 ha. With rapid industrialization, however, share of agriculture in GDP began falling rapidly and reduced to around 3%; moreover, althouth nearly 800,000 families farm land, only 13% are full time farmers; irrigated area fell 44% between 1962 and 1998 to 381,000 ha. With soaring incomes, people's food habits changed; and per caput rice consumption fell from 134 kg/year in 1974 to 59 kg in 1996 which also helped release water from agricultural uses (Sakthivadivel, Aloysius and Matsuno 2001)

Pakistan, Bangladesh and Nepal are still far more rural, poor and agricultural. Despite free movement of labour between rural and urban sectors, population pressure on land and water in agriculture is high and will likely stay so for the next 20 years. In acting resolutely to make agricultural use of groundwater sustainable, the prime barrier in these countries is not so much food security but livelihood security. India is sitting atop a huge buffer-stock of 60 million tons of food grains; and it is expecting a big harvest of 210 million tons in 2002. If anything, India's growing mountains of food stocks are becoming an embarrassment for the government because they feed rodents more than poor people who do not have the purchasing power to buy it. Acting decisively to curtail groundwater use in South Asian agriculture may invite stiff popular resistance if it is seen to hit the incomes and livelihoods of rural poor households who depend more than India's better off farmers on groundwater to protect and improve their crops.

Major technological advances being available—especially, GM crops—are far more effective in addressing the problem of food insecurity than improving livelihoods and incomes of poor people. China, which has embraced the use of bio-technology in agriculture enthusiastically, seems well on its way to enhancing its food production substantially in the next decade. However, South Asian economies will take longer periods of broad-based economic growth and transformation in order to shift sizeable chunks of South Asia's rural, agrarian population to urban industrial and tertiary sectors. In the interim, South Asian governments will tend to be lukewarm to any water management strategy that promotes environmental sustainability by putting rural livelihoods at risk.

Ironically, the nature of the political system many South Asian countries have may encourage their leadership to deal with the environmental challenge facing their water sectors with kid gloves. The parliamentary democracy in India, Nepal, Bangladesh, Sri Lanka and Pakistan seems to be at the heart of their 'soft states'. The vote-bank politics here inspire a populist myopia amongst the political class that makes it difficult for them to take a hard stand on national issues. The inability of South Asian states to act on some fundamental aspects of water governance—such as pricing water to at least meet O & M costs, reforming electricity pricing to save power sectors from ruin as well as aligning the cost of lifting groundwater to its scarcity value on the margin, instituting simple regulatory measures such as registration of wells and basic well-siting norms—suggest their incapacity to choose what is rational and sensible over what is populist, and panders to the vote banks that can sometimes destabilize popularly elected governments.

The Chinese state, in contrast has been a 'hard state' that has systematically transferred wealth from agriculture to build its industrial economy. There are several indications to this: at the county level, leave alone subsidies, farmers pay more for water and electricity compared to industrial users; agricultural taxes in China are a significant portion of the value of land, whereas agricultural land as well as income taxes are either absent (as in India) or levied at trivial rates (as in Pakistan). Since the 1960's public investments in agriculture has declined rapidly; for instance, the share of local governments in infrastructural investment (such as irrigation projects) has fallen rapidly from 63% in 1978 to 47% in 1985 (Wang and Huang 2002).

Summary

Will national water administrations in Asia be in a position to act swiftly and decisively to protect their groundwater socio-ecologies? In our analysis so far, we argue that China has in place more of the socio-economic and institutional preconditions needed to make direct as well as indirect management work on the ground (See table 4). In particular, [a] even as these are weakening, China's village, township and county level governance structures play a more proactive and effective executive and regulatory role than comparable local governance structures in South Asia; [b] China has in place, for well over a decade, a Water Law and a water permit system that are already enforced on industrial and municipal users where as South Asian countries are still debating a water law; [c] the Chinese water administration is better integrated and has a greater and more effective grassroots presence and reach compared to South Asia where water administrations are fragmented, and have

Table 4: Comparing Water Institutions and Policies in South Asia and China: Summary

	South Asia	China
1. Does the village government have significant regulatory role?	No, except in Baluchistan	Yes
2. Are there significant taxes on agriculture? Are these collected?	No.	Yes
3. Is there a system of registering and licensing groundwater structures? Is it enforced?	No	Yes; but not enforced strictly
4. Nature of the water bureaucracy?	Fragmented; thin presence	Less fragmented; but more presence
5. Water as an economic good; does water command an economic price?	No; most users pay a tax	Yes, most users pay a water price
6. Does the water administration have capability to enforce broad-spectrum measures?	No.	Yes; rice cultivation in NCP completely eliminated.
7. Are there institutional limits to 'competitive deepening of tubewells'?	Only indirect; unenforced	Avoided easily, even with privatization.
8. Adoption of water saving methods and technologies	Very limited	Extensive and growing
9 Macro-economic safety valves: Is there scope for shift of population from farm to off-farm livelihoods?	No; except in small pockets	Yes, with the work permit system liberalized..
10 Institutional reform: is the focus just on cost recovery or productivity and environment sustainability?	Focus on cost recovery through IMT.	Chinese water admin. in a 'franchise mode' rather than IMT

thin or no presence at the local level; [d] the Chinese are much closer to transforming water into an economic good than South Asians; a large proportion of Chinese water use—domestic, industrial, agricultural—is paid for based on consumption or its surrogate; most South Asian water charge is aimed at recovery of O & M, and is collected as a *tax* rather than as a *price*; [e] in search of viability for its water infrastructure and institutions, China is transforming its water bureaucracy into a business-oriented service provider which is likely to place water productivity at the centre stage; South Asia, in contrast, is trying to turn over irrigation management to water user organizations; such institutional reform may achieve better cost recovery but it is unlikely to mount effective regulation aimed at sustainable use; [f] finally, with work permit system being liberalized, a rapidly industrializing China is likely to witness massive population shifts from water-stressed North to wealthy South and East, especially the Pearl River delta enjoying economic boom; China's industrial growth presents it with a safety valve to take population pressure off its irrigated land; and its challenge of producing enough food is easier to meet than of creating millions of rural livelihoods, which is South Asia's central concern.

To South Asian policy makers, the lessons China's experience offers are four: [a] local resource management or community rule-making are unlikely to offer effective solutions to unsustainable groundwater use in the South Asian rural context where food and livelihood security are uppermost concerns of water users; effective regulatory frameworks and vigorous demand management require strong authority structures at micro, meso and macro levels; [b] making a national water policy or groundwater law has no meaning unless it is underpinned at meso and local levels by institutional structures to implement these; [c] the first essential step South Asian countries need to take in order to manage water better as an economic good is to start charging a price for it rather than a tax; to do this, two things seem essential: first, focus needs to expand from infrastructure creation to service provision and resource management; second, ways need to be explored to drastically reduce transaction costs of consumption linked pricing; in doing both these, the Chinese experience is valuable; and [d] finally, in the medium to long term, a big part of the solution to the upcoming groundwater crisis is economic growth and urbanization, and shifting people from farm to off-farm livelihoods.

III. Mexico: Aggressive Reforms in the Groundwater Economy

Like India and China, Mexico too suffers from chronic imbalance of population and water availability in different regions. Arid and semi-arid areas of Mexico account for

76% of the population, 90% of the irrigated area, and 70% of the industries but these receive only 20% of Mexico's total precipitation (Barker *et al.* 2000). As a result groundwater depletion is rampant in North, North Western areas and in the Mexico Valley. States like Sinaloa, Sonora, Guanajuato, Coahuila and Tamaulipas are water short but have intensive agriculture; Chiapas, Tabasco, Campeche, Yucatan and Quintana Roo are water abundant but have the bulk of Mexico's poverty. In the former, which constitute Mexico's food baskets, dealing with groundwater depletion is a critical policy issue that Mexico's water reforms have tried to grapple with.

Mexico's irrigation reforms—of which groundwater reforms are an integral part—are a product of its agrarian history and the larger program of restructuring the economy that began during the early 1980's. The agrarian structure we find in Mexico today can be traced back to the series of peasant uprisings that culminated in the 1915 revolution and ensuing 1917 constitution. The far reaching land reforms—driven by the principle 'land belongs to those who work it' —that were ushered in by the 1930's but that in fact took decades to consummate, declared the Mexican state as the custodian of all land and broke up large feudal estates into 100-800 ha holdings. Two different forms of land rights followed—*pequeña propiedad* ("small" private property) and the *ejido* (or agrarian collective). The former had unattenuated ownership rights over land; the *ejidatarios* (or *ejido* members) got a legal identity but had only usufruct on land; they could use and inherit land but not mortgage or sell it. Up to 1983, 25,589 *ejidos* were formed.

Mexico enacted its first Irrigation Law in 1926; this was replaced by a Federal Water Law in 1972. But it was the Law of the Nation's Waters of 1992 combined with an amendment to article 27 of the constitution in the same year that became a watershed in Mexican agrarian as well as water reforms. Up until 1989, all irrigation was managed by the Ministry of Agriculture and Hydraulic Resources; and like in India, the government policy towards agriculture and irrigation was guided by the socialist thinking of a welfare state. The reform process pursued four fundamental and far reaching aims: a) Make water infrastructure self-financing by withdrawing the government from its management; b) Improve the efficiency of water use by establishing tradable private rights on water as well as by involving users in managing water infrastructure; c) Restrict and even reduce groundwater depletion by the CNA (*Comisión Nacional del Agua)* operationalizing the authority to issue rights (concessions) to draw groundwater and by enforcing the concessions; d) Achieve basin level optimality in water use through basin level co-ordinating mechanisms. Did Mexico's reform process achieve all these aims? A discussion of this question is presented elsewhere (Shah, Scott and Bucheler 2002); here we focus on how far have Mexico's water reforms helped achieve sustainable management of its groundwater economy.

Before 1992, groundwater rights in Mexico were tightly linked to land rights, much like in Asia today (Wester *et al.* 1999). There was some discussion of creating private water rights separate from land rights during the 1980's itself; and a National Registry of Water Rights was created well before the sweeping reforms in water sector took place in 1992. In 1989, the National Water Commission (or CNA), was created as the first step to separating the management of water from that of the agrarian economy, recognizing the declining role of agriculture in Mexican economy and growing non-agricultural demand for water.

The new Law of the Nation's Waters aimed to [a] 'provide for administrative modernization, planning and programming' in the water resources sector; and [b] 'reinforce a more efficient and rational use of natural resources'. The National Water Registry was charged with the responsibility to maintain a national register of newly created private property rights in water. The design manual of the CNA provided that no user could impound or divert more than 1080 m^3 /year of water except by obtaining a 'concession' from the CNA. In sum, all water used for purposes other than domestic personal use, had to be 'titled'.

Thus, Mexico has sought to create tradable private property rights in water by: [a] first, declaring water as national property, thereby severing the linkage between land rights and water rights; [b] allowing existing users to get their use 'regularized' by obtaining a concession from

the CNA; [c] by setting up a structure for enforcing the concessions; and [d] by levying a volumetric water fee from concession holders (barring irrigators) which would help generate resources to maintain water infrastructure. Under the new Water Law, all diversions of water other than for direct personal use are allowed only through concessions. Even sand-mining in river beds—these are considered Federal property—requires a concession. Concessions for different users, uses and sources are for different periods and specified volumes. The Law enjoins the concession holders to abstain from over-stepping the agreed volumes, to establish mechanisms to measure volumes used and report these periodically to the CNA.

What has been the outcome and impact of this rights reform? Mixed, as of now. Large water users, especially industrial and commercial establishments have been quick to secure proper concessions and pay water fee to the CNA. This has been a significant source of revenue for the CNA. Surface irrigation associations (Water User Associations or WUAs) are few, organized and therefore easy to bring within the purview of the concessions; and since each WUA holds a concession on behalf of its members, it is administratively simple to formalize their water rights. Municipal Councils similarly are to obtain concessions that cover all users within their ambit. By and large, municipal diversion has conformed to the volumes they are entitled; however, municipal Water Boards have regularly defaulted on the payment of water fees to the CNA which recently had to write off M$ 72 billion owed by them to it by way of accumulated water fees. One expectation was that the new system of rights would stimulate an active market in water; however, this expectation has been largely belied because 'water rights are not rigidly enforced and legal processes to redress grievances are difficult, costly and drawn out" (Scott, Christopher *et al.* 2000).

The real difficulty has been with water rights of numerous agricultural users who account for over 80% of the water use and seem to be at the heart of the matter. In particular, there are three problems: [a] Getting agricultural users to get 'regularized' by obtaining a concession; [b] coping with the administrative workload involved in processing applications for concessions and issuing them; and [c] enforcing the terms of the concession. Even amongst agricultural users, tubewell irrigators have responded to the Law quite well. Most tubewell irrigators we interviewed, on private farms as well as in *ejidos*—held a concession or had already applied for one. One reason perhaps is that tubewells in Mexico are quite large, by Asian standards. A typical tubewell in Guanajuato goes to a depth of 150-250 meters, has a lift of 60-90 meters, and has a 75-150 hp motor-pump and a 6" outlet pipe yielding 30-60 litres/second. Thus, a typical tubewell may have a command area of 40-80 ha; only large private farmers have individual tube wells; most *ejidatarios* share tubewells through informal 'well societies' similar to the tubewell partnerships and companies found in North Gujarat (Shah and Bhattacharya 1998).

Another reason why tubewell owners keenly seek 'regularization' by securing concessions is that they are linked to the formal economy through their dependence on the Federal Electricity Commission for power supply. The Federal Electricity Commission would require a concession before issuing an electricity connection for a new tubewell. Then, there is also an incentive for existing tubewell owners. Power supply to agricultural users in Mexico is subsidized; farmers pay around Mex $ 0.23-0.28/kWh against the average power tariff of Mex $ 0.55-0.65/kWh. And although the CNA and the federal government have yet not used that stick, they have certainly issued threats that tubewells without concessions would attract commercial power tariff, while 'concessioned' tubewells will keep enjoying subsidized tariff. This is a major factor; an average tubewell in Mexico probably uses 50-80 thousand kWh of power in a year; and access to power subsidy at current rates would mean a saving of Mex $ 12-18000 /year in their electricity bill, high enough to make it worth getting the concession.

However, it is one thing to issue a concession to a tubewell; it is quite another to specify its volumetric water right and yet another to limit its pumping to the volume specified. The 'concession' in itself is nothing more than the registration of a well, which is easily done from the records of the Federal Electricity Commission in the Mexican context where all groundwater pumping is done

by electric pumps. The creation of a water right lies in entitling each concessioned tubewell to a particular volume of extraction. We found, however, that the volumes entitled are based on a combination of the current use implicit in the yield of the well and the area owned. Thus, groundwater concessions merely regularize the status quo and do not aim to curtail present levels of groundwater use, except through ban on new tubewells which can be more efficiently imposed simply by putting a cap on new agricultural power connections.

Monitoring the actual extraction and enforcing it to 'entitled volumes' has proved impossible even in a small state like Guanajuato where agricultural tubewells are all of 15,000 in number. The CNA has legal powers to undertake surprise inspections and monitor water use under concessions. However, it has only 2 field teams in Guanajuato; and if these were to make a single inspection visit to each irrigation well, it would take several tens of years to complete one round. Now, the state CNA has got 7 brigades of 2 members each against a request for 20 brigades. This is better but is still much less than what is needed to begin to monitor actual groundwater extraction. In law, concessions are supposed to forfeit if the concessioned volumes are not used by the holder; however, this provision can be enforced only if there is regular monitoring of water use by concession holders. This is proving well nigh impossible; and there is already talk of extending the ambit of the 'environmental police force'—already created at the Federal level primarily to enforce industrial pollution—to cover groundwater extraction.

Compared to tubewells, a far trickier animal is the *bordo*, a small tank-like water harvesting and storage structure—and *presas that are somewhat larger—which* have been proliferating in uplands of Mexico at a frightening pace.[10] *Bordos* and *presas* too are growing especially in up-land areas with intensive livestock farming for meat or dairying. In Guanajuato alone, around 200 large *presas* are organized as *Unidades de Riego*[11]—nominally controlled by the state agriculture department but are in fact farmer controlled and managed as much as smaller *bordos* and *presas* are. If the tubewells listed as *unidades* (because they have received some government assistance for drilling, etc.) are included, together, these informal water structures irrigate more land in Guanajuato than all the WUAs do together. Under the new Water Law, each of these structures needs a concession; but most, as yet, do not have them. *Bordos* and *presas* present a catch-22 situation for the Mexican experiment in creating private water rights: if their owners persistently avoid applying for concessions, the intent of the Water Law will be frustrated in substantial ways. However, if they begin applying for concessions in large numbers, it may raise important issues of administrative logistics as also of equity and integrated river basin management that Mexico is trying to achieve.

In the hilly upland areas of Mexico, and the catchment areas of major river basins, *bordos* have emerged as the backbone of a rainfed crop-livestock farming system. Conditions in these hilly upland areas are worse than in the plains. The new Water Law, under which all water bodies are required to be concessioned by the CNA has created enormous confusion for owners of the *bordos* which store 5,000 to 50,000 m^3 of water. Besides finding it pointless, upland farmers we interviewed were worried about the hassle and transaction costs which are out of all proportion to the value of *bordos*. Concessions have set into motion a new race for privatizing the rain water run off. Another major concern was also about how the Water Law hits the poor in the remote areas particularly hard. The government keeps issuing ordinances and new time limits for compliance. But people in the remote areas do not even know about these for months and get left out. In the meanwhile, the smart and aggressive use these proactively to entrench and strengthen their positions by legalizing them. They have found that getting concessions is an easy way of establishing private rights over what was so far open access run off.

10 IWMI estimated their number at 29,000 in late 1990's (Scott and Flores-López, submitted). The State Water Commission believed that although *bordos* are traditional structures, a large majority of these came up during the past 10 years as popular response to growing water scarcity. Local farmers we interviewed supported the view that a majority of *bordos* found today are less than 8-10 years old.

11 These are used by rainfed farmers essentially to get one irrigation to establish the rainfed sorghum crop.

This kind of mass manipulation also occurred in the *bajío* areas, the low lands of south-central Guanajuato for their intensive groundwater use in agriculture. Here, groundwater depletion is a 50 year old problem; the first ban on new groundwater structures was announced way back in 1948; and since then, 14 such bans have been issued. However, every announcement of an imminent ban—or injunction to regularize existing tubewells such as in 1995—here stimulated a flurry of tubewell making activity in the hope that if made before the deadline, they would get regularized. Indeed intended bans and injunctions for regularization can be counted as one of the chief reasons for the run away rise in tubewell density in central Guanajuato. One such injunction was issued without a time limit in 1995; another with a time limit in 1996; and yet one more was issued on February 2002 with time limit up to September 2002. Farmers also used other ways to manipulate the concession-grants. Many made new wells in the name of 'repositioning'. Fransisco García, a senior CNA official lamented that in 2001 against 250 applications for repositioning wells, 1000 new wells were made commonly with power connections drawn from a concessioned transformer.

The CNA's decision to form and support COTAS (Aquifer Management Councils) was born out of the recognition that concessions and private water rights by themselves would be of little help in getting the water users in the 'informal sector' to play the ball-game of sustainable water management, and that new mechanisms and structures need to be experimented with to engage this vital sector in implementing the spirit of the Water Law. To their protagonists in the CNA, COTAS were government promoted NGOs fashioned as user organizations; and Guanajuato, where these early experiments first began under the leadership of Governor (now President) Fox, continues to lead Mexico's COTAS experiment to date. Of the 47 COTAS in Mexico, 14 are in Guanajuato, one for each of the 14 aquifers delineated in the state. Now COTAS have been adopted as a national model and the CNA is promoting them in the rest of the country. However, federal COTAS differ from Guanajuato COTAS (Technical Councils for Water Management) in that the latter are termed water management *councils* that sound more inclusive where as the federally promoted COTAS (Technical Committees for Groundwater Management) seem limited in their scope. Guanajuato COTAS concern themselves with managing all water resource; COTAS in other states focus squarely on groundwater. Guanajuato COTAS are also supported more liberally with state financial support; each is provided a rented office, a car and salaries for a Manager, a technician and an administrative assistant. Federal COTAS have far more meager support from the CNA. Everywhere, however, COTAS have key design features that are common: their operational domain is defined by an aquifer boundary, which clearly gives primacy to their groundwater management role; they are all designed as representational non-profits; registered as a Civil Association, each has a general assembly, an elected board and a small hired staff. Recently, all the Guanajuato COTAS were federated in to a State Water Management Council with a representational structure akin to a COTAS. The Office of the Guanajuato Water Resources Council (CEH) is the organization that represents all water users in the state. In its evolutionary process, the State Council first brought the 14 COTAS together in this representational structure; but its ultimate goal is to bring all water users/stakeholders into the forum. They already have 6 representatives of surface irrigators now, 4 from two important irrigation districts of the state and 2 more to represent the 200 odd *Unidades de Riego*.

The idea of COTAS is bold; and the expectations from these structures high. A COTAS is expected "to be an IWRM[12] promoter in the state bringing together different actors and stakeholders to protect the water resources in quantity and quality". The State Water Commission of Guanajuato (CEAG) expects that a COTAS should become a local water management organization, and will mature to a stage where it becomes a rallying point for all water users; that as they get formally recognized by the Water Law (which for the present they are not), they will come up with and implement practical water management and conservation actions and policies; they will mediate water conflicts; enforce/implement national water policy on

12 Integrated Water Resources Management.

the ground level (Sandoval, 2002). A common expectation is also that the COTAS—particularly, their state-level federation—will become a powerful instrument of implementing the Law of the Nation's Waters; they will interact with authorities and water regulatory agencies and provide decisive inputs on the creation, establishment, control and changes in water management plans. Above all, COTAS are expected to mediate between the state and the federal water authority and water users they represent. This is why COTAS were designed as representational organizations.[13] The sub-text in all this is that with their closer grassroots presence, COTAS will do what the CNA can not: restrict groundwater extraction by enforcing the Water Law.

Will Mexico's COTAS fulfill these multifarious, often conflicting expectations? It is early days to say; COTAS even in Guanajuato, the state that pioneered them, are all of 4 years old; and according to Francisco García, Deputy Director of Water Administration, CNA, Guanajuato, COTAS will take time to become effective. "After all, Texas took 16 years to constitute its first aquifer management organisation through a state assembly decree, and 5 more years to actually put it on the ground. Mexico's COTAS need to be given time to congeal and find their feet." Guanajuato's COTAS have until 2004 to find their feet; after that, the financial support from the State's Water Commission will cease; and COTAS left without alternative sources of funds will have to liquidate their operating systems, and will in effect cease to exist.

Stuck in such a situation, the normal propensity of a member organization would be to turn to its members for sustenance; it would begin providing services that its members value and in turn expect them to contribute fees for such support. This is what Guanajuato's *módulos* (WUAs) do; for instance, as a member organization, the Irapuato *módulo* offers its members better irrigation service and has jacked water fees five times in five years, partly to fund its own growth and partly to improve the services. A fundamental design flaw in COTAS may well be its concept itself: it is not allowed to provide what a majority of its members value most, viz., unrestrained access to groundwater; and its members are reluctant to want to pay it membership fees for enforcing the Water Law on them—which its creators think is the mandate of the COTAS. It is not surprising then that industrial players—whose water use was closely regulated even before the new Law—have been quick to take to the COTAS and even dominate them; but the farmers, the prime target of the Water Law's groundwater provisions, have been staying away from the COTAS.

As a result, COTAS are ploughing along without a strong sense of direction. Most have no notion of formal membership. With its 20,000 concession holders, Guanajuato's 14 COTAS should each have 1000-15000 members with full user participation[14]; but their general assembly meetings often have a few dozen participants. The Ocampo COTAS, one of the few which offers formal membership has less than 100 members of the several hundred groundwater concession holders (Ocampo is not an important groundwater irrigation region). COTAS are little known amongst common people; and their presence on the ground is thin or non-existent. Some 45 farmers we interviewed in various parts of Guanajuato—these included all types, small holders as well as large farmers, men and women, a few young and mostly old farmers—all were uniformly blank on COTAS. Most COTAS boards

13 In a typical COTAS in Guanajuato, accordingly, the general assembly elects a 10 member board that has President, Treasurer, General Secretary, one representative each from agricultural users, public service (which includes domestic and municipal users) and industrial users. A back up candidate is elected for each of these which takes the total board size to 10. The General Assembly generally meets twice every year; the board meets every month. There are few women on elected boards; however, 5 are hired as employees by different COTAS. In keeping with their broader, more ambitious mandate of IWRM, the Guanajuato COTAS drew representatives from various stakeholder groups although their domain was defined by the aquifer boundaries. In these 14 COTAS, 12 of the 29 elected representatives of farmers represent surface water irrigators where as 17 represent groundwater users. In theory, only concession holders are official members of the general assembly of a COTAS; however, in practice, the State Water Commission staff ends up spending a great deal of effort in getting all users to participate.

14 As a matter of fact, the State Water Commission (CEAG) has tried to break out of the norm that only concession holders can be COTAS members; it has been trying to broaden participation into COTAS affairs from wider cross-section of the citizenry.

were elected by a general assembly attended by a small fraction (often 5-10%) of total concession holders.[15] Partly for that reason, the office bearers of COTAS enjoy little regard and allegiance of the wider public and citizenry, neither do they seem under pressure to respond to an aggregate of member priorities from COTAS. Many elected office bearers of COTAS seek to pursue their own ideals or have their own passions and bees in bonnets, and drive their COTAS in that direction rather than working on aggregated priorities of members, as would be the vogue in a responsive member organization (Shah 1996). For instance, the president of a predominantly agricultural COTAS has been able to focus all its work on issues related to industrial water use that he feels strongly about although most concession holders in the COTAS domain are farmers.

A major reason for member apathy is that the high-ground assumed by the COTAS leadership often fails to connect with the here-and-now priorities of its members. In Jaral de Berrios, one of the best performing COTAS according to Guanajuato Water Commission, only a couple of dozen farmers, all above 70 years of age participated in a council meeting to strategize for groundwater management.[16] Concerned about the bleak agricultural future of the region, the COTAS president, a large private land holder, delivered an impassioned speech advocating the need to restrict groundwater use by regulating the area under tube well irrigation, and presented an elegant formula to link total groundwater draft to the previous year's rain fall. The old farmers in the audience were unmoved; one 75 year old *ejidatario* got up and said, 'My farming is already down to 2 hectares; how much more do you expect me to cut?" Another rose and said, "It took me 6 years after making an application to get my concession; and by then, my tubewell needed to be deepened and I was ready for a new concession. Can't the COTAS help us cut through this maze?" Yet another farmer described how he put his life's savings in an expensive drip irrigation system, which failed and irrevocably damaged his well and pump, due to lack of technical support.

Many people we met thought COTAS have done well as 'talking shops'. Numbers support this suggestion; during the first half of 2001, all 14 COTAS together organized some 30 meetings in Guanajuato. But the participation often tends to be thin; indeed, an important criterion the State Water Commission (CEAG) uses in judging the appeal and robustness of a COTAS is the level and extent of participation in its meetings. Some COTAS seem to have served well as a public platform for raising and debating water issues. In Silao-Romita, the major purpose the COTAS has served so far is in mobilizing the community to protest the transport of groundwater from its aquifer to Leon, the largest industrial city of Guanajuato, a transaction wholly valid within the Law of the Nation's Waters.[17] Many COTAS are deeply into research, training and capacity building as a core activity, somewhat unusual

15 For instance, in the 4-year old Silao and Romita COTAS which also covers the town of Guanajuato, the general assembly included 2049 well owners, 93% of them agricultural, should reflect farmer concerns. However, a general assembly attended by some 100 members elected a manager of the General Motors as the President, a manager of the Leon airport as the Treasurer.

16 Jaral de Berrios aquifer, shared by Guanajuato and the neighbouring state of San Luís Potosí, faces critical problems of over draft but has only a few hundred wells; the Guanajuato side in fact has only 334 wells, 89% of them agricultural. Only 200 of these are concessioned yet; others have applied some years ago and were waiting to receive their concessions. These large tube wells, going to 250-280 m and using pumps of 75-100 hp produce discharges of 25-40 l/s which they deliver into a large tank and from thence, water conveyed by buried pipes to different fields. Typically, a well irrigates 30-35 ha and if all users use drip irrigation, the area irrigated can go up to 55-60 ha. However, only 3% of the tubewell irrigated area uses drip; and farmers feel reluctant to 'technify' their irrigation systems because of the dismal after-sales support of irrigation equipment companies. Many would also expect government support to install such technologies. Wells are private as well as group-owned, the latter common among *ejidatarios*.

17 Leon has its own groundwater concessions; however, in order to meet its growing municipal demand, Leon municipality (SAPAL) purchased groundwater rights from 3 well owners amounting to about 600,000 m^3/year for N$ 6 million at N$ 10/m^3, . They now intend to set up a 30 km pipeline to transport water to Leon. The Silao-Romita COTAS is averse to the idea primarily because it is not sure that the Leon municipality can be restrained to pump only the concessioned quota. It is difficult, if not impossible, to continuously monitor and account for the pumpage from each well; they suspect that once it is allowed to pump, Leon can pump the aquifer dry.

for a member organization which exists to provide services that members would pay for. Valuable as these service may generally be, it is doubtful if COTAS members will be willing to pay for them, and that at a rate that would enable the COTAS to survive. As a result, managers and staff of the Guanajuato COTAS—arguably, the stakeholder group most concerned about the future survival of the COTAS—are exploring strategies of resource generation from sources other than their members. Many will continue to look up to the CNA and state governments for continued support. Laguna Seca COTAS has been planning research collaboration with the Ecology Institute and State Department of Agriculture which the CNA will probably support.[18] The Silao-Romita COTAS hopes that a research collaboration with Guanajuato University's Agricultural Research Station on researching water saving irrigation technology will help it generate resources. The Ocampo COTAS has planned a range of services and activities to generate resources from members: such as registering *bordos*, tanks, wells, etc with the CNA so that members have secure rights; training and technical support in irrigation, *bordo* construction; help members deal with the CNA's titling process and concessions; help in installing small treatment plants at the community level. However, with its current human resource base, it is open to question whether the Ocampo COTAS can fructify this plan, or even a fraction of it.

In sum, the present role and future direction of the COTAS are unclear to say the least. The CNA expects them to implement the Water Law, in particular, help contain groundwater extractions to concessioned limits, and help curb illegal well-drilling. Ambitious COTAS presidents, such as in Jaral de Berrios, want to transform the COTAS into a strong water user organization that can mediate between the users and the authorities. Many COTAS managers view their role as one of promoting IWRM. There is no indication yet that COTAS are ready to play any of these roles. However, what they have been doing may not be without value. Many COTAS have been monitoring water levels; most have been carrying out water education campaigns. They have served as forums in which users can participate in discussing their water problems. And others have been trying to promote technification. At least in one COTAS, farmers shifted wholesale from cultivation of wheat to barely which uses less water.[19] In any case, regulating agricultural use of water, especially of groundwater, is a challenge that has nowhere been met fully; and perhaps, the CNA will be well placed to support COTAS for a long time to come with full recognition that they will not be able to achieve the ulterior goal behind the CNA support, *viz.*, to help CNA implement the provisions of the Water Law on the informal water sector. Considering that the 14 Guanajuato COTAS have cost the state Water Commission (CEAG) less than US $ 2.5 million to support for five years[20], one can easily argue that the capacity building and attitudinal impact COTAS can produce through targeted research and public education activity may justify such investment in view of growing importance of water in Mexico's evolution. An early vision of the COTAS was that they would foster self-policing by users themselves taking the responsibility of self-monitoring his extraction to the agreed volume. Even though idealized, some believe that such a scheme can work in Mexico aided by European style 'water notaries'

18 For a member organization to police and spy over its own members would be a curious role indeed. This is what Laguna Seca has been doing. This COTAS has already put its head in the lion's mouth and declared to the CNA several farmers making illegal wells clandestinely. CNA can never find these out; but being closer to the field of action, COTAS can; and Laguna Seca COTAS tipped off the CNA while the clandestine wells were being made.

19 This is a great achievement; however, besides the educational effort of COTAS, the key catalyst to this change has been the establishment of a Corona beer plant in its territory that created a steady, remunerative market for barley far better than wheat. This suggests that in the complex business of groundwater regulation, an ounce of positive incentive may do the work of a ton of regulatory effort.

20 The cost of catalyzing and sustaining COTAS in Guanajuato has been met by the State Water Commission (CEAG) through providing them budgetary support as follows:

Year	Support to 14 Guanajuato COTAS
1998	US $ 153,471
1999	US $459,184
2000	US $607,142
2001	US $510,204
2002	US$ 766,490

Table 5: Groundwater Governance: Comparative Analysis of Institutions and Policies in South Asia, China, and Mexico

	South Asia	China	Mexico
1. Government share in GW provision to agriculture	Miniscule; <0.01%	No	No
2. state provision of GW to urban settlements	Significant	significant	significant
3. state participation in GW monitoring	Yes	Yes	Yes
4. Incentives to private investment in groundwater development	Significant in India and Sri Lanka, often perverse; discontinued in Pakistan, Nepal, B Desh	None or insignificant	None
5. Incentives to operating costs	Huge in India; less in other countries	Nil or insignificant	Yes, energy subsidies
6. Targeted disincentives in capital or operating costs	None	None	None
7. Registration of GW structures	No	No	Yes
8. Permits to abstract groundwater	No	Yes, but mostly to villages, municipalities and industries	Yes, but water quantities unenforceable
9. Promotion of water saving technologies	Ineffective	Yes, strong	some
10. Promotion of small-scale water harvesting and recharge works	Strong in western India; but growing elsewhere in India	South-North water transfers	Yes, in highlands where bordo's are the mainstay of livestock farmers

that might be used to certify the actual extraction. We believe many conditions will need to be fulfilled before such a scheme might work reasonably well; one of these is high quality public education on groundwater issues. And COTAS are certainly equipped to deliver this.

IV. Conclusion

In this paper, we have reported results of field research on groundwater management institutions and policies in three regions of the world where agriculture, food and livelihoods depend heavily on intensive use of groundwater which is becoming increasingly unsustainable. Our purpose was to review institutions and policies in place to promote sustainability and draw lessons from comparative analysis. Table 5 summarizes our key conclusions from such a comparative analysis. Our overriding impression is that South Asian countries have not even begun to address the problem in any serious manner; China has but will take time before its initiatives bear fruit. Mexico has gone by far the furthest in creating a legal and property rights structure that might be drawing a leaf from an institutional economics text book. Interestingly, we find no evidence that these have helped Mexico move towards sustainability; and that Mexico's efforts need to produce better results before they can be held out as a model that other groundwater-using countries can follow. However, our comparative analysis does suggest the outline of a framework that tells us what might work where.

How countries respond to the challenge of sustainable management of their groundwater economies depends on a constellation of factors that defines the peculiar context of each country. This constellation of factors differs vastly across regions and countries; and these differences have decisive impact on whether an approach that has worked in one country will work in another with a different context. As a simple illustration of this point, table 6 sets out some key variables that define the organization of the groundwater economy in six different countries which make intensive use of groundwater in agriculture. The US uses around 100 km^3 of groundwater for irrigation; but to manage its economy, it has to monitor and regulate only around 200,000 pumping plants, each producing around 500,000 m^3 of groundwater/year. Mexico is in the same league as the USA. India uses 150 km^3; but to manage this groundwater economy, it has to manage the owners of over 20 million small wells, each producing an average of

Table 6: Structure of national groundwater economies

Country	Annual groundwater use (km^3)	No of Groundwater Structures (million)	Extraction/ structure (m^3/year)	% of population dependent on groundwater
India	150	19	7900	55-60
Pakistan-Punjab	45	0.5	90000	60-65
China	75	3.5	21500	22-25
Iran	29	0.5	58000	12-18
Mexico	29	0.07	414285	5-6
USA	100	0.2	500,000	<1-2

8000 m^3 of water/year. Clearly, the task of US groundwater managers is enormously simpler compared to their Indian counterparts. With just 95,000 agricultural tubewells, the task of governing Mexico's groundwater economy is even simpler [21].

The nature of the political system also matters. Iran has been able to impose a complete ban on sinking of new tubewells throughout its central plains that encompass 2/3rd of the entire country (Hekmat 2002).

Besides what is feasible and practical, there is also the question of social impacts of approaches adopted. In Mexico and the US, where a *miniscule proportion of* people depend on groundwater for livelihoods, governments may easily adopt a tough regulatory posture. In South Asia, where over half of the total population may directly or indirectly depend on groundwater use for their livelihood, it is not surprising that political and administrative leadership is reluctant to even talk about regulating groundwater use, leave alone acting on it. In point of fact even in China, where political resistance from farmers is not an overriding issue, and Mexico where irrigator class is small enough to be ignored, governments have steered clear of tough regulatory measures.

Table 7 lists a tentative set of 'contingencies' that seem to influence the way different countries respond to groundwater over-development. Countries where public

21 However, in actuality, even in Mexico, enforcing concessions on agricultural tubewells has proved almost impossible. Similar is the experience even in Spain where "With the passing of the 1985 Water Law, it was declared as of 'public ownership'. This represented a fundamental change in relation to water rights. Yet this drastic change, compounded by lack of knowledge and a poor information campaign (in relation to the legal changes and to groundwater use) has led to many situations of 'hydrologic disobedience' in relation to water rights and abstraction in almost every stressed aquifer. Indeed the question remains as to what came first, hydrologic disobedience or stressed aquifers'. A typical example of this situation is the Upper Guadiana basin (Lopez Gunn and Llamas 1999).

Table 7: Overall Context and National Strategies for Groundwater Management

Under-managed Resource with accent on supply-side measures	Larger Social and Political Context	Conducive to demand and supply-side management
Weak and unwilling to implement hard measures (India, Sri Lanka, Pakistan, Nepal)	Political System: Central and local authority structures	Capable of tough measures (e.g., Iran; China, Pakistan under early years of military rule)
Numerous small users (South Asia; North China plains)	Organization of the groundwater Economy	Few large users (as in US, Mexico, Iran)
Agri.contribution to GDP>30-50%; popu. Dependent on farming: >50% (South Asia)	Stage of Economic Development	Agri. Contri. To GDP<10%; popu. Dependent on farming: <20% (US; Mexico; Spain)
High (South Asia)	Relative significance of groundwater economy to national and household food and livelihoods security	Low (US; Mexico; Spain)
Water rights as an easement of land ownership (Asia)	Structure of property rights on land and water	Water rights independent of Land rights (Mexico's concessions)
Low (South Asia)	Experience and effectiveness with using law to regulate people's behaviour	High (*Europe*; US)
India, Iran	Perverse Incentives in GW irrigation (energy subsidies; tubewell subsidies)	Low (China, Pakistan, Mexico)
Low (South Asia)	Economics of groundwater irrigation: benefit:cost ratio	High (as in North China; Mexico)
Low (South Asia)	Capacity, reach and effectiveness of water bureaucracy	High (China, Mexico)

systems will aggressively manage the groundwater economy by proactively intervening in demand and as well as supply side will have some of all of the context factors in the middle column aligned in an enabling mode, as outlined in the right-hand column. Where some or all of the context factors operate in a disabling mode, public intervention will tend to be absent, or half-hearted or even perverse; here, proactive response to groundwater depletion will commonly be in the form of projects to enhance supply rather than containing demand. This is perhaps why no amount of opposition from within or outside will deflect China from its mega-project for South-North water transfer; and no matter how much scholars emphasize the upstream-downstream externalities of decentralized water harvesting and recharge, governments and communities in western and southern India will for long pursue these proactively as a strategy of sustaining groundwater irrigation and a more equitable allocation of a basin's water between catchment areas and downstream irrigation commands.

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