# Ecologically and Socially Embedded Exchange 'Gujarat Model' of Water Markets

Groundwater markets are highly developed in the state of Gujarat, as a result of which the Gujarat experience has been upheld as a model of how markets can enhance access to irrigation. This 'Gujarat model' rests on key assumptions about being able to shape and construct markets through policy intervention. In this paper, empirical comparative data on water markets in two villages shows instead that exchange processes are shaped by: hydro-geological factors which influence the risk of accessing water and the fixed costs of drilling wells; path dependence in the construction of irrigation infrastructure (wells and pipelines); and historical precedent and social norms which determine the institutional rules under which water is sold. But actual patterns of exchange rate shaped by complex local institutions. To understand how terms of exchange are structured and shaped over time requires attention to the micro-analytics of how real markets for groundwater actually function. Accordingly, the paper analyses local informal norms of exchange, and explores how they change over time.

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# I Introduction

wo decades ago, scholars of Indian irrigation noted that the risk asso ciated with accessing large quantities of groundwater, the lumpiness and costliness of investment in tubewells, and the difficulties of transporting water over uneven terrain excluded the effective private development and management of India's vast groundwater resources.<sup>1</sup> That groundwater development should be the exclusive province of the state is a view that has been proved wrong. By 1985-86, private tubewells outnumbered public tubewells in the state of Gujarat by a factor of three, a gap that all indications suggest has since widened considerably [Government of Gujarat 1993]. Privately owned dug wells outnumbered publicly owned dug wells by a factor of 719. More recently, driven by reports of seemingly vibrant markets for groundwater irrigation, particularly in the state of Gujarat, other scholars have enthusiastically proclaimed the benefits of the private development of groundwater in conjunction with markets as a means of ensuring broad and equitable access to irrigation [Shah 1993]. In this paper I argue that the pendulum

In this paper I argue that the pendulum has swung too far in the other direction. Claims for the efficiency and equity benefits of groundwater markets have an inadequate empirical grounding, and are based on a 'one size fits all' model of water markets that is insensitive to how groundwater markets are shaped by natural, social and historical factors. In particular, many proponents of water markets base their claims on assumptions that water markets follow the price-clearing and competitive market postulates of neo-classical economic theory.

Drawing on two detailed empirical case studies from Gujarat, I show that systems of exchange for groundwater are often governed by complex local institutions, and that these institutions do not correspond to those of the self-regulating market mechanism. Instead, opportunities for exchange are structured by hydrological factors and by historical contingency. As a result, markets can vary in their 'thickness' and in the institutional forms that govern exchange. In spelling out and explaining these institutional forms, this paper is a first step toward understanding the micro-analytics of how real markets for groundwater function, how they are governed and with what effects.

Why is this important? Groundwater irrigates over 50 per cent of India's irrigated land, and this proportion is growing. Empirical studies record some form of exchange of groundwater in Gujarat, Punjab, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and West Bengal. Since groundwater is an important source of irrigation in India, and since markets for groundwater are a significant and growing means of accessing irrigation, policy-makers must have an appropriate empirical basis for understanding these markets. Among these cases, the market for groundwater in Gujarat has been most comprehensively studied and widely cited, and is considered to be the most 'developed'. Much of this work has followed the pioneering lead of Tushaar Shah, who first brought widespread attention to the existence of water markets and also was instrumental in exposing the links between rural electricity policies and groundwater use. Understandings of water markets and policy prescriptions drawn from his ideas revolve around the question of how to promote greater competition in these markets [Shah 1993]. The implicit assumption is that competition can be created by outside intervention, and that more competition will lead to more efficient and equitable outcomes. These are important and influential conclusions, and since they emerge predominantly from the Gujarat case, this is an appropriate state in which to test these claims.

A second reason is the importance of the Gujarat experience to international discussions of groundwater markets. A recent compilation of experiences with water markets distinguishes between 'formal' markets where enforcement of the trade occurs by recourse to formal legal and institutional measures, and 'informal' markets where it does not [Easter et al 1998]. Also, formal markets are often for water rights rather than volumes of water. The description of these 'informal' markets for volumes of water in the absence of clear property rights over it, and enforced by local rules, draws heavily on the Gujarat experience and particularly on the work of Shah. Thus, it is important to examine the Gujarat experience from the perspective of international policy discussions as well.

With regard to the degree of 'formality' of water markets in Gujarat it is important to note simply that groundwater use in India is governed by a legal framework that ties rights to groundwater to land ownership. However, there is no legal limit to the amount of water a landowner can draw. Hence, markets for groundwater in India take on this 'informal' aspect where they are not based on well-defined property rights and are regulated by informal institutions rather than by formal ones [Singh 1990]. Although there are ongoing discussions over legal dimensions of groundwater rights I do not pursue this topic further in this paper.<sup>2</sup>

In addition, the very significant concern of groundwater depletion in Gujarat is outside the scope of this paper.<sup>3</sup> Village level institutions as described here are designed to address an allocation problem, rather than one of overall extraction which must be addressed at the scale of the entire aquifer. However, any solutions to the sustainability problem should be informed by an understanding of village level institutions of the sort spelt out in this paper.

In what follows, I briefly describe three sets of literature on groundwater markets, beginning with the influential work of



Well, pipeline and irrigation data are from surveys carried out in Ratanpura in 1995-96.

Tushaar Shah.<sup>4</sup> In the main body of the paper, I turn to a detailed comparison of two village level water markets as a basis for discussion of these theories. I conclude by revisiting the theoretical debate, and discussing the policy implications of the findings.

# II Theories of Groundwater Markets

Neoclassical economics: The most influential approach to the study of groundwater markets in India is the neoclassical economic analysis of Tushaar Shah [Shah 1991, 1993; Shah and Ballabh 1997; Shah and Raju 1988]. While others have written about the importance of groundwater in India's irrigation mix, notably B B Vohra (1982) and B D Dhawan (1982, 1988, 1993, 1995), much of their work has assumed that the large and lumpy investments necessary to access deep groundwater requires active state intervention. Shah was instrumental in drawing attention to the success of private exploitation of groundwater in conjunction with active groundwater trade in productively accessing groundwater from deep aquifers. In

addition, his work has most explicitly drawn the link between conditions of groundwater access and use and electricity pricing policy, although the policy implications of his results remain controversial [see, for example, Bhatia 1992].

At the heart of Shah's work on groundwater markets is a model of water markets as an oligopolistic structure. He appropriately points out that low well density, compounded by uneven topography and the potential for seepage losses restricts the possible set of buyers who purchase water from a given well-owner, and lends well-owners a measure of market power. State mandated spacing restrictions can limit entry and thereby reinforce this power [Shah 1993, 73]. The price of water sold is explained by the degree of monopoly power and the marginal cost of pumping water.<sup>5</sup> In addition to driving up the price, monopoly power can affect the quality of service - the adequacy and reliability of supply, for example - provided by water sellers since buyers have no recourse, although this insight is not represented in the model. The normative implications that follow are that public policy should be aimed at reducing the monopoly power of water sellers, which will lead to a more competitive, and hence efficient, market in which the rent captured by the seller will be reduced to zero.

The policy lever for bringing about this change is electricity pricing. Shah advocates a flat rate for electricity based on pump horsepower rather than a per unit rate (a policy since adopted in Gujarat) to encourage pumping and spur competition among sellers [Shah 1993: 93-95].<sup>6</sup> In addition, he proposes a progressive increase in the flat rate as pump horsepower increases in order to provide a disincentive to large pumps as a check against overpumping. Finally, he calls for careful management of power supply, by which he means ensuring timely water supply when farmers need it most - during the summer, and during the daytime – combined with rationing of power supply, to provide incentives for efficient use of water and to limit over-exploitation of groundwater.

Criticisms have been levelled at Shah's work on at least three grounds. First, on the topic of electricity pricing, as long as rationing of electricity is the constraining factor as is currently the case, lowering marginal costs to near zero will make no difference to the amount pumped. Electricity tariffs only become relevant to the decision on pumping when price rather than quantity becomes the constraining factor [Tata Energy Research Institute 1994: 26-31]. Second, critics argue that fixed rate electricity pricing has led to inefficiently high and wasteful use of water over time.<sup>7</sup> Moreover, the costs of the resultant draw-down of the water table are disproportionately borne by the poorest who are unable to chase the water table [Bhatia 1992; Dubash 1998]. Third, the underlying oligopoly model of Shah's analysis has been described as simplistic and incomplete because it does not adequately account for the spatial dimension of markets, hydrogeological factors and incentive and information problems which shape contracts for purchase and sale of groundwater [Palmer-Jones 1994]. The next sub-section deals with an approach that centrally addresses the last of these missing elements: information and incentive problems.

*Economics of information*: Shah's approach provides no insight into the wide range of transaction forms observed in groundwater markets. For example, he dismisses complex share payments for water<sup>8</sup> and in-kind transactions as an artifact of "early stages of water market

development" that with the onset of maturity "gives way to one or two standard and widely used contracts; and outright cash payment gains precedence over crop sharing contracts" [Shah 1991: 52]. But there is no explanation nor evidence cited for this evolutionary thesis, and the empirical record suggests that non-cash transactions are widely dominant and stubbornly persistent.<sup>9</sup> The strength of the economics of information approach lies in asking the question: what explains the choice of coexisting contract forms in groundwater exchange, and in particular, the prevalence and persistence of share payments for groundwater?

In a rare study of water contracts, Aggarwal (1999) examines water share contracts as a solution to a 'double-sided' incentive problem - providing a seller incentive for timely water supply, and a buyer incentive to provide appropriate labour effort. A share payment for water then represents a trade-off which provides both some incentive to self-monitor - sellers in their provision of water and buyers in the application of labour and other inputs. Alternatively, share payments could be seen as a trade-off between spreading production risk between the buyer and the seller on the one hand, and providing the buyer some incentive not to shirk in application of labour on the other. Aggarwal (1999), based on research in Sabarkantha district in Gujarat, finds more evidence for the first than the second hypothesis.<sup>10</sup>

The major strength of this approach is that it highlights the importance of risk and information in agrarian markets. Thus, in the case of water markets, Aggarwal's work singles out the importance of ensuring timeliness of water supply, a particular characteristic of irrigation provision, as a central element in structuring water contracts. This is a significant advance over Shah's approach, which glosses over the existence of multiple contract forms.

Its major weaknesses lies in the narrowness of the question – limited to explaining contractual form – that information economics asks, the lack of attention to historical and social context which limits the explanatory power of the approach,<sup>11</sup> and the lack of attention to the social basis of power in contractual relations.

*Political economy*: In an overview of approaches to the study of irrigation in India, Bharadwaj (1990) describes a production relations approach as one that examines the historical and social context within which access to irrigation is deter-

mined, with the emphasis on an understanding of the differential consequences across class of access to irrigation.<sup>12</sup> Power and its exercise is a central analytical category for her approach.

Wood's (1995) study of the emergence of pumpsets in Bihar is a good example of this approach. In contrast to Shah who looks at exchange primarily through the determinants of price, Wood is concerned with conditions of control over and access to water. He finds that access to water through exchange is critically dependent on a water buyer's structural location in social networks. Thus, while there is a myth of a single universal price of water within a village, an ability to pay, the price does not guarantee access to water, and, moreover, real prices are lowered for favoured clients. Access is decided on the basis of "moral circles of proximity".

Moreover, Wood locates water exchange in the broader context of agrarian exchange systems by noting that well-owners, in an example of "interlinkage" of contracts,<sup>13</sup> use their control over water to negotiate enhanced or additional access to the land of buyers and to their labour at peak demand times. Finally, he places the conditions of access for water within the context of markets for access to labour, bullocks for ploughing service and other variable inputs which show many of the same characteristics.

Janakarajan's work in Tamil Nadu [Janakarajan 1993, 1994] reinforces the importance of exploring contractual details by providing specific examples of how control over water can be used to buttress social and economic power. He finds cases where water purchasers are required to perform unpaid or underpaid labour services such as operating the pump and irrigating the well-owner's field. Moreover, buyers are often tied to particular sellers by village norms that limit supply to contiguous plots and by a seller's ability to refuse conveyance of water through his plot to other possible suppliers. Finally, Janakarajan documents "triadic" relations where sellers receive credit from merchants on liberal terms, in exchange for which they exercise their power over buyers to benefit the merchant by requiring buyers to sell their output to that merchant, usually at a discount.<sup>14</sup>

The central analytic variable for the political economy approach is the exercise of power, and its exercise is the main determinant of conditions of access to water. This is undertaken in a sophisti-

cated manner in Wood's work, and Janakarajan's work adds interesting contractual details that illustrate how control over water is used to extract surplus. Both analyses document instances where power relations curb or limit access, but fail to directly engage Shah's contention that access to water through markets can leave buyers better off than they otherwise would be. I argue that the point is not to develop blanket arguments about whether water markets do or do not work, but rather to look at how and why they work differently in different locations, under different social and hydrological circumstances and with what effects. This is what I turn to next.

# III Two Case Studies

With few exceptions, the field research on groundwater markets thus far has failed to lay out a consistent framework within which to describe field observations, with the result that the existing studies privilege one or the other perspective. Thus the neoclassical approach looks only at how price is mediated, the new institutional economics (NIE) approach examines exclusively contract form, and the political economy approach tends to focus on the exercise of power with the result that other interesting dimensions are missed. In this section,<sup>15</sup> I use a more inclusive approach that selectively adopts insights from all three perspectives. Recall that the empirical evidence from this region and from central Gujarat have been central to the influential policy prescriptions drawn by Shah and others. Hence it is important to take a closer look at the actual functioning of markets in this area.

Ratanpura in Mehsana district, and Paldi in Banaskantha district, offer an interesting contrast.<sup>16</sup> First, however, a few similarities. Both fall in a semi-arid zone, with sandy soil. Both sit above a rich layered alluvial aquifer with falling water levels; water depth is at 350 ft in Ratanpura and 150 ft in Paldi.<sup>17</sup> Both are strongly stratified by caste relations. Ratanpura is a patel dominated village, while Paldi has a multiplicity of castes, but which roughly stratify themselves into two broad groupings. In both villages, the higher castes own disproportionate amounts of land and wells. The striking contrast between the two, however, is that Ratanpura illustrates a highly 'thick' or dense system of exchange, while that in Paldi is relatively 'thin'. Yet, in a paradoxical outcome, there is far greater competition in Paldi than in Ratanpura. This empirical paradox guides the detailed description of the two villages, and provides the thread for the discussion of theories of groundwater exchange that follows.

I begin with a brief description of the patterns of ownership over land and wells in each village. I then describe the structure and functioning of groundwater exchange in the two cases in terms of their market 'architecture', density, and terms of exchange, and seek to explain the differences among the two cases.

If land is a good indicator of power in agrarian societies, then both Ratanpura and Paldi are societies with deep inequalities in power relations.<sup>18</sup> In Ratanpura over a quarter (29 per cent) and in Paldi, almost half (47 per cent) the households are landless (Table 1). Moreover, land ownership is strongly fragmented by caste in both villages. As we would expect from land ownership patterns, tenancy is considerably more prevalent in Paldi than in Ratanpura. In both villages, tenants are predominantly drawn from the lower castes.

Turning to ownership of wells, Table 2 shows that well-ownership is skewed toward larger land-owners in both villages. However, in Ratanpura, there are a fair proportion of medium sized farmers (5.1-10.0 bighas) who do not own wells, and several smaller farmers who do. By contrast, the divide between well-ownership and non-ownership is particularly sharp in Paldi. None of the larger farmers (keeping in mind that average holdings are much larger in Paldi) has to do without a well. This difference is explained, in part, by the pattern of well-ownership in Ratanpura. In several cases, wells are owned by kinship groups of three or four households. This shared ownership affords direct control over water to a broader set of landownership classes. In addition, there are two large 'partnership' wells, each of which has 13 partners who share costs and profits in proportion to their ownership share in the well. This form of ownership and management has enabled small farmers to share in economies of scale, and is a substantial example of collective action that is independently worthy of study.

Architecture: The 'architecture' of a groundwater exchange system is the spatial dimension of both land use patterns and the irrigation infrastructure that, together, determine the need and the capacity to move water. In these two cases, the 'architecture' is a function of hydrology and historical circumstances. Looking first at land, Table 3 shows that land is considerably more fragmented in Ratanpura than in Paldi and that the average plot size is much smaller in the former than in the latter.

It is, however, in the irrigation infrastructure - the number of wells, their location, and the number and density of pipelines from well to field - that the two cases really diverge. This divergence is best illustrated by maps of each village which show the area farmed by each village, and functioning wells and pipelines (Figures 1 and 2). In Ratanpura, a relatively small number of wells are clumped along the river that cuts through the village, most of which have access to a large command area through a complex and dense network of pipelines. The command areas of the various wells therefore overlap leaving considerable scope for competition. The

#### Table 1: Distribution of Land Ownership, 1991 (Per cent)

Population Percentile	Ratanpura	Paldi
0-20	0	0
20-40	4	0
40-60	13	6
60-80	22	28
80-100	61	66

Note: The procedure used to compile this data may exaggerate the number of landless households, since some households may have *de facto* control over land if not *de jure*. Source: Land ownership is compiled from the 1991

unpublished landownership census data obtained from the 'talati' for each village. The number of landless are computed by subtracting the number of landed households from the total number of households. The latter is taken from *District Census Handbooks* for Mehsana District and Banaskantha District, 1991.

#### Table 2: Well Ownership by Land Ownership (Per cent)

Land Owned (Bighas)	Well-Owner	No Well	Total
Ratanpura 0 0.1 – 5.0 5.1 – 10.0 10.1 – 20.0 20.1 – 30.0 > 30.1 Total Paldi	0 17 19 8 6 0 49	2 30 15 4 0 51	2 47 34 11 6 0 100
0 0.1 – 5.0 5.1 – 10.0 10.1 – 20.0 20.1 – 30.0 > 30.1 Total	3 11 17 17 11 11 69	8 19 3 0 0 31	11 31 19 17 11 11 100

Note: 1 bigha = 3/5 acre.

Source: Sample survey of Ratanpura (53 households surveyed) and Paldi (36 households surveyed), 1995-96. The sample was structured around water buyers and sellers and hence is underrepresentative of the landless. irrigated area can be divided into three distinct zones. Of these, Zone II exhibits the most dense pipeline network, flagging it as an area of possible intense competition. By contrast, buyers in Zone III have minimal choice. In Paldi, there are many more wells evenly distributed through the village lands, each of which has limited pipeline networks. Command areas scarcely overlap, leaving little possibility for competition. These differences are summarised in Table 4.

What explains the difference in irrigation structure? First, groundwater levels in Ratanpura are far deeper than in Paldi, which necessitates bigger and more powerful pumps.<sup>19</sup> When combined with smaller and more fragmented plots, wellowners in Ratanpura have an imperative to lay pipelines to their distant plots which has the added benefit of allowing them to irrigate fields along the way. Second, the surface hydrology in Ratanpura, specifically the river that runs through the village, has strongly shaped well location. In the early days of dug wells, this location provided quick recharge. Thus, although with deep tube wells this reason is no longer valid, pipelines and other infrastructure were laid based on this early hydrological consideration. This locked in the current pattern of well location, even though the current locations may not be the most efficient from the point of view of water distribution. In Paldi, well location was not shaped by any strong hydrological features, leaving farmers free to place wells in the most convenient location for purposes of accessing their fields. The result is two very different sorts of architecture which are shaped by hydrological circumstances and historical contingency.

Thickness: The 'thickness' of an exchange system is a measure of the degree of participation by buyers and sellers relative to the potential number of buyers and sellers. The implication is that in a thick market, the potential for competition is greater. No single measure captures this dimension completely. I use several measures: the number of wells from which water is sold and the proportion of water sold; the extent to which sellers themselves are buyers from other wells; the proportion of households dependent on groundwater purchase to meet irrigation needs. To antici-pate the discussion, I find a thick system of exchange in Ratanpura and a relatively sparse one in Paldi.

Water is sold from all but one well in Ratanpura, and, depending on alternative

forms of calculating this number, between 61 per cent and 71 per cent of the water pumped is sold.<sup>20</sup> Moreover, 13 out of 15 well-owners supplement their own water with purchased water. Most convincing, 90 per cent of landed households depend in whole or part on purchased groundwater and 44 per cent rely entirely on purchased groundwater for irrigation.<sup>21</sup> This density of transactions leads to a highly complex system of exchange which poses considerable problems of timing and co-ordination. For example, looking at wells located in the area with the greatest density of exchange (Zone III, also the largest section of Ratanpura), each well irrigates on average 44 different plots, a situation which calls for considerable co-ordination.<sup>22</sup>

A similar picture is hard to capture for Paldi because production relations between well-owners and irrigators demonstrate a 'multiplex' nature reminiscent of Wood's (1995) description of villages in Bihar. Specifically, many water transactions are bundled into existing landlord-tenant relations – water is added to the share tenancy relationship. Thus, only five out of 20 wells sampled sell water separately. However, if water provided to tenants is included, then the total rises to 11. On average, only 7 per cent of water pumped is sold outright, and another 17 per cent is provided to tenants. Yet, a surprisingly large proportion of households surveyed (61 per cent) are reliant in some form on groundwater purchasing, of which 39 per cent is accounted for by tenants. While I was unable to collect data on the number of plots irrigated per well for Paldi, a comparable measure of transaction complexity is the number of buyers per well: 0.6 for water buyers, and 1.2 of tenants are included.<sup>23</sup>

Thus, by a variety of measures, Ratanpura demonstrates a very thick system of ex-

change, with considerable reliance on the smooth functioning of groundwater sales. These sales are by no means unimportant in Paldi, but many of them are wrapped into ongoing tenancy relations. Moreover, the overall complexity of the system is far lower, in terms of the number of potential and actual buyers per well.

To fully understand this difference, it is necessary to shed more light on the trajectory of groundwater development in each village. In both cases, overpumping of groundwater has led to a fall in the level of water beyond the range of diesel engines. However, this turning point occurred in Ratanpura in the late 1960s when the village did not have access to electricity and hence to deep tubewells. Consequently, by the time an electricity connection was provided in 1973, there was a severe water shortage, considerable excess demand for water, and a perception that wells are highly risky which was driven by a rash of recent well failures. Moreover, land parcels were already fragmented far beyond the point where one farmer could productively use all the water discharge from a deep tubewell. An important response, therefore, and one made possible by kin networks, access to credit markets and so on, was to establish group-owned or partnership wells. This allowed partners to spread risk and take advantages of economies of scale. This, in turn, necessitated laying a maze of lines to the lands of all the partners. Finally, the excess demand assured investors in wells that they would be able to sell surplus water. In sum, deep water levels necessitated large wells with large capacity. Individuals with small and fragmented plots are incapable of productively absorbing excess irrigation capacity, which leads well-owners in Ratanpura to dependence on water sales to ensure the financial

	Ratanpura		Paldi	
	Well-Owner	Non-Owner	Well-Owner	Non-Owner
Average land owned (bighas)	8.2	4.0	17.3	2.2
Average no of plots	4.5	3.0	2.0	1.0
Average plot size (bighas)	1.7	1.3	9.0	2.0

*Note:* These data do not distinguish between individual, family and joint ownership of wells. *Source:* Sample survey of Ratanpura and Paldi, 1995-96.

Table 4: Architecture in	Ratanpura and Paldi
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	Ratanpura	Paldi
Plot size	small	large
Plot fragmentation	high	low
Number of wells	few (15)	many (50)
Spatial distribution of wells	clumped	even
Density of pipelines	dense in areas	sparse
Command area of wells	overlapping (esp Zone II)	little overlap

viability of their wells. Moreover, since farmers will not invest in a well unless they are assured of water sales, over time, the total irrigation capacity in the village has converged to a point very close to the total irrigation demand; there is little irrigation overcapacity in Ratanpura.

In Paldi, water levels fell beyond the point that dug-cum-bore wells (powered either by electricity or diesel) could reach only in the mid-1990s, long after electricity became available. Also, individual plots, as we have seen, are far bigger than in Ratanpura. The response of individual farmers was to drill wells that were sufficient to meet their own needs and lay pipelines only to the edges of their own plots. Since farmers responded incrementally as water levels fell, there was no reservoir of excess demand, as in Ratanpura, that would provide an incentive to install a large pump to provide excess capacity. However, since the technology itself is lumpy, in order to access deep levels of water, a minimum pump capacity is required. The result is that there is some inevitable excess irrigation capacity in Paldi.

As a result of these differences, water sales are structurally built into the irrigation system in Ratanpura; well-owners are dependent upon sales to break even. In the case of Paldi, well-owners can cover their fixed costs without having to engage in water sales. Thick markets, then, are largely the outcome of how the path dependent interaction of hydrology and changes in land fragmentation patterns are resolved. The particular form of the resolution is dependent on social considerations such as access to credit markets, and kin and caste ties that facilitate join action. Market thickness then is in large part contingent on the path dependent outcomes of historical, social and natural contingencies. In a finding that casts doubts on Shah's prescription to promote pumping and access to groundwater through markets, not all markets can be made thick.

*Terms of exchange*: The terms of exchange for groundwater include the amount paid, how it is determined or measured, the form of payment – typically in share or kind – and the timing of payment. In addition, as we have seen from Wood's work in Bihar, it is important to explore the conditions of access, and the relative control over timing and application of water.

The terms for water in Ratanpura are governed by an astonishingly complex pricing structure. There are four points worthy of note. First, terms of payment differ by crop and by season. The most significant is 'ucchak', a fixed payment in kind for irrigation of a unit plot of land. A second form is cash payment based on hourly provision of water. A third form is a one-third share of the crop payment, which was once the dominant form of exchange, but is now only used for a few minor summer crops.<sup>24</sup>

Second, the stated price is uniform across all buyers and sellers in the village [see Kolavalli and Chicoine 1989]. Indeed, the equality of terms of exchange for water is much emphasised both by buyers and sellers. Neither caste nor class played a role in determining the stated price. However, on closer examination, there were relatively small adjustments made as repayment of favours, favourable treatment of kin and so on. Yet, what is significant here is the shared conception of the prevailing price as the cognitive basis for transactions, and the moral content with which the single price was imbued.<sup>25</sup> This result is striking because, as we have seen, there is wide spatial variability in the density of pipelines across the village, and hence considerable variation in the scope for competition across the three zones. Glancing again at Figure 1, we would expect Zone II to be the site of heavy competition and hence lower prices.<sup>26</sup> Yet this is not so.

Third, the price structure stops at the village border; neighbouring villages have their own terms of exchange for water, and these can differ in quite substantial ways from those in Ratanpura. This is curious because cropping patterns, soil type and hydrology – the factors one might call upon to explain contract choice – do not differ much across these villages. There is clearly a strong 'village effect' that over-determines the slate of contractual options.

Finally, the menu of terms of payment has been in effect and unchanging over a period of several years. Moreover, the price within each contractual form has changed but little over the years, with the exception of the hourly rate which has steadily crept up. The architecture of the market has changed steadily over time, as wells and pipelines have been added or shut down, multiplying and changing water supply options. Yet these changes have had little effect on terms of exchange.

A critical element of the system of water sales in Ratanpura is the existence of unspoken norms and rules that govern the day-to-day provision of irrigation. The existence of these norms, which are undergirded by a moral basis, become apparent in the rare cases when they are violated, and are also made clear by the repeated recourse to and acceptance of these norms as a decision rule for settling disputes. There are three central elements to these norms. First, water provision is contracted for an entire cropping season, even in the case of hourly cash contracts.<sup>27</sup> Second, buyers are assured of timely delivery through institutionalisation of the 'vara' or water turn. According to this system, water delivery follows a set rotation among all users, including the wellowners. This system ensures that water is delivered on a timely basis, or at the least, that the burden of unreliable supply is distributed evenly over all the users. Despite these norms, there are still possibilities for a seller to discriminate between buyers. One important factor is the place allocated in the vara, which is set at the time of the first irrigation of the season. If too early, the field may not be prepared; if too late, the early days of summer heat could damage the late-developing crop. The third rule provides guidelines for the exercise of such discrimination: long-term users are to be rewarded with preferential treatment and, in the event of a severe shortage, are to be given preferential access. This norm modifies somewhat the vara rule which holds in ordinary times.

It is useful to dwell a little further on the importance of these rules. Recall that in Ratanpura, irrigation capacity and demand are quite closely matched, and that the market is highly complex-many buyers seek water from the same seller for spatially disparate fields. Under these circumstances, establishing an assured supply of water is extremely important. Under the old share payment regime, once the seller had agreed to provide water, his stake in a successful crop provided all the necessary incentive to supply timely water and for the full season. Under alternative contractual forms, these incentives no longer hold, but are replaced by the institutionalised norms described here.

In Paldi, terms of exchange have little of the complexity that characterises water exchange in Ratanpura. Instead, it is the production relations around water in Paldi that are complex. As discussed above, wellowners do three things with their water: they use it on their own land, they provide some of it to their tenants, and they sell some of it to other farmers who are not their own tenants (but who may be tenants of other landowners).

Looking first at direct sales of water, water

## Rationalisation of Export Promotion Schemes

is sold for a share of the crop.<sup>28</sup> By contrast with Ratanpura, there is fair variation in the share ratio. In 1996, I observed sales for 1/ 3. 2/5 and 1/2 all in use at the same time. with most clustered around a 2/5 share. Both buyers and sellers made it clear that the current period is one of flux, both technological and institutional. Deep tubewells are being drilled to replace old dug-cum-bore wells, with a resultant increase in supply over the village as a whole. As a result, in numerous cases, buyers have negotiated down the price of water, or sellers have bid down the price to gain additional buyers in the immediate environs of their well. In the not too distant past, the water price was uniformly 1/2 share. By contrast to Ratanpura, there are price changes over a relatively short period of a few years.

When water is provided to tenant farmers by a land and well-owner, the former uniformly receives 1/4 share and the latter 3/4. From conversations with both sides, it is clear that cognitively, of this 3/4, a 1/2 share is considered to be the water portion with the remaining 1/4 accruing for land. Hence, the reduction in water price negotiated by water buyers – from 1/2 to 2/5 – has not been obtained by tenants.<sup>29</sup> In Paldi, then, the market for water is fragmented by social class and, since class and caste are closely tied in this village, by caste.

Under conditions of excess supply of water at the village level, and a mosaic of relatively distinct command areas, problems of coordination, timing and assured access are simply not as relevant in Paldi as in Ratanpura. Moreover, share payments are the dominant contractual form, which carries built in incentives for timely and adequate supply of water. Hence, in Paldi, one does not observe the sort of institutionalised norms that are apparent in Ratanpura.

How do we understand these differences in outcomes in the two villages? In Paldi, we see well-owners competing, even in the context of little scope for competition, for the custom of buyers. This is in many ways what we would expect. In Ratanpura, however, where the scope for competition is far greater, there was a process of institutionalisation of exchange as a way of imposing structure and predictability on a highly complex exchange system. These institutionalised norms were structured around assuring reliable and timely access to groundwater. A lack of price competition among buyers is a crucial component of assuring this stability. Norms on price and quality of service proscribe competition on both these fronts.

It might be argued that the uniformity of prices across space is more simply explained by the story that Ratanpura represents a competitive market where price has been equalised across the village at the level of marginal cost of pumping water. This is an unlikely explanation. Since electricity is priced at a flat rate in Gujarat, the marginal cost of water is effectively zero. At Rs 20 per hour for cash hourly rates, water prices in Ratanpura are far above this equivalence condition.

More likely is the argument that prices are held constant across the village through a practice of collusion among sellers. Indeed, there is some evidence for coordination of price among sellers. Yet, this is not a one-sided imposition of a collusive practice. Instead, price co-ordination works within a villagewide compromise, a shared understanding of how the exchange system works. There are at least three elements to this shared understanding.<sup>30</sup>

First, there is an upper limit on acceptable water prices based on a 'cost-plus' computation. For example, a price hike is deemed 'fair' if electricity prices go up. Price rises have thus to be explained and legitimised in moral terms, and sellers subject themselves to the moral calculus of fair and unfair prices. Indeed, sellers are extremely hesitant about creating the impression that they are the first to raise prices. The weapons at the disposal of buyers in a village where the social and economic gulf between buyers and sellers exists but is not overwhelming, are social censure and reputation loss, and in the extreme, the threat of damage to irrigation equipment.<sup>31</sup> In Ratanpura, the price-leaders in the village tend to be the two partnership wells, which appear to have a greater degree of legitimacy with buyers than the 'private' wells, by dint of their joint ownership. The goal of providing water to partners rather than a pure profit motive lends them a 'quasi-public' character and hence enhanced legitimacy with buyers. Thus, in a villagewide price increase that I observed, the partnership wells served as a barometer of buyer consent and hence as a moderating force to limit the price increase.

Second, uniform terms and conditions for all is the glue of legitimacy for this arrangement, and carries a strong moral weight. Both buyers and sellers when asked the cost of or returns from irrigating an acre, will compute payments in terms of the common village price, demonstrating the 'grip on the mind' quality that distinguishes such moral norms from rules that are maintained purely by a structure of sanctions.<sup>32</sup> Third, in keeping with the overtones of a moral economy right to subsistence, at times of scarcity access to minimal levels of water is widely assured.

Both buyers and sellers benefit from this compromise. Sellers benefit from assured demand in a context where they must cover high fixed costs of electricity supply, avoid potentially damaging price wars, and manage to keep prices at relatively high levels. Although unorganised, buyers manage to maintain price increases within a moral cost-plus calculus, and ensure stability of supply.

In sum, while water exchange is increasingly de-personalised in Ratanpura, the normative content of the exchange relationship has been retained through the creation of village level institutions such as price norms and timing and delivery norms. These institutions are forged through the political manoeuvrings of social groups of buyers and sellers who bring to the negotiation strengths and weaknesses that arise from their structural location in village society. In Paldi, the negotiating position of buyers and sellers is also determined by their structural location, but the negotiation operates bilaterally, free of any village regulatory structure. It is this observation of social institu-

#### Table 5: Thickness in Ratanpura and Paldi

	Ratanpura	Paldi	
		Water buyers	Tenants
Per cent of water pumped that is sold Per cent households who rely on purchased ground water Number of owners who buy	61-71 90 13 out of 15	7 22	17 39 3 of 25
Complexity of water management	high		low

#### Table 6: Terms of Exchange in Ratanpura and Paldi

	Ratanpura	Paldi
Contractual forms	diverse (flat, hourly, share)	share
Variation in terms of exchange	negligible	variation across class
Degree of institutionalisation	high: institutionalised rules	low: built-in incentives

tionalisation of norms of exchange that leads me to claim that thick markets are not synonymous with price competition. Indeed, it is the lack of price competition and the institutionalisation of exchange around goals of stability that enable thick markets to operate in Ratanpura.

# IV Theories of Groundwater Markets Revisited

The two case studies provide a rich basis on which to revisit the three theories of groundwater markets described above. First, the implications of the oligopolistic model are that markets can be made more competitive by providing incentives to sellers to increase pumping and sales. Yet, in complete contradiction of this expectation, the case studies illustrate little competition in a thick market and substantial competition in a thin market. Where there is a measure of oligopoly power, in Ratanpura, it is not the threat of competition that ensures discipline and keeps prices within limits. Rather, it is the effect of social norms enforced at the village level that play this role; price signals are filtered through and mediated by village norms.

The evidence also calls into question the viability of using electricity prices as a tool to make markets thick and competitive. In Ratanpura, there is a tight market due to the close match between capacity and demand at the village level. Here, water sellers race to turn on their pumps when the electricity turns on, not because they want to recoup fixed costs, but because of the rationing of electricity supply and the consequent worry that they will not be able to adequately supply all their customers. Thus rationed electricity, and hence constrained water supply, lead sellers to urge buyers, and buyers to urge each other, to use water as efficiently as possible. In Paldi, the limited market architecture disbersed wells with few pipelines - made increased sales an unlikely outcome of flat rate pricing. Instead, flat rate pricing has led to inefficient water use by well-owners, who pay no penalty for wastage. With regard to electricity pricing, there is no evidence that a shift to a flat rate spurred a more dense market where already there were considerable sales, nor that it created an impetus for sales where sales were limited by architecture.

Second, the strong impact of village level norms and rules hold implications for the economics of information. Concerns Figure 2: Pladi: Wells and Pipelines

Source: Village outline: District Land Records Office, Palanpur, Gujarat. Well, pipeline and irrigation data are from surveys carried out in Paldi, 1995-96.

of timely access to water and other problems of information and uncertainty may be addressed at least as much through the development of social norms as through contractual form. Moreover, where contractual form does play a role in mitigating risk and information asymmetries, these contracts are likely to be reinforced and supported by a broader villagewide normative framework which could account for their maintenance over time. This attention to village level effects is in contrast to the emphasis on bilateral contracts of the information theorists.

Third, political economy accounts of the exercise of power must address the possibility that there exist village level normative checks to the exercise of this power, as in Ratanpura. The conditions of access work more equitably in institutionalised Ratanpura than in competitive Paldi. In the latter, those with bargaining power may be able to negotiate better terms from sellers, but those who lack such power, such as tenants, are unable to do so. The two cases suggest that power, too, is mediated through village norms.

# V Conclusion

The Gujarat experience with 'informal' water markets has influenced both Indian and international policy debates over groundwater use, and the role that markets play in determining the terms and conditions of access. This paper has argued that the literature on markets for groundwater has not, so far, done justice to the complexity of how groundwater markets in Gujarat are shaped and how they function. That the markets are 'informal' should not be equated with an assumption that they are unregulated. The view presented here of groundwater markets as socially and ecologically embedded leads us to challenge existing views of markets in two important ways. First, there are limits to whether thick markets can be easily created *ex post*. Second, thick markets should not be equated with competitive markets, nor should it be assumed that they will evolve toward competitive outcomes. Instead thick markets are potentially governed by local level institutions which provide stability and reliability in exchange.

The divergent outcomes in the two case studies described here provide the basis for three elements of a general framework within which to understand the structure and functioning of groundwater markets. Confirmation and enrichment of this framework will require subsequent study of a larger sample of villages.

First, surface hydrology and topography play an important role in determining the location of wells, which, when combined with patterns of land fragmentation and ownership, partially determine the pattern of pipeline networks.

Second, the size of landholdings relative to the average discharge from a well (in turn a function of groundwater depth) strongly determines the need for the social organisation of irrigation and also partially determines the architecture. If landholdings roughly correspond to discharge, as in Paldi, there is little or no need for either collective ownership or sales of water, nor for extensive pipeline networks. If holdings are small and well discharge is relatively large (due to deep groundwater levels), as in Ratanpura, then collective ownership and/or dense systems of exchange are required if groundwater irrigation is to be profitably accessed. Under these circumstances, markets are likely to be both thick, complex and tight, as in Ratanpura, and require effective solutions to the problem of groundwater co-ordination if they are to function effectively.

Third, while spatial characteristics, land patterns and water depth exert a powerful shaping influence on groundwater markets, the actual form of outcome depends on socio-economic factors such as the distribution of land ownership, access to credit and caste. Analysis of specific village characteristics is required to understand these path dependent outcomes. The existence and content of institutionalised norms are likely to be different under alternative socio-economic conditions.

The discussion in this paper cautions against policy manipulation based on a generalised understanding of how exchange systems for groundwater operate, and particularly one based on neoclassical models of oligopolistic or competitive markets. Policy interventions aimed at concerns of equity and sustainability must be based on a sufficiently realistic understanding of the structural conditions of groundwater access and the path dependent emergence of village level institutions that regulate groundwater access and use. This paper has attempted to sketch this understanding.

# Notes

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- 1 See, for example, Dhawan (1982), although more recently, Dhawan (1993) has allowed that he failed to anticipate the scope for private development of groundwater.
- 2 For debates over recent efforts to legislate rights over and regulate water use, see Saleth (1994) and Moench (1994; 1998). For an interesting discussion of the history of groundwater use in Gujarat, see Hardiman (1998). For discussion on the hydrology of groundwater availability and use, see Bradley and Phadtare (1989), Phadtare (1988), and Kavalanekar and Sharma (1992).
- 3 The urgency of the sustainability question is underscored by estimations which suggest that groundwater levels in north Gujarat are falling at the rate of 3.3 m per year [Kavalanekar and Sharma 1992]. Moreover, legal and administrative attempts to address this problem have met with limited success [Bhatia 1992; Moench 1994].
- 4 I restrict myself to the literature on India, to the exclusion of some other very interesting work in other parts of south Asia, notably Bangladesh [Wood and Palmer-Jones 1990], and Pakistan [Meinzen-Dick 1998; Strosser and Meinzen-Dick 1994].
- 5 Thus, variations in price across regions are explained by these factors [Shah and Raju 1988].
- 6 In response to arguments that flat rates will undermine the financial viability of the electricity suppliers as consumption increases dramatically, Shah notes that flat rates allow savings on metering and collection costs, as well as pilferage.
- 7 Shah seeks to address this problem by rationing water which places outside limits on the level of water extraction. That water tables continue to fall in deep aquifer areas of Gujarat suggests that rationing has not been stringent enough to meet this objective.
- 8 Share payments refer to an arrangement whereby a water provider is paid in the form of a share of the final crop output.
- 9 Share-based transactions are also cited by Aggarwal (1999), Wood (1995) and Janaka-rajan (1994).

- 10 There are several other stories that could be constructed and tested to explain share payments, drawing on an extensive parallel literature on the topic of share cropping in land. For an extensive review of this literature, see Otsuka, Chuma and Hayami (1992).
- 11 For example, information economics cannot explain why share payments persist over time and space, when incentive and risk factors are by no means constant, nor why contract forms remain the same across a village even though sets of contractual parties have widely differing endowments and risk attributes.
- 12 In some early work that draws in part on this tradition, Jairath (1985) outlines different "modes of irrigation" in Punjab. She finds that large landowners systematically have greater access to the cheaper and more efficient forms of irrigation.
- 13 There is an exhaustive literature on interlinkage both from the political economy and new institutional economics perspectives. The genealogy of the idea goes back at least to Bhaduri's (1973) thesis that a landlord-creditor can manipulate the conditions of access he provides to the land and credit markets to skim off more surplus than if he were operating in only one of the markets. He went on to argue that this leads a landlord-creditor to suppress investment in productivity enhancing measures that may allow creditors to escape debt-traps, thereby stunting productivity and agricultural growth. New institutional economists have embraced and further developed the first point while refuting the second [see Bardhan 1989 for a summary of the debate].
- 14 This is a specific example of the triadic exchange relations which as Basu (1986) explains can leave the weakest party, who typically has no exit option, worse off than if they were outside the relation.
- 15 This section is drawn from fieldwork conducted in north Gujarat during 1995-96. The author is grateful to the American Institute of Indian Studies for a research grant, and to the Institute for Rural Management, Anand, for institutional affiliation during this period.
- 16 These village names are fictional to protect the confidentiality of respondents.
- 17 Since this discussion is limited to water markets in areas of deep alluvial aquifers, I do not discuss the use of diesel powered extraction devices which are largely used to access more shallow sources of water.
- The use of land as a measure of agrarian class 18 structure is deeply contested. This measure does not account for differences in quality of land or whether it is irrigated, it assumes that production technologies are the same everywhere, and it relies on a fairly arbitrary translation from land size categories to class categories. Finally, land ownership does not account for 'secondary' relations of exploitation such as credit arrangements. The main merit of the measure is its ease of use compared to alternatives. I provide land ownership here as an indicative rather than as a conclusive measure, and request the reader to keep in mind its considerable shortcomings.
- 19 Indeed, while in Ratanpura most irrigation is obtained through deep tubewells of 700 ft or more, Paldi is in the process of transitioning from 'dug-cum-bore' wells of about 200 ft to deep tubewells.
- 20 If sales from partnership wells to partners is defined as a water sale, this figure is 71 per cent; if not, then 61 per cent.
- 21 While no farmers rely exclusively on canal

irrigation, which is unreliable and infrequent, 37 per cent supplement purchased or their own groundwater with canal irrigation.

- 22 The largest well irrigates 97 separate plots, while the smallest irrigates 21.
- 23 In addition to private sellers, there are two public tubewells in Paldi. The public wells have a reputation for inadequate and unreliable supply, but water from these wells is priced at far less than the private wells. It is important and significant that small farmers, most often also low caste farmers, depend heavily on the public tubewells for irrigation.
- 24 There are some important differences across the three contractual forms in terms of the incentives afforded to buyers and sellers. For example, share contracts place some of the production risk on water providers, giving the latter a stake in timely irrigation provision. Similarly, the two in kind payment forms insulate the water buyer from output price fluctuations as compared to the hourly cash rate. In addition, the hourly payments place the cost of leakage from the pipeline delivery system on the buyer, while in the other two systems, these costs rest with the seller. These sorts of arguments are central to the new institutional economics literature discussed above which focuses exclusively on choice of contractual form. Assessing the merits of the NIE approach requires a lengthy discussion which I have undertaken elsewhere [Dubash 1998]. In brief, I find that while the functionalist arguments of the NIE shed some light on the choice of contractual form, the empirical data point to several cases where contractual choice runs counter to the suppositions of the theories and is additionally shaped by the exercise of power to benefit some groups over others, and by the effect of institutional norms and the legitimacy of particular contractual arrangements over others.
- 25 This result bears a strong resemblance to Wood's (1995) findings in Bihar.
- 26 This expectation is spelt out in a paper looking at credit markets fragmented by the availability of information on potential borrowers [Basu and Bell 1991]. Thus, if two creditors have one captive segment and one segment in which they compete, the resultant 'fragmented duopoly' would lead to different prices in the two segments. By analogy (with density of pipelines analogous to information on creditworthiness) we would expect to see water sellers taking advantage of their monopoly segments, such as in Zone III in Ratanpura.
- 27 There are occasional cases where spot sales of water take place, but these are typically to substitute for the contractual arrangement in the event of, for example, equipment failure.
- 28 In Paldi, the cost of other agricultural inputs – fertiliser, seed, and pesticide – is customarily shared between the landowner and the tenant alone.
- 29 There are also a few cases of three way transactions between a tenant, a landowner and a well-owner. The evidence suggests that in these cases the water arrangements are typically made directly with the landowner. In keeping with this observation, the water output share in these arrangements more closely mirrored the first transaction form described above, water sales to farmers, than the second, sales to tenants.
- 30 The literature on water markets does contain references to 'social constraints' [Saleth 1998] operating on exchange, but there is little effort to explore what these might be, what their effect is and how they are created and reinforced.

- 31 The latter is a credible threat and has occurred at least once before.
- 32 Elster (1989) discusses the difference between moral norms and outcome-oriented rules.

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