How Informal Water Markets Function:

Empirical Evidence from South India

1 Introduction

Water is, besides land and labour, one of the essential factors in agricultural production. If there are regular rainfalls during the cultivation season and if, in case that there is a period without rainfall, there are enough perennial streams, ponds, or groundwater resources, the farmers can afford – either because they are wealthy enough or because they have access to credit - to buy and run the necessary irrigation equipment, and if they can insure themselves against crop losses, then these farmers do not face any extraordinary economic situation which would be worth considering. But in a number of developing countries where agriculture is monsoon-dependent, a farmer who wants to avoid crop losses caused by the failure of ill-maintained public irrigation systems, or by the lack of rainfall, is often driven to participate in an informal market for irrigation water, the reasons being missing or incomplete credit markets and the absence of perennial streams or ponds. The term 'market' is somewhat elastically in this context, for what is observed are personalized contracts where both parties often have few or no alternative partners to contract, rather than auction markets in a clearly defined good which is traded at a common price. The good in question is groundwater (the contractual units are either hours of irrigation, area irrigated, or number of irrigations) extracted by farmers who own a well and a pump-set. Describing and explaining the different payment modes associated with these groundwater transactions - especially the coexistence of fixed rate payments and share contracts under which the buyer gives a share of his crop output to the water seller in exchange for the water received – will be one of the main tasks of this chapter.

There are numerous contributions dealing with the phenomenon of informal groundwater 'markets' in developing countries, all but two of them (as far as I can determine)[1]

[1] The exceptions are Jacoby/Murgai/Rehman (2001) and Kajisa/Sakurai (2000).

of a purely empirical nature.[2] Those dealing with India "(a) provide an idea of the magnitude and value of Indian water trading, especially at the national level, (b) outline the technical and institutional environment within which Indian water markets are operating, (c) describe their major economic and institutional features, (d) evaluate their efficiency, equity, and sustainability implications, and (e) suggest the legal and institutional changes needed to make them an efficient institutional option for groundwater management" (Saleth, 1998). In my opinion, however, none of these contributions provides a satisfactory detailed depiction of the pattern of groundwater transactions and of the associated payment modes at the household level. Most of these studies are at a rather aggregated level and therefore fail to provide the information that is necessary to set up a model capable of explaining the choice of different contractual forms.

This was the main reason which led me to undertake the study whose results are presented here. My aim was to gather information on such questions as: At which point in time during the cultivation period the contractual form is chosen? Is it the well owner who dictates the contractual form and the terms of the contract, or do the parties bargain over the terms of the contract? If the contract has been chosen, who then decides how much groundwater will be supplied, and how much of the other inputs such as labour, fertilizer etc. will be employed in the production process? Does a contract with a well owner assure a supply of irrigation water, or is there no way of assuring that the seller will deliver the amount of water agreed upon in advance. The answers to these questions are of particular interest if one wants to shed some light on the fact that fixed rate payments and sharecropping arrangements coexist in some local water markets, but not in others. Since the same payment

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[2] See, for example, Saleth (1998), Meinzen-Dick (1998), Satyasai et al. (1997), Janakarajan (1993), Shah (1991). Empirical Studies focusing on groundwater trade in Tamil Nadu's agriculture are Janakarajan (1991a, 1991b, 1994).

modes can be found in the markets for tenancies, we will also have to investigate the question whether the reasons for the choice of a share contract are the same in both markets. To put it in another way, can the existence of sharecropping arrangements in both cases be attributed to the same form of market incompleteness, such as a missing insurance or credit market, or by the incompleteness of the groundwater market or the tenancy market itself. These are the questions to which the descriptive material in this paper can help provide an answer.

What this chapter cannot do, however, is to calculate the exact price of one unit of water under the various contract forms and then compare them in order to identify risk premiums or monopoly markups. This is done in the studies of Jacoby et al. (2001) and Kajisa and Sakurai (2000). Due to the limitations of the data, no attempt will be made to provide an econometric analysis of contractual choice in informal groundwater markets or to test corresponding models thereof. Such an attempt has been made by Satyasai et al. (1997). Further, we do not assess the extent of the trade in groundwater - the number of buyers and sellers involved and the total monetary value of the water traded – as found in Saleth (1998) and Janakarajan (1993). Nor is there an account of the degree to which groundwater is overexploited and the related lowering of the water table in the study area. Two older studies concerned with these issues are Bhatia (1992) and Moench (1992).

The remainder of the chapter is organized as follows: section 2 describes the study area, section 3 the sample. Section 4 presents some summary statistics of trade in groundwater in the sample villages. In section 5, we comment on the details of some groundwater transactions in the sample villages. Section 6 wraps up the chapter.

2 The study area

During January and February 2001, 4 of the 7 villages forming a civil village or village panchayat in Nanguneri Taluk, Tirunelveli District, Tamil Nadu, were studied with special emphasis on informal groundwater transactions. The panchayat is located in a rather drought-

prone area, and is surrounded by 7 rain-fed tanks, which provide the surface irrigation water for the so-called *wetland*. These tanks are filled during the monsoon season, and in years of good rainfall, they are a reliable source of irrigation water until the end of February. From the tank, the water reaches the fields through a system of small canals. The second category of cultivable land is the so-called *dryland,* which has no access to tank water, and depends wholly on rainfall and groundwater irrigation. The third category is the *second priority land,* which has access to irrigation water only every second year from a nearby river, and which has no access to tank water and well irrigation. In the alternating year, another village panchayat has the right to take water from the nearby river for irrigation purposes.

In connection with the rotation of rights to water from the river, the farmers told us an interesting story, which reminds one of the state of affairs described by Wade (1979 and 1982). Despite the agreement with the government over the release of water every second year, the farmers complained that they had to bribe the government officials responsible for the distribution of the waters between the two panchayats in order to receive the water they were entitled to. There was strong competition between the villages in the canal system to have the canal outlets opened in their favour. The higher the bribe payments, the higher were the chances that the gate would be opened for the village at the time when the farmers needed the water the most. This competition for the river water gave rise to a well-organized institutional arrangement: Guards who had to take care that the river dams were not broken by farmers of other villages in order to steal water, and the choice of two farmers assigned to collect the money from all other farmers which was needed to pay the bribes and to pay for the services of the guards. For each 0.8 acres of second priority land a farmer cultivated, he had to pay a contribution of 50 rupees. Thus, once again, an inefficient – though 'fair' - distribution system set up by the government has been replaced by an illegal system based on bribes, leading to a more efficient distribution of the water, since the bribes are very likely to reflect the willingness to pay of the groups of farmers. But the revenue from this 'water

auction' does not accrue to the government and can be employed in the operation and maintenance of the canal system, instead it remains in the pockets of the government officials. Thus, auctioning off the rights to the river water each day or each week or creating a market for water rights would get the government some revenues and distribute the river water more efficiently.

The 540 acres of wetland belonging to the 4 villages studied depend on 2 of the 7 tanks. The total area of dryland is 600 acres, but cultivable dryland, including the land of second priority, amounts to only 100 acres. These villages comprise 390 households, of which 86 are registered as landowners and 95 are registered as landless agricultural labourers. For some odd reason, there was no information on the remaining households in the VAO's (Village Administrative Officer) records, but he told us that not all landowners or landless labourers might have been registered. Other occupations are, for example, shopkeeper, *beedi* rolling, shepherd, miller, and trading in agricultural products. Of the 86 wells owned by households, 22 are located in the wetland areas and 64 in the dryland. It is not clear, however, how many households are well owners, because often 2,3, or even 4 households share ownership in a single well.

3 The sample

Since the main purpose of this field study was to gain a more detailed insight into the exact nature of the single groundwater contract rather than to survey many households[3] in order to obtain a data set with which it would be possible to estimate models of contractual choice in the context of informal groundwater markets, we did not employ a special sampling method, but instead tracked down farmers who were available and ready to answer our questions.

[3] This, by the way, would not have been possible with only one interviewer in the space of two months.

Concerning the choice of the village panchayat to be studied, we were looking for villages in which groundwater was sold at a fixed rate as well as under sharecropping arrangements. An interesting general pattern was discovered while travelling through Tirunelveli district in search of a suitable study village: In all of the villages where we stopped to make a short inquiry into the local arrangements, there were active groundwater markets; but in the villages which had access to the Tambraparni Irrigation System (which depends on the perennial Tambraparni river), farmers reported that there existed no sharecropping arrangements at all, and that all groundwater transactions were made in the form of a fixed payment per hour. In the villages which only had access to a rain-fed tank system, however, share contracts were found to be very common. This pattern seems to be related to the fact that a perennial river is a more reliable source of irrigation water than a rain-fed tank system, especially as far as the length of the period for which surface water is available for irrigation is concerned. This implies that in the villages located in the river-fed irrigation system, only a modest volume of groundwater is traded as a substitute for the surface water, whereas in the tank-dependent villages, farmers often have to rely on the informal groundwater markets for one-third of the cultivation season. We will discuss this issue in greater detail in the next section.

Since one of our primary aims was to study sharecropping arrangements in informal groundwater markets, we chose 4 villages in a rather drought-prone area irrigated by a rain-fed tank system, where a large number of such contracts were found. For a household to be selected into the sample, it had to own land, lease in land, or both. On this basis, 49 households were chosen from the total of 390 households. Also, one man was interviewed who worked as an 'irrigator' for a landlord who was selling groundwater from his wells to a number of farmers.

4 Irrigation and informal groundwater transactions in Nanguneri Taluk

Traditionally, the irrigation water for these 4 villages comes from 2 rain fed-tanks, and reaches the fields through a system of small channels. The access to canal water of the single field is regulated by outlets. The order and the frequency with which each plot receives water is determined by rules made by the village collective.[4] The farmers reported that in the past, the tanks had been a reliable source of irrigation water from October until March, and that at present, in years of good rainfall it is still possible to receive tank water until March, but that nowadays the tank already dries up at the end of January in years of bad rainfall, as happened in the season in which this study was conducted. The reasons for this development are the following: The first is that the system of canals and the dam of the tank are increasingly ill-maintained, which leads to losses of water through breaches in the dam or because the water seeps away through the unlined channels. The second lies in the fact that many farmers grow more water-intensive crop varieties than hitherto, so that the same amount of water is sufficient only for a shorter period.

The main cropping season in our villages is from mid-October until the end of February or the beginning of March. In this season most of the farmers cultivate paddy (rice), a crop which needs a constant supply of water, and which is very sensitive to the water regime in the field. If the surface water resources in the tanks are used up by the end of January, farmers face the problem of supplying their crops with enough water for another 30 days. The farmers who own wells and pump sets will extract groundwater themselves, whereas the other farmers either have to wait for rain – which may or may not come – or gain access to other farmers' groundwater resources through purchases of irrigation water. This kind of access to irrigation is restricted by the fact that another farmer's well must be located not to far away

[4] There is an own literature on how the distribution of surface water is regulated in such villages, but we will not address this issue here.

from the farmer's own field, and that this well must have the capacity to serve more than the well-owning farmer's own crops.

In our sample, 39 out of the 50 households are well owners. Of these 39, 28 have one or more wells (max. 4 wells), whereas 11 farmers own only a share of a well (the minimum share is 0.25). For example, owning a share of one-fourth of a well means that the share owner is entitled to one-fourth of the well's capacity and that, on the other hand, he has to bear one-fourth of the operation and maintenance costs. Five of the farmers owning more than one well are also owners of a share of a well. There are 8 farmers who own wells in both the wetland and the dryland areas.

Table 1 Pattern of well ownership (number of households)

	only share of a well	at least one well	total
only in wetland	2	10	12
only in dryland	9	10	19
in wetland and dryland	0	8	8
total	11	28	39

The total number of wells (or, more appropriate, the number of shares of well capacities) owned by the sample households is 48.91 (including share wells), of which 23.25 are located in the wetland, and 25.66 are located in the dryland. Of the 30 households owning wetland plots, 20 are owners of a well or a share of a well located in the wetland; of the 34 sample households owning plots in the dryland, 27 are owners of a well or a share of a well located in the dryland.[5] In the wetland owned by the sample households, there are 0.29 wells per acre, whereas in the dryland, there are 0.25 wells per acre. Thus, although, the dryland has

[5] A χ^2-test for equal proportions is not appropriate, since the categories are not mutually exclusive, i.e. farmers may own land in both the wetland and the dryland areas.

no access to tank irrigation, the number of wells per acre on the different kinds of cultivable land is approximately the same. An interesting fact is that in only a few cases is water from dryland wells traded. The farmers told us that normally only farmers who own a well in the dryland cultivate their dryland plots, because no surface irrigation water other than rainfall is available in the dryland[6], and because the capacity of one well is not sufficient to irrigate more than the holdings of the well owner himself for a whole season. The exclusive dependence on uncertain rainfall and on groundwater irrigation is also the reason why only less water-intensive crops like vegetables, chillies or cotton are normally cultivated in the dryland, but some farmers manage to cultivate paddy or even banana on their dryland plots. It was reported that farmers with adjacent plots sometimes exchange some irrigations (in alternating years or season), but that usually there is no water trade against money. However, in our sample there are at least three farmers who own only a well in the dryland, and are selling groundwater.[7]

There are 7 households in the sample which reported selling water in this season, and 15 households which reported buying water in this season; two households of the latter reported selling sometimes water, too, both but not necessarily in the same cropping season (in this season, they were active only on the demand side).

Table 2 The terms on which water is traded (number of households)

	seller	buyer

[6] The farmers who own dryland plots, but no well in the dryland, cultivate their dryland plots only in years of good rainfall.

[7] Since we do not have detailed information on whether a farmer is selling water from his wetland well or his dryland well, we can conclude that there is water trade in the dryland only in the cases were the seller has a well only in the dryland.

only fixed rate per hour (cash)	0	6
only share contract	1	6
fixed rate per hour and share contract	6	2
fixed payment in kind	-	1
total	7	15

Six of the seven households selling groundwater have both kind of contracts with different buyers at the same time, whereas only two household buying groundwater have both kind of contracts with different sellers at the same time. We will describe this latter cases among others below in greater detail. The average number of buyers served by each seller is 8.71 (std.dev. 7.91), the minimum is one buyer and the maximum is 20 buyers. The average number of sellers from which a buyer receives water is 1.20 (std.dev. 0.78), the minimum is 1 and the maximum is 4.[8] The fact that sellers have different kinds of contracts with different buyers in the same season indicates that the payment mode is related to the characteristics of each pair of transactors, and that there is no market with a uniform price and a standardized product.

Table 3 and Table 4 show information on the differences in well and land ownership between buyers, sellers, and non-transactors.

Table 3 Well ownership (number of households)

	sellers	buyers	non-transactors	total

[8] The inconsistency between the fact that each seller in the sample on average has 8-9 clients and the fact that in the sample 49 cultivating households there are only 15 buyers, can be explained by the fact that, according to statements of respondents, we have by far the two biggest water sellers of the whole village panchayat in our sample. Leaving these two aside, the average number of buyers served by each seller is 4.20 (std.dev. 2.17), with the minimum being one buyer and the maximum seven.

owns wells only on wetland	1	6	5	12
owns wells only on dryland	3	6	10	19
owns wells on both wetland and dryland	3	0	5	8
owns no well	0	3	7	10
total	7	15	27	49

Table 4 Land ownership (number of households)

	sellers	buyers	non-transactors	total
owns only wetland	0	5	7	12
owns only dryland	2	3	11	16
owns land in wetland and dryland area	5	7	8	20
owns only second priority land	0	0	1	1
total	9	15	27	49

The strongest differences between sellers and buyers concerning their well ownership are, firstly, that 3 of the buyers do not own a well, whereas, of course, all sellers own a well, and, secondly, that 3 of the sellers own one or more wells in both the wetland and the dryland, whereas this is the case for none of the buyers. Comparing this with the pattern of land ownership it is interesting that 7 of the buyers own both wetland and dryland, but none of them owns wells on both kinds of land. The respective numbers are not so far apart for the sellers where 5 own both kinds of land, but only 3 own wells on both kinds of land. Thus, there is a first indication that there may be gains from the groundwater trade. For the non-transactors, well ownership does not match land ownership in all of the cases, too, in that sense that there are to few wells compared with the respective landholdings. But for some reason to be investigated later in section 5, they did not participate in the groundwater market.

Since a lot of cells have expected counts less than 5, we used Fisher's exact test to test the hypotheses of equal well and land ownership patterns between the three categories of households. The hypothesis cannot be rejected for both tables.

In the following, we will present some further tables which will underline the differences and similarities between buyers, sellers, and non-transactors concerning their endowments with wells and land.

Table 5 Well ownership (average number of wells per household)

	sellers (n=7)	buyers (n=15)	difference (sellers-buyers)	non-transactors (n=27)
on wetland	0.86 (0.90)	0.55 (0.78)	0.31 (0.82)	0.33 (0.51)
on dryland	1.07 (0.73)	0.31 (0.48)	0.77 (0.57)	0.50 (0.62)
on all land	1.93 (1.37)	0.86 (0.70)	1.07 (0.95)	0.84 (0.81)

Standard deviations are in brackets.

The average number of wells per seller or buyer, broken down by land type, is set out in Table 5. On all land, the average for sellers is more than twice as high as that for buyers. According to the t-test, the difference is found to be significant at the 5% level[9]. Comparing the average number of wells per household on wetland, the difference is positive but not statistically significant, whereas on dryland, the difference is positive and significant at the 1% level. One would expect that in the market (wetland or dryland) with the stronger difference in the relative endowments, there would be more trade in water than in the other market, but if one believes the statements of the farmers, this is not the case. For the non-transactors, the average number of wells per household on all land equals that of the buyers,

[9] If the variable is not normally distributed, it remains the case that the t-test is robust, but caution is still needed in interpreting the results.

whereas the average number of wells per household on wetland and dryland is exactly the reverse to that in the buyers' case.

More convincing in this context may be the average number of wells per unit of land, which is reported in Table 6 for the different categories of land.

Table 6 Well ownership (average number of wells per acre)

	sellers	buyers	difference (sellers-buyers)	non-transactors
wetland	0.15 (0.11) n=5	0.23 (0.26) n=12	-0.07 (0.23)	0.26 (0.23) n=15
dryland	0.33 (0.20) n=7	0.28 (0.40) n=10	0.05 (0.33)	0.26 (0.25) n=19
total own land	0.24 (0.09) n=7	0.35 (0.33) n=14	-0.11 (0.28)	0.28 (0.18) n=23
total land (including leased-in land)	0.22 (0.09) n=7	0.27 (0.27) n=15	-0.05 (0.23)	0.22 (0.19) n=27

Standard deviations are in brackets.

It is interesting that the differences are negative for all land categories except dryland, that is, the buyers seem to own on average more wells in the respective land categories than the sellers. One would expect it to be the other way round. But none of these differences is significantly different from zero at any conventional significance levels using an unpaired t-test[10]. Thus, where the average number of wells to land ratio is concerned, there is no evidence of a difference between the endowments of buyers and sellers. The number of wells to land ratios of the non-transactors are not remarkably different from those of the two other categories. Another feature of well ownership which has a bearing on the availability of irrigation water is the depth of the wells. The deeper the well, the greater is normally the amount of groundwater which can be extracted from it. In Table 7 we report the average well

[10] Non-parametric tests yield the same results.

depth and the average well depth per unit of land. Since households may own more than one well, the average depth of these wells is used in the computations.

Table 7 Average well depth and well depth per unit of land (in feet)

	sellers (n=7)	buyers (n=15)	difference (sellers-buyers)	non-transactors (n=27)
average depth	74.89 (57.16)	32.80 (21.71)	42.09 (36.19) [t-value 2.54]	34.18 (23.51)
average depth of the deepest well	87.86 (62.95)	32.20 (21.05)	55.66 (38.71) [t-value 3.14]	35.22 (24.73)
average depth per acre of total land	10.60 (9.11)	10.96 (9.76)	-0.37 (9.57) [t-value –0.08]	12.57 (13.60)

Standard deviations are in brackets.

It can be seen from Table 7 that the average well depth for the sellers in our sample is almost twice the average well depth on the buyers' side. The difference is significant at the 5% level. The difference is even larger and significant at the 1% level if one compares the means of the deepest wells of sellers and buyers. But if one compares the average well depth per acre of total land of buyers and sellers, one finds a negative difference, though one that is not statistically different from zero using an unpaired t-test. One explanation for the fact that the sellers have on average deeper wells as the buyers, but that the well depth to land ratio is not on average higher for the sellers than for the buyers, is that the capacity of a well may be an increasing function of its depth. This would explain why the sellers have 'surplus' groundwater, which they can sell to other farmers with a similar well depth to land ratio. We do not have data on capacity, nor do we have detailed and complete information on the groundwater extracting devices used by sellers and buyers. But it is clear that a deeper well requires a more powerful extracting device to make efficient use of its capacity. Again, the figures of the non-transacting households are very similar to those of the buyers. Thus, it will

have to be explained why this group does not participate in the market by looking at some cases in detail in section 5.

Some farmers reported that they leave a fraction of their land uncultivated due to foreseeable shortages of irrigation water. Table 8 shows the ratio of uncultivated land to the number of wells owned by buyers, sellers, and non-transactors. Only the buyers owning a well were used in computations.

Table 8 Uncultivated land (acres) per well

	sellers (n=7)	buyers (n=12)	difference (sellers-buyers)	non-transactors (n=20)
acres of uncultivated land/well	0.18 (0.31)	1.52 (1.08)	-1.34 (0.89) [t-value –3.17]	1.17 (1.42)

Standard deviations are in brackets.

The difference between the sellers' and the buyers' uncultivated land per well is negative and significant at the 1% level. That is, there is strong evidence that the buyers have more difficulties than the sellers to supply their holdings with sufficient irrigation water from their own wells. The non-transactors, on average, leave approximately the same amount of land per well uncultivated as the buyers.

Table 9 gives an overview of the different kinds of landholdings of buyers, sellers, and non-transactors.

Table 9 Average landholdings of buyers, sellers and non-transactors (in acres)

	sellers (n=7)	buyers (n=15)	difference (sellers-buyers)	non-transactors (n=27)
own land	9.57 (6.42)	3.74 (4.12)	5.84 (4.93) [t-value 2.59]	3.26 (3.45)
leased-out land	0.86 (2.27)	0.10 (0.39)	0.76 (1.28) [t-value 1.29]	0.34 (1.02)
leased-in land	0.14 (0.28)	0.42 (1.02)	-0.28 (0.86) [t-value –0.70]	0.92 (2.10)
uncultivated land	0.54 (0.92)	1.38 (1.30)	-0.85 (1.20) [t-value –1.55]	1.43 (2.35)
total land	9.71 (6.31)	4.15 (4.12)	5.56 (4.88) [t-value 2.49]	4.18 (3.49)

Standard deviations are in brackets.

The differences in Table 9 are significant at the 5% level for the categories 'own land' and 'total land': The sellers own on average more land than the buyers, this pattern not being changed by the leasing in of land. If the landholdings of a household can be seen as a proxy for the household's wealth, and wealth in turn can be seen as a proxy for the household's risk aversion, then the buyers in the sample tend to be on average more risk averse than the sellers, and the non-transactors are approximately as risk averse as the buyers. Concerning the leasing in and out of land, there seems to be no difference between sellers and buyers, that is, the tenancy market does not seem to work in favour of a more efficient water allocation. The question arises, why do the farmers with the low capacity wells not lease out their land to farmers with high capacity wells, instead of leaving the land uncultivated? Or, equivalently, why are the farmers with high capacity wells not willing to lease in the land of the farmers with low capacity wells? One explanation could be the availability of other production factors, such as labour. If the sellers with their larger own holdings are short of family labour or face high costs for hired labour, then they will not cultivate additional land, but will rather prefer to supply their surplus water and let the buyer supply the labour. Also, the groundwater deals seem to be less risky for the sellers than potential tenancy contracts: The tenancy contracts are made at the beginning of the cultivation season, which means that the well

owner does not know at that moment how much groundwater he will need for his own holdings. The groundwater contracts, in contrast, are more flexible, since in most cases they are made during the season and, as the season proceeds, the well owner gains more information concerning his groundwater needs.

The figures for buyers and non-transactors in Table 9 are again very similar, apart from the fact that the non-transactors, on average, seem to lease in and out slightly more land than the buyers.

Table 10 Average costs of irrigation equipment

	sellers	buyers	difference (sellers-buyers)	non-transactors
operation and maintenance costs (rupees/year)	2625 (3018) (n=7)	1723 (980) (n=12)	903 (1959)	2000 (1753) (n=20)
investment in wells and pumpsets (rupees)	124,286 (185,802) (n=7)	41,455 (55,591) (n=11)	82,831 (121,973)	69,367 (57,374) (n=18)

Standard deviations are in brackets.

In Table 10, the average costs per year for the operation and maintenance of the wells and the pumpsets and the average initial investment in the irrigation equipment are set out. Especially the interpretation of the figures for the investment in irrigation equipment deserves some caution, since some of the farmers inherited their well and therefore could not give an exact number for the well's value. None of the differences in Table 10 is significant at any conventional significance level, but the sign of the differences is positive in both cases as one would expect, indicating again that the sellers are on average wealthier than the buyers. Also, a higher investment in irrigation equipment should enhance the groundwater extracting capacity, so that there is a higher amount of water that can be sold. The non-transactors seem to have invested a higher amount in their irrigation equipment on average than the buyers,

which could be one reason why they do not have to participate in the groundwater market (on the demand side).

Having examined the differences between the endowments of buyers and sellers, we now turn to a comparison of the two different categories of buyers. In the following, we will investigate the differences in the endowments of buyers who pay a fixed cash amount per hour of irrigation water and buyers who pay a share of their crop output after the harvest.[11] In the computations, we will take into account only the buyers who exclusively pay in one of the two payment modes to obtain stronger results. Thus, we have six cash buyers and six share buyers (two were doing both and one was paying a fixed payment in kind).

Let us consider first the land holdings of the two categories of buyers in Table 11.

Table 11 Average landholdings of the two buyer categories

	fixed payment in cash (n=6)	share (n=6)	difference (cash-share)
total own land	4.61 (6.17)	2.78 (2.05)	1.83 (4.60)
wetland	0.79 (0.84)	2.58 (2.18)	-1.79 (1.65)
dryland	3.9 (6.56)	0.28 (0.43)	3.63 (4.65)

Standard deviations are in brackets.

For total own land, the difference is positive but not statistically different from zero. The difference between the wetland holdings of the cash buyers and the share buyers is negative and just significant at the 10% level. The corresponding difference between the dryland holdings is positive but not significant. Thus, there is at least a hint, even if not significant, that farmers with larger dryland holdings more frequently have fixed-payment groundwater contracts, whereas farmers with larger wetland holdings seem more frequently to have share

[11] It does not make sense to do this comparison for the sellers, too, since all except one of the sellers in our sample reported offering both kind of contracts.

contracts. A reason for this may be that in most cases, the crops grown on dryland do not need a regular supply of water, whereas mostly water-intensive crops like paddy, which are also very sensitive to water shortages and therefore need a constant water supply ,are grown on wetland. In this case, the farmer with the larger dryland holdings will normally need only a few 'turns'[12] of groundwater, whereas the farmer with the larger wetland holdings will eventually need groundwater for one third of the cultivation season.

Consider, therefore, Table 12, which shows the average number of groundwater 'turns' bought by the different categories of buyers and the average number of sellers from whom they bought water during the season in which this study was conducted.

Table 12 Average number of turns and average number of sellers

	fixed payment in cash (n=6)	share (n=6)	difference (cash-share)
average number of turns	7.5 (3.15)	38.17 (24.92)	-30.67 (17.76)
average number of sellers	1.5 (1.23)	1.00 (0.00)	0.5 (0.87)

Standard deviations are in brackets.

The result is very clear for the average number of turns bought by the two categories of buyers: the difference is negative and significant at the 5% level. That is, buyers and sellers who trade with each other in high volume during the season seem to opt for sharecropping contracts, whereas those who do so on a small scale seem to prefer the fixed payment in cash

[12] The farmers reported that one 'turn' is normally the delivery of three hours of groundwater a day produced with a standard pumping device

(which is normally paid per hour of irrigation water received). The reasons given by the buyers and sellers for their respective choices of the payment mode will be listed and discussed in the next section. The other difference, the number of sellers from whom the two categories of buyers bought water, is positive, but not significant. It is interesting that each of the share-buyers purchased from a single seller, whereas the cash-buyers on average bought their groundwater from more than one seller. Especially if a farmer has only a single plot for which he needs additional irrigation, it lies in the nature of a share contract that there can be only one water seller. If, as in the case of the cash-buyers, the payment is not related to the output of the buyer, the only restriction on the number of sellers is the availability of sellers, which in turn is determined by the distance of other farmers' wells from the potential buyer's fields and the groundwater supply of those wells. Also, it is said by some farmers that a sharecropping contract with a seller means an assured supply of water, whereas a farmer who buys water against a fixed rate probably has to deal with several sellers to cover his water needs. Since we do not have adequate data, we are not able to determine whether the contractual form depends on the number of potential sellers available, i.e. whether the contractual form depends on the degree of competition between sellers, or whether it is rather determined by other factors (some of them already mentioned above) and then in turn determines the number of sellers.

In Table 13 the well ownership patterns of cash- and share-buyers are reported.

Table 13 Well ownership of both types of buyers

	fixed payment in cash	share	difference (cash-share)
number of wells per acre	0.42 (0.37) (n=6)	0.11 (0.12) (n=6)	0.32 (0.27)

total well depth per acre (in feet)	17.90 (10.51) (n=6)	6.79 (8.52) (n=6)	11.11 (9.57)
number of wells per acre wetland	0.29 (0.34) (n=4)	0.10 (0.17) (n=6)	0.19 (0.25)
number of wells per acre dryland	0.31 (0.41) (n=5)	0.14 (0.20) (n=2)	0.17 (0.37)

The first two differences in Table 13, which are statistics based on the total number of wells a farmer owns, are both positive and significant at the 10% level. That is, cash-buyers seem to own on average a larger number of wells per acre than share-buyers, and the sum of the depths of their wells per acre seems to be on average higher than that of the wells of the share-buyers. These findings go with the finding above, that cash-buyers buy a smaller number of groundwater 'turns' than share-buyers, since the number of irrigation devices per unit of land is a factor which determines to what extent a farmer has to rely on the informal groundwater market.

The other two differences, average number of wells per acre of wetland and dryland, respectively, are also positive but not significantly different from zero. At least, the direction of these differences is as expected, the cash-buyers owning on average more wells per acre in both wetland and dryland. The number of observations in these two cases is smaller than in the case in which we take into account all wells, since not all buyers own both wetland and dryland.

It should be mentioned at this point that all the comparisons made for the both categories of buyers are not very meaningful for the sellers, since in our sample all sellers trade groundwater with several buyers using both payment modes.

Another interesting question in comparing the two categories of buyers is to ask which of the contracting parties chose the mode of payment. Table 14 is a frequency table which

displays the answers to this question. There seems to be a remarkable difference between the answers of the cash-buyers and that of the share-buyers. Four of the share-buyers reported that it was the seller which dictated the payment mode, whereas only two of the cash-buyers reported to have no say in the choice of the payment mode. Also, one of the share-buyers told that it was the 'system' which dictated the payment mode. This statement rather lets one assume that in this case, too, the seller left the buyer with no choice concerning the terms of the contract. On the other hand, four of the cash-buyers reported that they bargained with the water seller over the terms of contract, i.e. that both had a say in the choice of the payment mode, but none of the share-buyers reported to have bargained with the well owner over how to pay for the groundwater. Of all buyers, only one share-buyer told us that he chose the payment mode himself.

Table 14 Who chose the payment mode (number of households)

	fixed payment in cash buyer	share buyer	total
seller	2	4	6
buyer	0	1	1
bargaining (both)	4	0	4
'system'	0	1	1
total	6	6	12

To see whether these differences find statistical support, we employed Fisher's Exact Test for equal proportions, all cells in Table 14 having expected counts less than 5. The hypothesis of equal proportions between the cash-buyers and the share-buyers is rejected at the 10 % level. Thus, it seems that the buyers who ended up with a contract which specifies a fixed payment per hour had more often a say in the choice of the contractual terms than the buyers did, which ended up with a share contract. This leads one to conclude that the share-buyers in our sample had little or no bargaining power at all, whereas the cash-buyers had at least enough bargaining power so that they were not from the beginning nailed down to a certain payment

mode. The situation of the different categories of buyers seems to be reflected in their bargaining power: A farmer who needs 30 days or more of groundwater irrigation is dependent on the groundwater deliveries of his seller, since otherwise he may well lose his entire crop; in contrast, the farmer who needs only some occasional 'turns' during the season is in a better position to bargain with the seller, since he will not lose his entire crop without these purchased turns and therefore might decide to do without purchased groundwater and accept a lower yield instead.

Before we turn to some detailed case studies in the next section, we report some summary statistics for the terms of payment in Table 15.

Table 15 Summary statistics for the terms of payment (by method)

		mean	std dev	min	max
buyers	fixed payment per hour (n=7) (in rupees)	27.86	6.36	20.00	40.00
	share (n=7)	0.50	0	0.50	0.50
sellers	fixed payment per hour (n=7) (in rupees)	27.86	9.94	20.00	50.00
	share (n=8)	0.50	0	0.50	0.50

The average amount per hour of groundwater paid by the buyers paying in cash is exactly the same as the average amount per hour of groundwater received by the sellers selling groundwater against a fixed rate (note that we do not confine the comparison to matching pairs of sellers and buyers), the standard deviation being slightly higher in the latter case. The relatively small standard deviation in both cases and the perfect correspondence of the average prices on both sides of the market can be interpreted as evidence for a well functioning groundwater market with a uniform price, at least in the segment where water is traded in form of a few 'turns' per season and against a fixed cash payment. In the market segment for groundwater share contracts the picture is completely homogeneous: all share-

buyers and all share-sellers reported that their share of the crop output was fifty percent[13]. Thus, as often mentioned for tenancy contracts in the literature, the fifty-fifty sharing rule seems to be adopted under a wide variety of circumstances. In our sample, for example, there is no difference between the crop share paid by a buyer who receives groundwater irrigation for thirty days and that by a buyer receiving two months of groundwater irrigation, even though a longer period of additional groundwater irrigation does not mean that the maximum attainable crop output thereby increases. The effect of thirty days more irrigation coverage is only that the crop does not fail as it would without the supplementary irrigation. Considering these facts, one may ask whether sellers subsidize their buyers this way or whether they make profit using the sharing rule. One possibility is that most sellers have a pool of buyers with whom they trade groundwater against a crop share. Some of these buyers then will receive water for only one month, whereas others will receive water for two months. Given that output does not differ too much between the different buyers, the seller will get approximately the same amount of output as if he had demanded different shares from his buyers. Given a mixed pool of buyers, always applying the same sharing rule could be a method for the seller to diversify risk. Also, a common 'rule' saves on transaction's costs and hard feelings about asymmetric treatment.

5 Some qualitative features of informal groundwater transactions

In the following, we will use some representative cases in order to illustrate how actual groundwater contracts in our sample villages are entered into and actually function. This will help us to complete the picture we already have gained from looking at the summary statistics

[13] It should be mentioned here that in all cases, no input costs were shared. That is, the only contribution to production by the seller is groundwater.

above. The section will start with a description of the share-buyers' situation, followed by a description of the terms faced by the cash-buyers, a description of the sellers' situation and a summary of the reasons households gave for not participating in the groundwater trade. At the end of this section, we will address the issue of how groundwater contracts are interlinked with tenancy contracts in the sample villages.

5.1 The share-buyers' views

Buyers often have a share contract in one season and in another a fixed payment arrangement, depending on the supply of tank water. In this subsection, we will examine some cases of buyers who had a share contract in the survey period.

One farmer told us that he normally approached a nearby well owner at the beginning of the cultivation season in order to agree with him on eventual groundwater deliveries later in the season. In normal years, he needed ten to fifteen days of groundwater irrigation, and the well owner - on whom he was dependent, since there was no other farmer's well near enough to his fields – offered him only a share contract. But he added that he would not have been able to pay in cash for this amount of water. He claimed that, in general, a well owner who was not a friend, a relative, or the buyer's employer, would have forced the buyer into a share contract, even if the latter expected to need only three or four days of groundwater irrigation.

Another buyer who owns a well himself has to buy water, since the capacity of his well is not always sufficient. He asks the owner of a nearby well for water at the moment he needs it. If this is early in the season, the seller will offer a share contract, but if it is for two turns at the end of the season he will pay in cash. He said that sometimes, when groundwater became very scarce at the end of the season, the water rates rose and that therefore he preferred to have a share contract in the case of a bad water situation. He also claimed, that under a share contract there was an incentive for the seller to deliver the water at the right time. In his opinion, the water situation decided which party had the greater bargaining power in negotiating of the terms of the sale. He once had been forced by the well owner into a share

contract, although he had needed water for only three or four days, because the well owner had claimed that the water in his well had been very scarce. Shortly after the contract had been made there had been a heavy rainfall so that there had been no further need for groundwater irrigation, but he still had had to pay the full crop share. This buyer also mentioned that besides the crop share, the well owner demanded services such as field labour in exchange for the groundwater from him.

A further buyer said that she normally approached the well owner only when she needed the water, not before she starts cultivation. It happened in the past that she suffered heavy crop losses because she asked for water too late. This year, she handed the land over to the well owner after 30 days of self-cultivation. For the remaining 60 days of the cultivation season, the well owner was responsible for the irrigation of the land, all other inputs having been applied by her before. She also said that it would be impossible for her to pay in cash for 60 days.

Two other share-buyers gave very similar reasons why in their opinion share contracts are in use. First of all, for most of the buyers, it is not possible, except for a few days, to pay the cash rates charged by the sellers, since they are lacking liquidity. The share contract is a means for farmers to save their money invested in cultivation in seasons in which they need groundwater for a month or more. Without the possibility to enter a share contract, they would either have to leave their land uncultivated or let themselves in for a gamble for rain which they are going to lose with high probability. Also, under a share contract, if the crop failed in spite of the additional groundwater applied or because the well owner did not deliver enough groundwater, one would not lose the cash payments that would have been made already under a contract specifying fixed cash payments per unit of groundwater. On the other hand, sellers choose share contracts because these contracts mean secure earnings from water trade, even if their buyers do not need much water because there is enough rainfall during the remaining time of the season.

Another explanation of how it is decided whether the buyer pays in cash or a share of his output was given by a farmer who was presently receiving groundwater from a well owner. He said that the well owner reserves the right for himself to decide at the end of the season which payment mode to employ. He claimed that the well owner chooses the cash payment if the market price for paddy is low, and the share payment if the market price for paddy is high. This story sounds quite incredible, since it would mean that there is no bargaining power at all on buyer's side, who in this case is not one of the poorest farmers.

5.2 The cash-buyers' views

Cash-buyers are often those farmers who own a well themselves but need 3 or 4 additional irrigation turns, either because their well has not enough water or because some of their land is more easily served by the well of another farmer. In the latter, the groundwater is often not traded against money, but the farmers exchange water from their wells, sometimes in the same season, sometimes in consecutive seasons.

One farmer reported that, 30 days before the end of the cultivation season, he was looking for someone who was willing to sell water to him against a cash payment. He thought that he would need only four or five turns of water for three hours until the end of the season, but the well owner he had asked was only willing so far to deliver the water under a share contract. he, however, thought that a share contract would mean that he would pay too much for the little groundwater he would need until the end of the season. It was not clear from his statements from how many potential suppliers he could buy water, but it seemed there was some choice, since he mentioned that he was still looking for someone selling groundwater against cash. He also said that he only looks for groundwater sellers during the season, once he becomes aware that the tank water may not be sufficient. This farmer's account is an indication that the contract chosen might depend on the time during the season at which the potential buyer asks for water. For some farmers, it may be very clear early in the season that they will have to enter into a share contract if they want to avoid losing their crop. But for

others it may be worth waiting as long as possible in order to not be forced into a share contract which would mean to pay a too high price for the groundwater.

Another farmer told just the opposite story. She owned a well only in the so called 'dryland' (where, in her opinion, there is no water trade on a large scale), but she also cultivated two separated fields in the so called 'wetland'. For one of these fields, she was buying water for two or three further days against cash. For the other field, she thought that she would still need groundwater for one week or more, and therefore would prefer a share contract. But the well owner did not accept a share contract, since he was in urgent need for cash. She claimed that the crop is always secure under a share contract, because in this case the well owner himself is taking care of the irrigation of the crop. In the case of spot purchases against cash, it may happen that one is refused a water delivery if groundwater is scarce, since the well owner gives priority to his share-buyers.

Another case which deserves attention is a farmer who received his four days of irrigation neither under a share contract nor in exchange for cash payments, but in exchange for the promise to plough the well owner's field in the next season supplying his own bullocks. This buyer said that he always received the amount of water he needed from this seller.

As the numbers from the descriptive statistics in section 4 already suggest, most of the cash-buyers purchase water for only a few days. But it seems to happen very often, as in the case illustrated above, that well owners try to force farmers who want to buy some groundwater turns against cash into share contracts. The reason is clear: The less groundwater the buyer needs under a share contract, the higher will be the profit of the seller at the end of the season. If the prospective buyer managed to persuade the well owner to sell him the water against cash, he still faces another problem: In the case of limited groundwater supply, the well owners will give priority to the irrigation of the fields of their share buyers, since they do

not want to lose their investment because of crop failure. So it may happen to a cash-buyer that his demand is rejected by the well owner with whom he already has an agreement.

5.3 The sellers' views

Since most of the sellers sell water under both payment methods considered here, we do not differentiate between cash-sellers and share-sellers in this section. The accounts of their groundwater sales given by well owners often resemble each other in some major aspects, but they might differ in others.

Consider first a farmer who owned one well in the wetland and reported selling water to up to five farmers. He said that he was normally able to allocate about 50 % of his well's daily capacity to other neighbouring farmers by pumping during the day, having irrigated his own plots during the night. Farmers who might need additional irrigation water during the cultivation season normally contacted him before the start of cultivation in order to be entitled to water later in the season. But the exact terms of the contract were determined only when it was clear how much water the buyer needed, since the method of payment depended on the amount of water demanded by the buyer. He claimed that the decision which payment mode to employ was that of the seller. If farmers had demanded water for half of the cultivation season, then he offered a share contract, whereas if they had demanded only about ten turns, he would have sold the water for 25 rupees per hour. The reasons he gave for this decision rule were the following: If the farmers had had to pay for half the season (i.e. for about 45 days) the rate of 25 rupees per hour, their water costs would have exceeded their returns. Therefore, farmers would rather have left their land uncultivated than paying for 45 days of water in cash. In this case, his water would have remained partially unused, since the pool of farmers to whom he could sell water was limited. Thus, both parties would have been better off in this case if a sharecropping contract had been chosen. Further, the farmer said that in a share contract he was sharing only the output with the buyer and no costs; thus, water was his only contribution to cultivation. He also would have offered share contracts for crops other

than paddy, but it was mostly for paddy that farmers needed supplementary irrigation water over such a long period. This farmer was using electric pump-sets to extract the groundwater, and due to some state regulation he was receiving free electricity. Thus, there are mainly only fixed costs for groundwater extraction, except the operating and supervision costs.

Also interesting is the case of the biggest water seller in our sample villages. He reported owning three normal wells and one very deep bore well, and selling water to a minimum of ten and a maximum of twenty buyers. He also received free electricity and sold about one half of his groundwater capacity to other farmers, applying the same rule as the farmer above for the choice of the payment mode: Farmers who needed groundwater irrigation early in the season, shortly after transplanting, received the water against a share of the crop output, whereas farmers who needed water for some days at the end of the season normally paid in cash. He sometimes sold water against labour on his own fields. Especially worth mentioning is that he employs an 'irrigator', a man whose exclusive task is the irrigation of the well owner's and his buyers' plots. This irrigator told us that he received for his services one eighth of the yield of the well owner's fields and that for each of the well owner's share contracts he received one-fourth of the well owner's fifty percent of the buyer's yield, whereas he would have received nothing if the buyers had paid in cash. Since all potential buyers had to negotiate their contracts with him, he had a clear incentive to offer share contracts in most of the cases.

Another seller with a very deep well sells about one fourth of his groundwater to five other farmers. All of these farmers have a share contract with him. Concerning the payment method chosen, he said that there was no choice in the matter, since they would not have been able to pay for the whole amount in cash. On the other hand, he told us that farmers who paid him a 50% share of their paddy crops had often not enough paddy for themselves after having paid him so that they had to buy additional rice in the ration shop. Presumably, they were covering the remainder of their costs out of their 50%. He himself, in contrast, was able to sell

paddy on the market. But if the buyers had paid him less than 50 % of their crop outputs, then the corresponding amount would not have been enough to cover his costs of the groundwater extraction. Therefore, the buying of groundwater for half of the season or so was only a temporary solution. He pays only a fixed fee per year for his electricity supply, so that there are also no other variable costs of groundwater extraction than his time and the wear and tear on the equipment. Thus, the statement that the proceeds from a sharecropping contract are just sufficient to cover the costs of the groundwater extraction seems to be questionable. In the case of this seller, the earnings from the groundwater sales may serve also to pay off the loan which he took out for the installation of his bore well. Unfortunately, we do not have information on yields, prices, and input use, so we are not able to verify the claims made in this context by buyers and sellers.

The accounts of their water contracts related by three other sellers also show exactly the same pattern: They sell water both under share contracts and against fixed cash payments, the payment mode depending on the number of days for which the buyer needs groundwater irrigation. The present season was bad where the availability of tank water was concerned; therefore most buyers needed groundwater irrigation for one month or more. The farmers would rather have left their land uncultivated than to pay in cash for so many days of irrigation. Therefore, share contracts were very popular in the season under inquiry, in which mostly paddy was cultivated. The practice is for farmers to inform the sellers before they start cultivation that they may need water later in the season, but the terms of the contract are only negotiated when the farmer requests the first release of groundwater to his fields.

5.4 The non-transacting households' view

The reasons mentioned by households for their non-participation in groundwater trade are always the same: They do not sell groundwater either because their well's capacity is not sufficient or because there are technical restrictions on the groundwater transport. They do not purchase groundwater either because they get enough water from their own well or because

they cannot buy groundwater due to the same technical restrictions on the groundwater transport. These technical restrictions are in the case of the potential sellers either that the fields of potential buyers are too far away or that the potential seller's fields and wells are situated lower than the potential buyer's fields. For potential buyers, the distance is an obstacle to groundwater trade, too, as well as landholdings that are situated higher than the wells and holdings of a potential seller. Some well owners told us that they would sell water but that they were surrounded by farmers with high capacity irrigation equipments who only would buy water if their pumpsets broke down. So there would be merely an exchange of groundwater in emergencies, and no trading in groundwater. Many of the non-transacting farmers who had landholdings only in the dryland area claimed that they did not buy or sell water because in dryland, everyone was owning a well and therefore there was no need for water trading. But as mentioned earlier, in the sample there is some evidence of water trade in dryland. One farmer reported that he wanted to purchase water but that he could not due to a family argument with the owners of the only well within reach.

5.5 Interlinking between groundwater transactions and tenancy contracts

One question that comes to mind when considering the groundwater transactions in the sample villages is, why does the water only go from the well owner to the land owner, as apposed to the land going from the waterless land owner to the well owner for cultivation? When we asked several well owners for an explanation of this phenomenon, the answers we received were always the same: The well owners were not able to lease in land, since they had not even enough time to cultivate all of their own land, and since it was not easy to hire labourers in the local labour market. Therefore, the well owners with surplus water in their wells preferred to apply this water to land which had been already prepared with all necessary inputs, especially labour, instead of renting in this land and cultivating it entirely by themselves.

There are, however, some cases in our sample villages where the trading of groundwater and the leasing in and out of land are at least somehow interlinked.

One well owner who was also selling water to one other farmer under a share contract with a 50 % sharing rule, told us that he was leasing out land together with two wells to another farmer. The contract for this kind of lease was such that the party who provided the land and the wells received one third of the crop output and that the party who provided all other inputs received two thirds of the crop output. He (the well owner) also had to pay for the maintenance costs of the two wells and pump sets. The pump sets were run with free electricity. It is surprising that the well owner receives a higher share of crop output under the contract where he only provides the water than under the contract where he provides both the land and the water. An explanation for this may be that under the groundwater contract the field to be irrigated comes under his supervision which requires some of his time, whereas under the tenancy-cum-water contract none of his time is required for cultivation. Another explanation could lie in the different bargaining positions the well and land owner holds when the two different contracts are negotiated. In the case of the pure groundwater contract he will normally be the owner of the scarce resource, groundwater, because the buyer will normally approach him in the middle of the cultivation season when most farmers are in urgent need of irrigation water. So he will be able to dictate the terms, all more so if he is the only one from whom the buyer can obtain water. The boot will be on the other foot if it is the other party which is the holder of the scarce resources, namely, labour in the tenancy-cum-water contract. This contract is negotiated before the start of the cultivation season and not in an acute scarcity situation. Thus, the prospective tenant will not be totally devoid of bargaining power.

Another farmer was leasing in land together with a well. He paid 50 % of his crop output to the land and well owner. The well, however, is used not only by the tenant, but also by the landlord himself. Also in this case, the tenant has to supply all inputs besides land and water, the well owner being responsible only for the maintenance of the well and the pump

set. If the tenant needs money to invest in cultivation, he receives credit from the landlord which he has to repay in kind but without interest.

In yet a further case, a farmer was leasing in land together with a well. He provided all inputs other than land and water, and paid one third of his proceeds to the landowner. The well owner in turn has to look after the well and the pump set and to pay the land revenue. It was said by the farmer in question the choice of contract depended on the amount of tank water available. In this case, the well and land owner left the choice to him, and he preferred a share contract, since tank water was very scarce in that season. He thought that the choice of a fixed payment would have been too risky, since groundwater was of inferior quality to tank water and therefore led to a much lower yield[14].

One household was leasing out its entire holding to a farmer who owned a well. Land is the only contribution of the household. It was stated that as long as this tenant used only tank water in cultivation, he had to pay one-third of his proceeds to the landlord. But as soon as the tenant had to rely on groundwater from his own or from another farmer's well for one day or more, the landlord's crop share would be reduced to one fourth. Thus, there is again evidence that the terms of contracts change according to the scarcity of resources employed in cultivation. In two other cases under similar contracts, the landlord paid the cash rates for the additional groundwater bought by his tenant directly to the water seller because the water from the well leased-in together with the land was not sufficient.

Another household was leasing land in both directions, together with a well. The leased out land was 8 km away from the village. The household only had to look after the pump set, and received one third of the output. Their leased in land is located in the village. The contract for this land is for five years, the rent being an annual payment of 5000 rupees in

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[14] It was told by several farmers that the worse quality of groundwater compared with tank water had a negative effect on crop yields.

advance, whether they cultivated or not. They claimed that the leased in land depended entirely on the well leased in together with it, and that they would lose the crop if this well did not have enough water. These seem to be high stakes, but this household also cultivated a lot of its own land in the village, a fact which would suggest that the household is rather wealthy and therefore may be not too risk averse.

One farmer reported that he was leasing in land together with a well, paying one third to the land owner as usual. He also cultivated his own land, but only with tank water. If he wanted to use water from the leased-in well, he would have to pay one half of the output to the well and land owner.

The tenancy contract under which one third of the output goes to the land and well owner is very common in our sample villages. Only very few farmers reported that they were leasing under fixed rent arrangements. When asked for the reasons for the popularity of this contractual pattern, the answer most farmers gave was that due to the often insecure water situation in the villages, the risk of paying a fixed amount is felt by the farmers to be too high. One farmer said that he had switched to a share contract after his entire crop had failed due to water scarcity. Under that arrangement, he had paid a fixed rent of 5000 rupees per year. Several farmers told us that until the year before the study, the share for the land and well owner had been one half, but that in a panchayat-wide, concerted negotiation between landlords and tenants, that had been lowered, since the tenants had not been able to cover their input costs out of their share of the poor yields realised in recent years.

6 Conclusion

The aim of this chapter was to empirically explain the functioning of groundwater contracts, using a South-Indian village panchayat as an illustrative example. One important conclusion, which can be drawn from looking at the summary statistics and especially at the case studies, is that water due to its overall scarcity and due to seasonal scarcities in the particular case is

often the input according to the availability of which the contractual terms are set, even if it is another input originally contracted on such as land. This can be seen very clearly from the fact that the terms of the tenancy contracts in the villages were changed because the deteriorating water situation in the villages had an adverse effect on the farmers' yields. Concerning the contracts where groundwater is the input contracted on, it is the scarcity situation of the particular buyer which determines his bargaining power vis-à-vis the seller and in that way the terms of the contract, too.

A noticeable characteristic of informal groundwater transactions in our sample villages is that the underlying contracts are in all cases negotiated for only one season, that is there are no long term contracts as they are often found in the market for tenancies. This is probably one of the biggest differences between groundwater and tenancy contracts. Also, from the example of groundwater transactions it can be seen in what a flexible manner the different payment methods are used to cope with the incompleteness of different markets at once: On the one hand, the share contract gives the groundwater buying farmer credit which he would not obtain from a bank, whereas at the same time it serves as an insurance for the well owner that he receives an income even if his groundwater extracting facilities, in which he has invested a lot of money, are not working at full capacity because of unexpected rainfall. In contrast to the choice of payment modes in tenancy contracts, the payment method used in a particular groundwater transaction is strongly related to the number of days which remain till the end of the cultivation season and to the believes of the farmers about the amount of rain to be expected during this period. The contractual terms in tenancy contracts are not handled that flexible; they are set before start of cultivation and are therefore not as perfectly adjusted to the state of nature as those in the groundwater contracts are. However, the risk sharing achieved by the use of sharecropping contracts seems to be a motive for the choice of this contract form in the market for tenancies as well as in the groundwater market. Another aspect common – but slightly different in each case - to share contracts in both markets are

the incentives which this contract form provides. But instead of providing incentives for the supply of an input (normally labour) which cannot perfectly be monitored by one of the parties as in tenancy contracts, the share contract in groundwater transactions provides incentives for the supply of an input which can be monitored very easily but which can also be sold alternatively by its owner in spot sales. Of course, the latter argument holds for the tenant's labour in tenancy contracts, too.

These are the conclusions which can be drawn from looking at the case studies in this paper. However, in order to assess these results on a more general level, one would have to estimate a model of contract choice. The data set appropriate for this task should contain the following information which was not covered by the survey underlying the present paper: First of all it would be important to cover a larger number of households for a completed cultivation season. This would allow to gather data on such things as how many water was sold and purchased, how many of the inputs other than water has been applied to the crop, how much output was produced, and what were the costs of extracting the groundwater, information which is essential if one wants to assess the earnings and costs of farmers involved in groundwater transactions. Also required would be exact information on the area irrigated, on the time in the season when no more tank water was available, and on the time in the season when the farmer bought his first groundwater irrigation turn, in order to find out how these facts influence the choice of the contract form. The number of well owners from which the farmer could possibly buy water will also have a bearing on the contract choice. Further, data would be needed on household characteristics such as household wealth, number of family members working, assets owned, etc., since these characteristics would help to quantify the households attitude towards risk and since they provide information on the households endowment with productive assets. It would also be interesting to identify matching pairs of sellers and buyers, although the choice of a contract partner is more restricted than in the case of a tenancy contract due to the restricted transportability of

groundwater. Finally, it would be useful to have a time series of several cultivation seasons and data from different areas to see how differences in rainfall and differences in agro-climatic and groundwater conditions influence contract choice in groundwater transactions.

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Appendix I: Questionnaire

For well owners:

1. How many wells do you own? What are the respective depths of your wells? Are the wells located in the wetland and/or in the dryland?
2. How many pumpsets do you own?
3. How many acres of land do you own? How many acres in the wetland, how many acres in the dryland?
4. I) Do you lease out land? How many acres? If yes, how does your tenant pay for the leased-in land?

   II) Do you leave some land uncultivated? How many acres? Why?

   III) Do you lease in some additional land? How many acres? How do you pay for the leased-in land?
5. What crop are you cultivating this season?
6. How much money did you invest in your well(s) and in your pumpset(s)?
7. What are the operation and maintenance costs of the well(s) and the pumpset(s) per year?
8. Do you sell water to other farmers?

If yes:

i) Do you agree with them on the water deliveries at the beginning of the crop season, or do they come and ask you for water as they need it?

ii) Do you can always fulfil the water needs of the farmers with which you agreed on water trade?

iii) To how many farmers do you sell water?

iv) What percentage of your pumping capacity do you sell to other farmers (percent of total running hours of the pumpset)?

v) What is the maximum distance from your well to a buyer's field?

vi) How do the farmers pay for the water they receive from you?

If cash:

i) How many rupees per hour?

ii) Who chose the contract form?

If share contract:

i) What is the share?

ii) Do you share only the output, or also costs other than labour costs?

iii) Who decides whether share contract or fixed payment? Why did you enter into a share contract?

iv) Do you receive any other services from your buyers?

v) Do you deliver any other inputs to your buyers?

If not selling water:

i) Why you don't sell water?

9. Do you buy water from other farmers?

If yes:

i) From how many farmers do you buy water?

ii) Do you agree with the well owners at the beginning of the crop season on the water deliveries you will need later in the season, or do you approach them at the time you need the water?

iii) How many irrigation turns you will need during this crop season?

iv) Do you get always the amount of water you need?

v) What is the maximum distance of a seller's well to your field?

vi) How do you pay for the water you receive?

If cash:

i) How many rupees per hour?

ii) Who chose the contract form?

If share contract:

i) What is the share?

ii) Do you share only the output, or also costs other than labour costs?

iii) Who decides which payment mode is chosen? Why did you choose a share contract?

iv) Do you receive any other inputs from the well owner?

v) Do you have to render any other services to the well owner?

For farmers who do not own a well

1. Do you own land?

If yes:

i) How many acres in wetland and in dryland?

ii) Do you lease out land? How many acres?

iii) Do you lease in some additional land? How do you pay for the leased in land?

iv) Do you leave some land uncultivated? Why?

If no:

i) Do you lease in land? How do you pay for the leased in land?

ii) What crop are you cultivating this season?

iii) Do you buy water from other farmers?

If yes:

i) From how many farmers do you buy water?

ii) Do you agree with the well owners at the beginning of the crop season on the water deliveries you will need later in the season, or do you approach them at the time you need the water?

iii) How many irrigation turns you will need during this crop season?

iv) Do you get always the amount of water you need?

v) What is the maximum distance of a seller's well to your field?

vi) How do you pay for the water you receive?

If cash:

i) How many rupees per hour?

ii) Who chose the contract form?

If share contract:

i) What is the share?

ii) Do you share only the output, or also costs other than labour costs?

iii) Who decides which payment mode is chosen? Why did you choose a share contract?

iv) Do you receive any other inputs from the well owner?

v) Do you have to render any other services to the well owner?

If no:

i) Why?

Appendix II: Definitions of variables

wellown:	wellownership of the household
landown:	acres of total land owned by the household
watertrade:	household involving in the trade of groundwater
leaseout:	acres of land leased out by the household
leasein:	acres of land leased in by the household
numwell:	number of wells owned by the household
depwell1:	depth of first well (in feet)
depwell2:	depth of second well (in feet)
depwell3:	depth of third well (in feet)
depwell4:	depth of fourth well (in feet)
nuwetwell:	number of wells located in wetland
nudrywell:	number of wells located in dryland
wetland:	acres of wetland owned by the household
dryland:	acres of dryland owned by the household
uncland:	acres of land left without cultivation in this season
crop:	crops cultivated by the household in this season
wellpuinvest:	investment in wells and pumpsets (rupees)
opmain:	operation and maintenance costs for wells and pumpsets (rupees/year)
paywab:	payment mode for water bought
bcash:	cash amount for water bought (rupees/hour)
bshare:	outputshare for water bought (in percent)
paywas:	payment mode for water sold
scash:	cash amount received for water sold (rupees/hour)
sshare:	outputshare received for water sold

paylanin:	payment mode for land leased in
incash:	cash amount paid for land leased in (rupees)
inshare:	outputshare paid for land leased in
paylanout:	payment mode for land leased out
outcash:	cash amount received for land leased out (rupees)
outshare:	outputshare received for land leased out
maxdist:	maximum distance from well (s) to field (b)
numsell:	number of farmers from which water bought
numbuy:	number of farmers to which water sold
wcumlin:	number of wells leased in together with land
indep:	depth of wells leased in together with land (feet)
wcumlout:	number of wells leased out together with land
outdep:	depth of wells leased out together with land
reasunc:	reason for leaving land uncultivated
whomode:	who chose payment mode
reashare:	reason for choosing a share contract
turns:	how many turns of water you have to buy
time:	time of agreement on water deliveries
percent:	percentage of the extractable groundwater per day given to others

Appendix III: Code

wellown: yes = 1

no = 2

watertrade: no = 0

seller = 1

buyer = 2

seller and buyer = 3

crop:

no crop = 0	chillies = 5
paddy = 1	oilseeds = 6
banana = 2	vegetables = 7
cotton = 3	coconut = 8
groundnut = 4	others = 9

payment mode: cash = 1

share = 2

kind other than share = 3

cash and share = 4

reasunc:

lack of tankwater = 1	others = 6
lack of rain = 2	
no access to well = 3	
lack of labour = 4	
lack of money to invest = 5	

whomode:

seller = 1	'system' = 4
buyer = 2	
bargaining = 3	

reashare: not enough money to pay in cash (buyer) = 1

risk sharing = 2

assured water supply (buyer) = 3

seller prefers to have crop instead of money = 4

seller wants to have assured income even if he does not have to irrigate because of enough rain = 5

time: before start of cultivation = 1

after starting cultivation =2