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PRA-PALM Series - 9

Exploring the Interactive Effect of Wells In Hardrock Areas of Peninsular India - An Illustration of the PRA Approach

This paper is a contribution from the Department of Agricultural Economics, University of Agricultural Sciences (UAS), Bangalore, to the MYRADA PRA-PALM Series. It constitutes Working paper No.1, under 'Equity Issues in Groundwater Development', a project of the UAS, supported by The Ford Foundation, New Delhi.

This paper represents a first attempt by the UAS (Department of Agricultural Economics) to use the PRA approach in exploring the interactive effects of wells; the approach has been subsequently modified and adapted for use elsewhere.

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Dates: 6th to 9th July 1994

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What is interactive effect of wells?

The phenomenon of interactive effect of wells, also known as well interference, refers to the groundwater nexus between wells. Here, among accidentally connected wells, withdrawal of groundwater from one well will result in reduction of groundwater yield and water level in the other. In practice, it is likely that there may be either one well to one well interaction, or one well to many wells multiple interactive effects. The interference phenomena are obscure; to the extent that one or more wells may be causing the problem, it is proper to study the predicament faced by farmers due to 'cumulative' well interference, since it is difficult to discern the effect of a specific well on another well. By 'cumulative' we mean the sum total effect of over-pumping of ground water from several (types and numbers of) wells resulting in the reduction of yield and water levels in the surrounding wells. The National Geophysical Research Laboratory, Hyderabad, conducted thousands of pump tests and recorded the discharge and water levels for wells with different interwell spacings. They concluded that the isolation distance between (i) open well to open well should be 82 metres; and (ii) open well to dug-cum-borewell or borewell should be 250 metres, to avoid the problem of interference. Hence, wells which are spaced below the threshold isolation limits prescribed are likely to be more affected from interference than those wells which pass this threshold.

Why study interference?

The well interference problem poses serious threats to sustainability and equity in well irrigation. A large farmer who can afford to dig, drill, or deepen many irrigation wells can seriously hamper the irrigation prospects of neighbouring small farmers irrigating with one or two wells. In the long run, the small farmer may be forced to shift his/her operations to dryland agriculture. There is a clear equity issue here. When the process of withdrawal of groundwater without regard to recharge efforts goes unabated, the resource itself may become unsustainable, clearly reducing the economic life of the well, which underscores the sustainability issue.

Statistical and PRA approaches

In this note we provide a combination of statistical and PRA approaches for selecting farmers to study and analyse the equity issues involved due to interference of irrigation wells. It is to be noted that either statistical or PRA approaches singularly cannot provide efficient study guidelines for the choice of the study taluks, villages, and farmers. The statistical approach provides the first step is sampling for choosing the taluks and villages; the PRA approach is the second and final step for choosing the farmers from among the villages selected for studying well interference problems, both the approaches running complementary to one another.

Why statistical approach is necessary to identify the taluks/villages suffering from interactive effect(s) of well(s)

At the taluk/village level, it is difficult to have a list of taluks/villages which suffer from well failure due to interactive effect(s) of well(s). Hence, we need to generate a realistic index which uses the available secondary sources of information. We developed five different indices, each providing a proxy for locating the taluk/village having well failure due to interactive effect(s) of well(s), and chose one of the five indices which best reflected the problem. The chosen index is: the number of irrigation pumpsets per million cubic feet of utilisable groundwater for irrigation in a taluk (or village)[1]. This index reflects the dependency of a number of wells on a unit of groundwater for irrigation. Hence, the taluk or village with the highest number of wells per unit of groundwater reflects high well interference problems compared to a taluk which has the lowest number of wells per unit of groundwater. For a comparison of the well interference problems in the most affected and the least affected taluk, we have chosen the taluk with the highest number of wells per unit of groundwater in each agro-climatic zone of Karnataka state. The details of the statistical approach used are provided in Appendix 1.

Why PRA approach is necessary to study the interactive effect(s) of well(s) within a selected village or a portion of the village

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1 We are thankful to Sri V.Jagannathan, Senior Hydrologist, Central Groundwater Board, Southern Region, Jayanagar, Bangalore for developing this index.

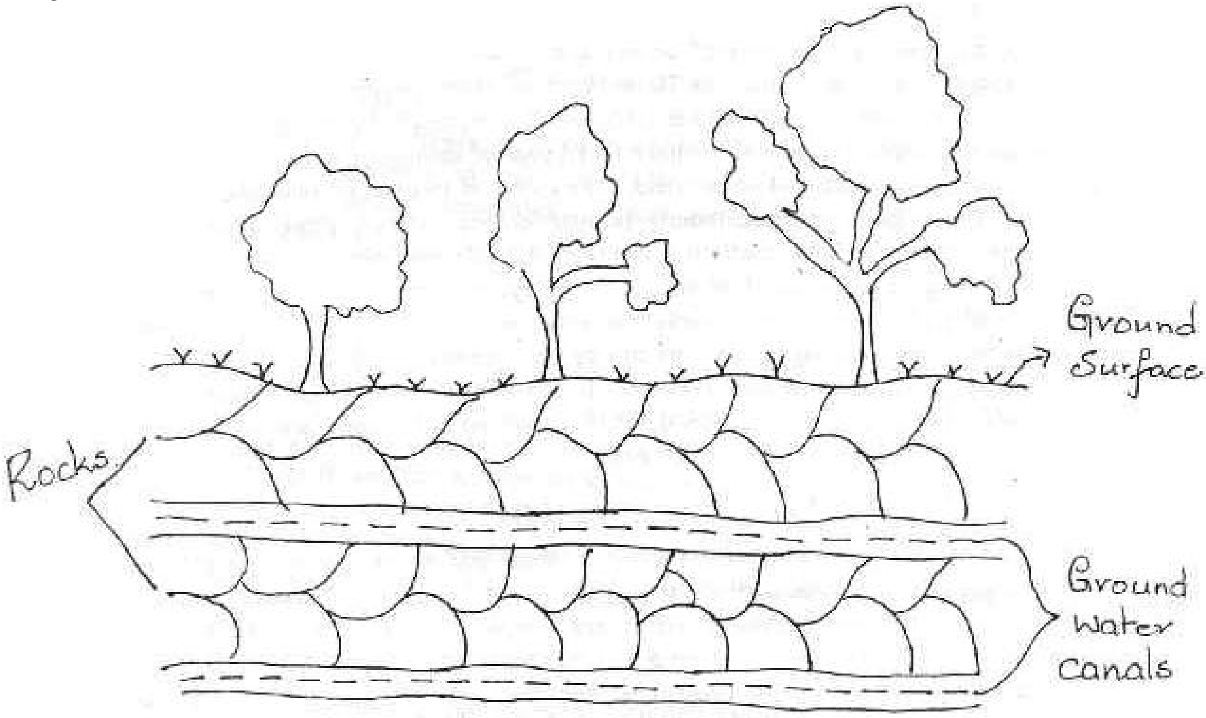
The secondary source of information to locate well failure(s) largely due to well interference (by one well to another well) or cumulative well interference (by one well to many well or by many wells to one well, or among many wells themselves) is not available with the Department of Agriculture or Department of Mines and Geology, or any other source. The only recourse to such a vital information is through PRA mapping of closely spaced or densely located wells with respect to: (i) year of drilling of wells, (ii) inter-well distance, (iii) depth of wells, (iv) water yield, (v) method of locating groundwater in well, and many other variables which contribute to interference. Hence, after choosing the taluk and the village using the statistical approach already highlighted, locating closely spaced wells through a base map of all wells in the village or a portion of the village aids in identification of pockets of density of wells in a village or its portion. The location of wells in the village and their mapping can be done only by the farmers of the selected village. In addition, mapping of items (i) through (v) listed above cannot be done singularly but by the cumulative efforts of the farmers. Hence the PRA mapping is ***sine-quo-non*** to the study of well failure due to interactive effects of wells.

PRA approach to choose the study area within a village and interact with farmers

For the purpose of developing the PRA techniques necessary to understand the perceptions of farmers, water diviners, and others involved in groundwater irrigation, the Bhattarahalli village in Kolar taluk, Karnataka State, India, was selected. Since this was more in the nature of a training programme for the UAS team in the use of PRA techniques, the village was selected at random by MYRADA out of many villages in the taluk that have a large number of irrigation borewells. The information diffusion on groundwater exploration is by 'word of mouth' among farmers in the absence of agricultural extension efforts. The local water diviners play a crucial role in the diffusion of information. It is debatable whether the farmers get the **right** information on groundwater exploration from their peers and local diviners. Hence, it was also necessary to understand the perception of occurrence and movement of groundwater by local water diviners (water witches), since they provided (as we later found out) 60% of the groundwater location points and wield great influence with regard to groundwater exploration.

The local diviners were asked to figure the underground water system. Their perception is reflected in the following diagram:

Diagram 1



The local diviners were asked to explain (i) direction of movement of groundwater, (ii) method used in water divining, and (iii) the hydro-geological formations. It appeared that each diviner's perception was distinctly different from the others. We could discern the following methods of divining groundwater from their answers :

1. Y-shaped tree stem (the stick should be lean and wet)
2. Plumb ball method :
    - i) magnifying lens and thick copper wire tied to a thread.
    - ii) magnifying lens and precious stone tied to a thread.
    - iii) magnifying lens and metal watch tied to a thread.
3. Dehusked coconut.
4. Young boy feeling giddy at the point where groundwater is located.
5. Asking boon from god in a temple.
6. North-east geomancy (deva moole).
7. Anjana method (witchcraft)
8. Head torch method.
9. Where the following are located : termite hill, Calotropis gigantica var. albiflora.
10. Geophysical survey.

Only a few of the above methods were mentioned by the local diviners and the remaining were obtained during informal interactions with the local diviners of other areas. The 'Y' stick and 'Plumb bob' were the more often adopted local divining methods. One diviner opined that the groundwater availability increases as we move from south to north in the area where the PRA was conducted. The diviner mentioned that normal groundwater yielding fractures could be cited at three distinct depths : 75 feet, 145 feet, and 185 feet. This was ratified by the geologist also. Some of the local diviners mentioned that groundwater would be flowing in a canal beneath the rocks underground (as shown in the underground water transect). This highlighted the misconceptions farmers have with regard to groundwater occurrence. Infact, the size of the fractures in the rocks of hardrock areas is limited to around 5 millimetres where groundwater would be flowing. The hardrock system cannot support the existence of underground canals. Some others mentioned that rainfall is the only source for underground water. They also mentioned that a good volume of groundwater can be traced to intersections of north-south and east-west directions on the ground. They believe that groundwater exists only in fractures and gaps. The groundwater joins a river at some place during its flow.

One of the local diviners who was acknowledged by the geologist as a person with a better understanding of groundwater than the other local diviners, suggested that both 'local' and geo-physical methods be used in locating groundwater; 'local' method to locate the point for drilling and geo-physical method to estimate the depth and yield. The geologist agreed with few of the opinions of the local diviners and the geologist was taken to a farmer's field. The 'Plumb Bob' local diviner and the geologist interacted in divining a well point. Incidentally the 'Plumb Bob' diviner's location was ratified by the geologist, but he attributed the success of the local diviner to a chance factor.

PRA MAPPING

Understanding the situation of failed wells from the perspective of farmers is crucial since they are the ultimate field decision makers and investors for coping with the well interference problems. The farmers' perception of failure may be entirely different from the technical definition of well failure. For instance, according to NABARD, a dug well or dug-cum-bore well is considered a failed well if it yields below 5000 gallons per day in rabi season, and a borewell is considered failed if it yields below 1000 gallons per hour. The farmers' perception of failure may be different from the technical definition, as the technical definition of well failure is a sort of overall average and discounts the coping mechanisms adopted by farmers to use whatever available scarce groundwater.

The well failure in our study is defined as **:**

i) well that dries up because of new well(s) coming in (but not because of decline in rainfall).

ii) well that loses a large degree of its yield because of new well(s) coming in (but not because of decline in rainfall), and

iii) well that is deepened because of new well(s) coming in.

In order to obtain field impressions of well interference in Bhattarahalli village, we conducted PRA exercises and developed maps of {1} year of drilling of wells, {2} interwell distance, {3} water yield, {4} depth of wells, and {5} method of locating groundwater in well. We have a limitation in our study. In our maps, we were unable to obtain information on items {1} to {5} above for all the wells in the village, as all the well-owning farmers could not be present for various reasons. This PRA was our first attempt to get ourselves acquainted in several PRA techniques. Accordingly, we have mapped the data only for the wells for which information was available.

PRA RESULTS

We present the following findings drawing inference from the five PRA well maps (Map 1 : Year of drilling wells; Map 2 : Distance with other wells and numbering of wells; Map 3 : Yield of wells in thousand gallons per hour; Map 4: Depth of wells; Map 5 : Location of wells by local diviners and geologists).

Once the wells were located on a map, the following picture emerged over a period of several hours (spread over 2 days)

Table 1 : Well Information

Number of open (dug) wells	21
Number of borewells	58
Number of drinking water wells (borewells)	3
T O T A L	**82**

Table 2 : Open (dug) well information

Particulars	Presently Working	Working Earlier But Now Failed
Dug wells with inwell bores	-	12
Dug wells without inwell bores	-	9
T O T A L	-	**21**

Dug wells have been in existence for several decades, and used for irrigation. The average depth of dug wells is 40 ft. The practice of drilling in dug wells began in the 1970s. The last inwell bore was done in 1987. Inwell boring was begun in search of higher volumes of groundwater. All dug wells have been abandoned for irrigation purposes due to insufficient water. The average life of a dug well was ascertained to be 11 years, and that of dug-cum-borewells 8 years. Farmers switched from dug wells to dug-cum-borewells after 11 years of using dugwells; they used the dug-cum-borewells for a further period of 8 years before finally abandoning the wells. Since the 1980s the use of local, labour intensive water lifting devices such as Kapile, Yetha and Persian wheel have been given up since they can only lift water from shallow depths of dugwells. A majority of the dugwells are now being used as groundwater storages.

Table 3 : Borewell Information

Number of successful borewells	32	55%
Number of borewells that failed at the time of drilling	16	28%
Number of borewells that were successful and failed subsequently	10	17%
T O T A L	**58**	**100%**

The first borewell was drilled in 1972 and is functioning without problems to this date (1994). This point was located by a geologist, and is 400 metres away from its nearest neighboring borewell. It was drilled to a depth of 120 ft., while water was struck at 80 ft., itself, and yields 9000 gallons per hour (GPH). Presently, the average depth of borewells is 207 ft., and the average depth at which water is struck is 117 ft.

The race for borewells could be well understood by considering the case of a farmer who drilled 11 borewells of which only 3 are functioning; the remaining suffered initial failure. The average yield of borewells which worked initially but failed later was 1750 GPH. The

Central Groundwater Board, Government of India, have drilled an observation borewell and an exploratory borewell very close to the village.

The local water diviners provided locations for 60% of the wells and the remaining 40% were located by geologists. Of the currently working borewells, water diviners showed 50% of the points and geologists showed the remaining 50%.

The average distance between all types of wells is 462 ft., which is well below the recommended threshold isolation distance. This, coupled with the fact that all dugwells, dug-cum-borewells, and 17% of the borewells have failed after a period of time, provides good evidence to believe the presence of interactive effects in wells.

The above findings provide us insights regarding the degree of well failure and interactive effects among irrigation wells. A better understanding of interference is made possible by adopting the PRA approach to map several other features that impinge on well failure. In order to understand well failure and the equity implications thereof, PRA mapping of the following features is helpful in analysing what different categories of farmers do when there is well failure, what their economic losses are, and how they cope with the situation :

- Land holding size of well owning farmers.
- Type and present status of well.
- Seasonal variations in depth of water and yield of the well.
- Type and capacity of pumpset.
- Year of well establishment, well failure, and inter-well distance.
- Cropping particulars
- Area irrigated by each well.
- Number of wells owned by each farmer.
- Sources of finance for well establishment.
- Proportion of income realised from irrigated, unirrigated, food and non-food crops.
- Coping mechanisms adopted by farmers to endure well interference.

Conclusions

It was not within the scope of this preliminary exercise to study coping mechanisms and address equity issues. The PRA mapping exercise has provided us guidelines for locating farmers who are suffering from well interference, as a first step towards looking at equity questions and developing a strategy for extension education, water management, credit support, and related aspects that can combine economic development with resource conservation and management. (For example, we found that in adherence to NABARD Guidelines the banks are not extending credit to farmers for well drilling in many parts of Kolar District since the area is considered to have over-exploited its groundwater potential. The farmers have overcome this situation by simply turning to private sources of finance for well drilling. This does not solve the problem of over-exploitation; on the other hand the better-off farmers drill several wells while the poorer farmers cannot even drill one well since they are not seen to be credit-worthy by the private lending sources.)

This PRA exercise also indicated that there is a race from farmers towards drilling more and more borewells even though the proportion of failure is around 50%. The farmers expressed difficulty in appreciating that dugwells and dug-cum-borewells can also fail because of interactive effects of these wells on each other. They did not perceive that dug wells and dug-cum-borewells could interfere with one another; they did, however, we perceive that borewells do interfere with dug wells and dug-cum-borewells.

APPENDIX I

Statistical approach to select the study taluks and villages

The well interference in a hydro-geological phenomenon prevalent in all the agro-climatic zones of Karnataka. Since these zones have a great degree of variance, the study on interference would suffer from limitation if generalisation of results is attempted by studying areas where groundwater exploitation is intense. In order to obtain a realistic estimate of the intensity of well interference problems in different taluks of Karnataka, the data on the taluk-wise utilisable groundwater for irrigation (from the Central Groundwater Board, Government of India, Bangalore) and number of irrigation pump sets for the year 1992-93 (from the Karnataka Electricity Board) were obtained. Then the ratio (Number of IP sets : Million cubic meter of utilisable groundwater for irrigation) was computed for each of the 175 taluks. The taluks were then sorted in descending order of magnitude of the ratio. The taluks were later classified according to agroclimatic zones of the State in order to obtain the variability in groundwater use across crop types, soil types and climatic types. The agroclimatic zones chosen were North Eastern transition zones, Northern transition zone, Northern dry zone, Central dry zone, Eastern dry zone and Southern dry zone. The North Eastern Dry Zone, Southern transition zone, Hilly zone and coastal zone were not considered as they had favourable situation regarding groundwater interference. The taluk with the highest number of IP sets per MCM of utilisable groundwater for irrigation in each of the six selected zones was chosen for the study.

At a state level meeting with geologists, irrigation specialists, remote sensing specialists, Statisticians, Land Bank officers and irrigation specialists, the taluks chosen using statistical method were confirmed to be facing the well interference problem relative to other taluks. For the selection of villages within the selected taluk, the village-wise availability of groundwater for irrigation was computed by using the ratio [(net sown area for the village)/(net sown area for the taluk) x (utilisable groundwater for irrigation of the taluk)]. The data on net sown area for the village and the taluk pertain to 1986-87. The village-wise number of wells (for 1986-87) per MCM of utilisable groundwater for the village was then computed. The villages were later ranked in the descending order of the number of wells per MCM of utilisable groundwater for irrigation. For the purpose of choosing the sample farmers, four villages with a high number of wells per MCM of groundwater were chosen, During this choice, villages with any kind of surface irrigation facility (from major, medium or minor irrigation sources) were excluded and only the top four villages which do not have any sort of surface irrigation facility were considered in order to confirm, whether the villages so chosen do reflect the problems of well interference, the research team visited each of the villages and contacted the farmers to confirm the prevalence of well interference phenomenon.

END NOTES:

We provide a likely list of equity and sustainability concerns for groups of farmers/resources.

1. Early comers vs. late comers (in the absence of law of prior appropriation).
2. Late comers vs. early comers (in the presence of law of prior appropriation).
3. Farmers in non-tank command area vs. farmers in tank command area.
4. Farmers located in rural areas vs. farmers located near urban areas.
5. Food crop growing farmers vs. cash crop growing farmers.
6. Drinking water well users vs. irrigation well users.
7. Drinking water well use vs. irrigation well use.
8. Groundwater for agriculture vs. groundwater for industry (region).
9. Farmers in low rainfall vs. farmers in high rainfall areas.
10. Farmers in 'dark' area vs. farmers in 'white' area.
11. Farmers in 'dark' area vs. farmers in 'grey' area.
12. Farmers in 'grey' area vs. farmers in 'white' area.
13. Farmers in area with good electricity supply vs. farmers in area with poor electricity supply.
14. Farmers located in areas with dense wells vs. farms located in areas with sparse wells.
15. Farmers whose wells are interfered vs. farmers whose wells are not interfered.
16. Farmers with dug wells(s) vs. farmers with bore well(s).
17. Farmers with dug-cum-bore well(s) vs. farmers with borewells.
18. Farmers with shallow borewells(s) vs. farmers with deep borewell(s).
19. Farmers with one (poor yielding) well vs. farmers with many (good yielding) wells.
20. Farmers with many (poor yielding) well vs. farmers with one (good yielding) wells.
21. Farmers with competitive arrangements vs. farmers with cooperative arrangements.
22. Farmers in Non-riparian areas vs. farmers in riparian areas.
23. Farmers located away from irrigation channels vs. farmers located close to irrigation channels.
24. Farmers without groundwater storage structures vs. farmers with groundwater storage structure.
25. Farmers in areas where there are no water markets vs. farmers in areas where there are water markets.
26. Farmers with falling water tables vs. farmers with adequate water tables.
27. Farmers with declining water quality vs. farmers with adequate water quality.
28. Farmers with good access to electricity vs. farmers with poor access to electricity.
29. Farmers with centralised regulations vs. farmers with decentralised regulations in groundwater management.
30. Farmers paying pro rata tariff vs. farmers paying flat tariff.
31. Farmers using diesel power vs. farmers using electrical power for groundwater extraction.
32. Farmers in the downstream vs. farmers in the up streams.

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