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Impact of Probability of Well Success on Unit Cost of Irrigation in Karnataka

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Abstract: The negative binomial probability of drilling a successful well in hard rock areas of Karnataka is estimated to be around 0.3, which has fallen from 0.60 during the 1990s. By incorporating the weighted probability of well success and failure, it has been estimated that out of the total investment on drilling and casing of irrigation well in hard rock areas, the investment on failed wells formed around 70 percent of the total investment. Thus, by improving the probability of well success by adopting sustainable cropping pattern and suitable coping mechanisms such as drip irrigation, recharging of borewells, sharing of borewell among siblings, substantial investment on failed wells could be saved which is worthwhile for small and marginal farmers. The current unit cost of well irrigation by NABARD underestimates the loan sanctioned to the tune of 60 per cent, which imposes substantial costs on marginal and small farmers. It is therefore crucial to revise the methodology of estimating unit cost by NABARD as proposed in this study.

Keywords: Borewell irrigation, Cost of drilling and casing, Negative binomial distribution, Probability of well success

India's agricultural production journey from external dependency to meet foodgrain requirements at the time of Independence to self-sufficiency today is intricately tied to the groundwater resources of the country (Dipankar 2019). But, today the ever growing demand for agri-horticultural and dairy products from peri-urban fringes is adding to the increasing dependence on groundwater resource where the resource is being over exploited. These areas also suffer from limited recharge attempts/efforts on small and marginal farms where natural resources are limited (Kalphana 2018). About 65 per cent of the geographical area of the country constitute hard rock area (Roopal 2016) fraught with low groundwater recharge, below 10 percent of the rainfall. The resulting probability of well success is fast reducing. Nevertheless to mention that borewells have been the order of the day. In these areas, in order to strike a successful well farmers drilled more than a well or a couple of wells depending upon the probability of success of well widely varying from farmer to farmer (Kiran 2014 and Nagaraj et al 1996). Thus, the probability depends upon the history of drilling experience, which involves the initial and premature failures of wells prior to obtaining a successful well. Accordingly, investment on all types of wells needs to be accounted in costing of irrigation well. Usually farmers consider the investment on water yielding (or successful) well, treating non-yielding wells (or failed) wells as redundant.

The cost of groundwater irrigation thus need to reflect the investment/cost of initial failure, premature failure and success wells and cost of coping mechanisms such as water storage structures, drip system and so on, weighted with the probability of well success. There have been seldom attempts towards costing groundwater, due to issues inter alia such as (1) definition of well – to include or exclude the variable cost of drilling and casing, the fixed cost of water extracting structures (motor, pump, electrical installation), water delivery structures (pipes, drip / sprinkler systems) (2) incorporation of probability of well success and probability of well failure in the costing of irrigation wells, (3) internalization of externality of groundwater irrigation reflected in increasing initial failure, the associated (4) determination of life and age of well. Due to these complications, it was easy for Commission for Agricultural Costs and Prices (CACP) to treat investment on irrigation well as fixed cost and by assuming a fixed number of years of life, could compute depreciation as the (fixed) cost of irrigation. The purpose of this article is to explore whether the probability of well success has increased or reduced over time, how does the probability of well success varies with adoption of coping mechanisms to combat the predicament of groundwater irrigation and to examine the influence of incorporation of probability of well success and failures in estimation of investment on irrigation borewell.

MATERIAL AND METHODS

A total of 120 sample farmers representing four categories such as farmers sharing well water among siblings (n=30), farmers with drip irrigation for broad spaced crops (n=30), farmers who have recharged irrigation borewell/s (n=30) from Chitradurga district and farmers who have adopted drip irrigation for narrow spaced crops (n=30) from Kolar districts of Karnataka state were selected. Farmers sharing well water and those who have recharged irrigation well/s were selected following snow ball sampling. Random sampling technique was followed to select drip irrigation farmers. Kolar and Chitradurga are the hard rock areas representing Eastern and Central Dry Zones of Karnataka. The primary data pertaining to size of land holding, year of drilling of borewell, investment made on drilling and casing of borwell, year of functioning of borewell, depth of well, yield of functioning well, cropping pattern etc., were elicited from sample farmers using well structured interview schedule.

Probability of well success: The NBD probability function with probability of success 'p' and probability of failure 'q' (=1-p) is given (Manjunatha et al 2014) as under

$$P_x\{nb(x;r,p)\} = \binom{x+r-1}{r-1} p^r q^x$$

$$;\ for\ x = 0,1,2,3,...,\ r-1, r \ge 0; 0 < p < 1$$

$$Mean = \frac{rq}{p} \quad and\ Variance = \frac{rq}{p^2}$$

NBD probability of borewell success (r >1) is

$$p = \frac{r}{(r + Mean)} = \frac{Mean}{Var}$$

and q = (1-p) is the probability of borewell failure. The Chi-Square statistic is employed to test the goodness of fit of the distribution.

Estimation of economic investment on irrigation borewell: The estimated total investment to obtain one successful borewell = {(l/p) (p) (cost of successful borewell) + (1-p)/ (p) (cost of failed borewell)}= (cost of successful borewell) + (q)/ (p) (cost of failed borewell)

RESULTS AND DISCUSSION

The sample farmers who are sharing irrigation water among their siblings have experienced the largest probability of obtaining successful borewell of 0.68, in Chitradurga district receiving a modest rainfall of around 450 to 650 mm (Central Dry Zone). They experienced a higher probability of obtaining successful borewell, by sustainably using groundwater, which resulted in honoring isolation distance between wells and reducing proliferation of irrigation wells. However, the situation was different in the case of other three sample categories whose probability of well success was modest ranging from 0.27 to 0.32 (Fig. 1). Thus, with the low probability of well success, farmers in Eastern Dry Zone having drip irrigation for narrow spaced crops had to drill three borewells to get one successful well. Similarly, farmers in Central Dry Zone having drip irrigation / recharged borewell had to drill four borewells to get one successful well. The number of wells to be drilled to obtain successful borewell by shared well farmers was just equal to one (Table 1). From the preceding results it could be inferred that the probability of well success on farm in general was modest at 0.30. While the probability of well success observed during 1990's was in the range of 0.55 to 0.66. Reducing probability of well success is apparent over the years. It might be due to violation of isolation distance, cumulative interference due to

Table 1. Estimated Negative binomial probability of obtaining successful borewell in hard rock areas of Karnataka adopting various coping mechanisms

Particulars	Drip farms connected to narrow spaced crops	Drip farms connected to broad spaced crops	Farms with borewell recharged	Farms sharing their well water with relatives
No. of farms with zero borewells drilled before one successful well (= No. of farms with no failures)	6	15	6	21
No. of farms with one borewell drilled before one successful well	7	3	6	5
No. of farms with two borewells drilled before one successful well	6	4	6	3
No. of farms with three borewells and above drilled before one successful well	11	8	12	1
Total no. of farms	30	30	30	30
Total no. of wells on all farms in each category	139 (27.36)	150 (29.53)	159 (31.30)	60 (11.81)
Negative Binominal probability of obtaining one successful well= 1/(1+Mean)	0.32	0.28	0.27	0.68
Mean number of successful borewells per farm	2.06	2.57	2.70	0.47

Note: Values in parenthesis indicate percent to grand total number of wells (508)

Table 2. Estimated cost of borewell incorporating probabilities of well failure and success in hard rock areas

Particulars	Drip farms connected to narrow spaced crops	Drip farms connected to broad spaced crops	Farms with recharged borewell	Farms with shared borewell
Cost of drilling and casing per successful well (Rs)	100207	30519	31180	27459
Cost of drilling and casing per failed well (Rs)	77929	32003	26779	24828
Probability of successful well	0.32	0.28	0.27	0.68
Probability of failed well	0.68	0.72	0.73	0.32
Weighted cost of successful well {(3/3)*(1)}	100207 (37.70)	30519 (27.05)	31180 (30.10)	27459 (70.15)
Weighted cost of failed well {(4/3)*(2)}	165599	82292	72401	11684
Estimated investment on drilling and casing of an irrigation well = (5+6)	265806	112811	103581	39143
Total number of wells to be drilled to obtain one successful well	3.13	3.57	3.7	1.47
Average depth of borewell (ft)	717	342	342	274
NABARD's unit cost of casing and drilling for the average depth of borewell	96888	41162	41162	32656
Deviation in unit cost fixed by NABARD (%)	-63.54	-63.51	-60.26	-16.57

Note: Values in parenthesis indicate percentage of weighted cost of successful well in total investment

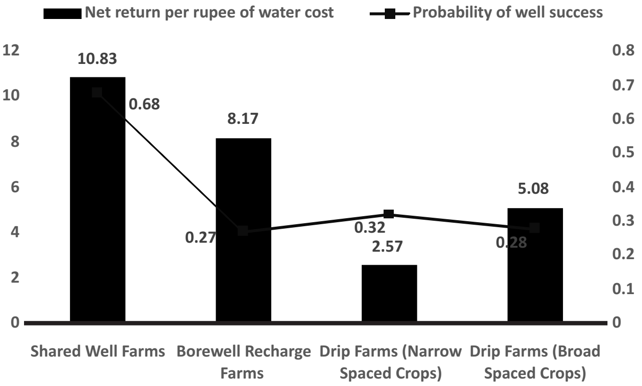

Fig. 1. Economic efficiency and probability of well success on farms with different coping mechanism

mushrooming of borewells and increasing negative externality. The influence of probability of well success and failure/s was incorporated in the estimation of investment on irrigation well by assigning appropriate weights. Accordingly, the proportion of weighted cost of successful well ranged from 27 to 38 per cent for the drip farms connected to narrow spaced crops, broad spaced crops and on borewell recharge farms. The rest proportion was accounted for cost of failed wells which formed 73 to 62 per cent of the total cost of well. This was due to violation of isolation distance between wells, which resulted in mushrooming of irrigation borewell and the consequent effect of cumulative interference in increasing negative externality. The proportion of cost of failed well was the lowest in the case of shared well farms (30%) due to non violation of isolation distance and reduction in proliferation of irrigation wells.

The average depth of borewell was 717 feet in the case of drip farms connected to narrow spaced crops, 342 feet in drip farms connected to broad spaced crops and borewell recharged farms and was 274 feet in shared well farms. The estimated unit cost by NABARD for this depth worked out to Rs. 96888, Rs. 41162 and Rs. 32656. The percentage deviation in estimated economic investment on irrigation borewell from NABARD's unit cost ranged between -16.57 to -63.54 percent. Hence, the funding agency like NABARD needs to consider the probability of well success and failure while estimating the unit cost of irrigation well in hard rock areas (Table 2). The economic investment on irrigation borewell was Rs. 265806, Rs. 112811, Rs.103581 on farms with broad spaced crops, borewell recharged farms and shared well farms. Thus, the probability of well success played a crucial role in the overall cost of drilling and casing of irrigation well (Table 2).

CONCLUSIONS

The probability of well success has reduced over the years. Improvement in the probability of well success could save 70 per cent of the investment on drilling and casing of borewells. The NABARD's current procedure of providing unit cost of borewell is lower by about 60 percent, since it ignores the weighted probability of well success and failure. The methodology adopted in this study will benefit NABARD and in turn scores of small and marginal farmers in availing appropriate unit cost for borewell.

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