



## Rainfall Uncertainty and Drought Proofing Strategies by farmers in Southern India

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**ABSTRACT:** Droughts are a common occurrence in semi-arid areas and their frequency and intensity is expected to increase further with increasing variability in rainfall distribution. Based on a study of 120 farmers from 4 districts in Karnataka and Tamil Nadu, this paper identified the range of measures farmers adopt in response to droughts. Despite significant negative externalities, farmers assign higher priority to drilling new wells rather than investing in water conservation structures or demand management strategies. Among the different strategies followed, adoption of drip irrigation and purchase of tanker water for providing life-saving irrigation to perennial crops yield the highest financial return. Expansion of micro irrigation and reuse of municipal waste water are suggested as drought mitigation strategies.

**Keywords:** Rainfall variation, drought proofing, well investment, cost of water, micro irrigation, waste water reuse

### 1. Introduction

Drought has been a common phenomenon and its occurrence is not a shocking one. For a period 1871 to 2002, India experienced 22 droughts, of which 5 were severe. Drought is a normal feature of climate, and it will keep occurring at intervals. Meteorologically,  $\pm 19\%$  deviation from the long-term mean is considered as normal whereas deficiency in the range of 20-59% is considered as moderate drought and more than 60% is severe drought (Samra, 2004).

To manage droughts, the Central and State governments have implemented several measures like construction of larger reservoirs, water harvesting structures, designing institutional arrangements for drought monitoring (like Indian Meteorological Department), early warning, relief measures and so on. There are essentially two major drought proofing measures on a long-term basis: [1] harness water through further spread of irrigation, groundwater and watershed development; and [2] evolve and spread drought resistant and short duration high yielding varieties (Ahluwalia 1991). In recent years, augmenting groundwater through artificial recharge and watershed development programs has also assumed importance (Palanisami and Kumar 2006).

Keeping recurring droughts one side and farmers' responses on the other, this paper aims to examine drought proofing measures adopted by farmers in response to recent

drought of 2015-16 and the effectiveness of these measures. Such an exercise can help the planning process for tackling future droughts in different parts of the country.

### 2. Data and Methods

Our study relied on field survey conducted during May-August 2017 in two districts (Coimbatore and Tirupur) of Tamil Nadu and two districts (Tumkur and Bijapur) of Karnataka. The data pertained to the agricultural year 2015-16 and the survey covered 30 well irrigated farmers in each district. Water availability at farm was calculated by collecting water in bucket with timer and the same was calculated for one hour which again multiplied by number of hours water was pumped in a day. Some of the details available from recent studies in selected locations in Karnataka were also utilized (Palanisami and Doraisamy 2016; Water Technology Centre 2015; Palanisami *et al.* 2015).

### 3. Rainfall analysis by Gamma distribution

Variation in rainfall was the key factor contributing for the droughts and farmers interventions in managing the crop production. The annual average (normal) rainfall of the Coimbatore, Tirupur, Tumkur and Bijapur districts are 746, 700, 578 and 744 mm respectively. The coefficient of variation in rainfall was also high among the districts indicating high variability (risk) in getting the required rains during the crop seasons. In order to get an idea about the

probability of getting the normal annual rainfall, the probability distribution of annual rainfall was analysed using the gamma distribution:

$$f(x) = \frac{\lambda^k x^{k-1} e^{-\lambda x}}{\Gamma(k)}, \lambda, k > 0$$

where  $k$  and  $\lambda$  are the parameters of the distribution that are estimated from the observed rainfall data from 1970-71 to 2015-16. The mean rainfall and its standard deviation are estimated by the formula

$$\text{mean} = \frac{k}{\lambda}$$

$$\text{Standard Deviation} = \sqrt{\frac{k}{\lambda^2}}$$

The quantity of rainfall, say  $x_\alpha$  for which  $Pr\{\text{Rainfall} \geq x_\alpha\} = \alpha$  is obtained from the equation

$$\int_0^{x_\alpha} f(x) dx = 1 - \alpha$$

The values of  $x_\alpha$  for various values of  $\alpha$  are obtained using the MATLAB. The results indicated that the probability of getting the mean annual rainfall will be only 30% thus confirming that it is unlikely that the region will be enjoying the normal annual rains every year (Table 1). The variability in rainfall is one of the main reasons for abandonment of the rainfed agriculture by the farmers which ultimately resulted in the intensification garden land agriculture where wells are the primary source of irrigation. Also over years, farmers have resorted to various drought proofing measures in order to sustain their livelihoods. Hence analysis of farmers response to droughts is considered important.

**Table 1** Expected quantity of rainfall (mm) for a 30 % probability of exceedance

Districts	Rainfall (mm)
Tirupur	698
Tumkur	742
Bijapur	570
Coimbatore	742

#### 4. Drought Proofing: Farmers response

##### 4.1 Drought proofing measures adopted at farm level

Out of the 120 farmers surveyed, 67% reported that they invested in drilling additional bore wells followed by adoption of drip irrigation to conserve water; 20% followed

the traditional flood irrigation method but reducing the quantum of water they normally used to irrigate; about 10% farmers followed the fields as the wells dried up; and rest of the farmers adopted organic farming along with drip and mulching. Some farmers were forced to cut down 15 to 20% of the existing (old) coconut trees in order to adjust water use among the productive trees. Regarding the cropping pattern, of the total sample, 60% cultivate perennial and annual crops (such as arecanut, coconut, grapes, sugarcane, banana etc.) while the rest grow mostly vegetables, onion and maize.

##### 4.1.1 Supply management

Majority of the farmers expressed that their water level dropped significantly resulting in less number of pumping hours. From the normal pumping of 7 hours/day, it dropped to 2 hours/day and then reduced further to 1 hour/day.

Most of the farmers in our sample invested in additional bore wells with depths ranging from 700 to 1000 feet. Additional well drilling is the measure farmers always do to manage the water scarcity. The rate of well failure ranged between 70 and 90%. Even then, farmers felt that some additional supplies will be useful to save the standing crops. As a consequence, the market for well drilling machines increased significantly. The annualized cost of well investment ranged from Rs.18,500 to Rs.52,500 per farm (Table 2).

Average area irrigated during the drought year was about one-third of the farm area. Even with drip, only marginal increase in area irrigated was observed and this might be due to water scarcity where farmers experienced difficulties in allocating water among the standing perennial crops such as coconut, arecanut, sugarcane and banana. Farmers who used to grow only seasonal crops like vegetables had reduced the area to almost one-fourth of the farm area. Cost of irrigation water ranged from Rs.2.1 to Rs.9.2 /m<sup>3</sup> under minimum well water pumping situation compared to Rs.1.6 to Rs.6.2/m<sup>3</sup> under normal or maximum well pumping situation.

The water availability varies from bore well to bore well depending on the volume of water delivered during pumping with an average capacity of 7.5 to 10 HP submersible motors. Among the sample farmers with in different pumping categories (like 1 inch to 2.5 inches delivery pipes), the average water supply worked out to 6,010 litres per hour.

Farmers in Coimbatore and Tirupur districts made attempts to buy water from urban areas through tankers. The cost of water from tankers ranged between Rs.1,500 and Rs.2,000 for 12,000 litres (Rs.125 to Rs.150/m<sup>3</sup>). It required about 4 trips to provide one irrigation for one acre of coconut trees.

Particulars	Tumkur	Bijapur	Coimbatore	Tirupur
Rainfall during 2015-16(mm/year)	382.0	377.0	257.6	254.3
Average farm size (acres)	4.2	4.6	5.6	6.3
Maximum depth of existing well (feet)	690	570	710	650
No. of new wells drilled/farm during the year	2	1	2	2
Average depth of new wells (feet)	800	750	1000	1000
Well failure rate (%)	70	65	90	90
Capital cost per well (Rs)	65,000	60,000	80,000	85,000
Annualized cost (AC) of new well (Rs/year)	40127	18520	49387	52474
Minimum water pumped ( m <sup>3</sup> /year)	6374	8660	5980	5650
Maximum water pumped ( m <sup>3</sup> /year)	9486	11475	8750	8270
Average water pumped (m <sup>3</sup> /year)	7930	10067.5	7365	6960
Average area covered with flood irrigation (acres)	1.4	1.8	1.3	1.2
Average area covered with drip irrigation (acres)	2.2	2.8	2	1.9
Cost of water (Rs./m <sup>3</sup> ) with minimum water pumped	6.30	2.14	8.26	9.29
Cost of water (Rs./m <sup>3</sup> ) with maximum water pumped	4.23	1.61	5.64	6.35

Source: Field survey.

#### 4.1.2 Demand management

Demand management measures are done in all the possible ways to manage the drought situation. About 80% of the farmers used drip systems and the capital cost of drip system ranged from Rs.22,000 to Rs.40,000 per acre depending on the crop and inter-crop spacing. 65% of the farmers have not availed any subsidies and invested in drip mainly due to acute water scarcity, 5% have applied recently for subsidy and are waiting while the remaining 30% have benefited from government subsidy which ranged from Rs.10,000 to Rs.15,000 per acre.

In several cases, farmers applied plastic and organic mulches to minimizing evaporation losses. As such, field observations and discussions with farmers indicated that about 2-5% water saving is possible due to these practices. Trenches were made with a length of 24 feet, width of 3feet and a depth of 2.5feet. The cost of mulching ranged from Rs.5,000 to Rs.7,500 per acre. Other practices adopted by farmers include organic practices like use of cow dung based manures and panchakavya spraying to avoid pest attack and diseases.

Reduction in applied water was observed in all crops studied. This was mainly due to the adoption of drip irrigation. The reduction ranged from 26% in grapes to 38 % in pomegranate and sugarcane. In the case of onion, maize

and tomato, the reduction was 25%, 34%, and 36% respectively.

Cost of water from different investment measures was worked out. The results show that the most cost effective measures were recharging bore wells and investing in percolation ponds. Demand management measures like adoption of drip irrigation has comparatively lower cost vis-à-vis options like tanker water purchase (Table 3).

**Table 3.** Cost of water under different drought proofing measures

Drought proofing measures	Cost (Rs./m <sup>3</sup> )
Recharge bore well	1.7
Percolation ponds (PP)	2.8
Drip irrigation	3.3 to 5.0
Additional (new) borewell	4.5 to 6.5
Farm pond	5.5 to 8.5
Farm trenches	20.8
Water purchase from urban areas	125 to 150
Waste water reuse	1.5 to 5

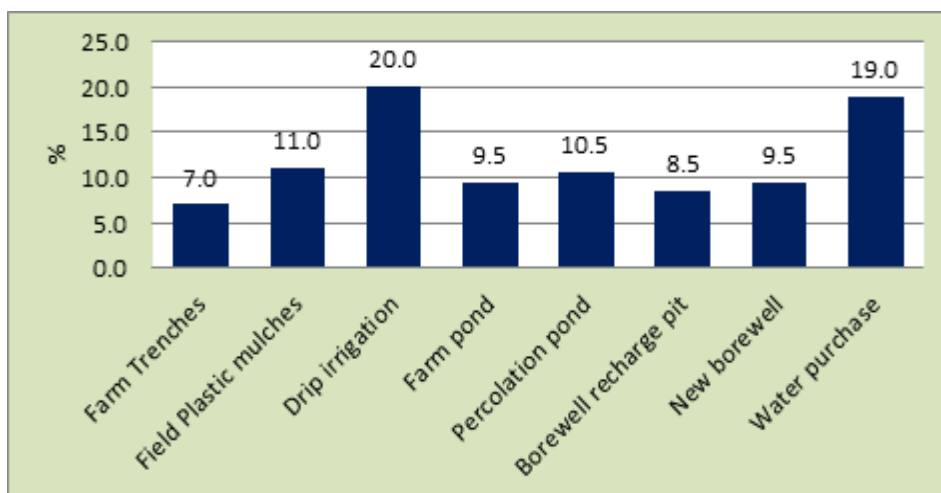
While investing in a new borewell promises reasonably cost effective water, it should be noted that each new well pumping water would lead to further exploitation of the aquifers. In areas where the level of groundwater Development is classified as “critical” or “over-exploited”, well drilling is not advised.

**4.2 Comparing different drought proofing measures**

Given the investment in different drought proofing measures, it is important to examine their relative merits in terms of benefits, rate of return and constraints which can help for planning the up-scaling of these drought proofing measures (Table 4).

**Table 4.** Comparison of different drought-proofing measures

Measures	Current Performance	Constraints for Upscaling
Farm trenches	Adoption: Very low. Benefit: Increase in yield 3 to 5%	The technology was not accepted by the farmers. They say it is disturbing the field plot layout hampering tractor movement for inter cultivation operations.
Field plastic mulches	Adoption: Low. Benefit: Increase in yield 5-8%	Initial cost high; should be replaced in each season due to poor quality of plastic
Drip irrigation	Adoption: Moderate. Benefit: Yield increase 12-15%	Initial cost high; poor knowledge on maintenance of the system
Surface water harvesting structures – farm ponds	Adoption: Moderate. Benefit: Improvement in water table depth by 3-4 feet; 1-2 supplemental irrigation provided for 1-2 acres.	Initial investment is high. Not direct use during droughts due to no rains. Silting is the major problem due to ploughing fields in each season.
Percolation ponds	Adoption: By group of farmers/community. Benefit: Helps recharge groundwater by 3-4 feet in wells located in a 0.5 km radius	No direct use during drought due to no rains. Silting is the major problem. More evaporation losses.
Borewell recharge pits	Adoption: Low to moderate. Benefit: Water table increased 2-4 feet post monsoon season; average area increase 1 to 1.5 acres with ID crops	Initial investment high; Location of the borewells and pits different
New bore well	Adoption: More extensively done. Benefit : Can cover 1-2 acres	Investment high and well failure is also very high
Water purchase from tankers	Adoption: Practiced in coconut farms due to failure of existing wells. Benefit: 2-3 life saving irrigation to existing trees	Water costly; even then, water not available in peri- urban and urban areas for transport through tankers



**Fig 1.** Comparison of rate of returns across drought proofing measures



## 5. Conclusion and Recommendations

The probability of getting the mean annual rainfall will be only 30% thus indicating the uncertainties in getting adequate rains every year. Hence farmers resorted to several supply augmentation measures. Most of these supply side measures (percolation ponds, farm ponds, recharge wells etc.) are inter-linked and have impact during post rainy seasons. However, during droughts, vast majority of farmers' investments are made for drilling new boreholes for instant supplies. The cost of well drilling works out to be Rs.180 crores in Coimbatore district and Rs.100 crores in Tirupur districts thus showing capital formation in agriculture is increasing through investments in borewells. This investment behaviour indicates that farmers always and in all ways make this every year. However, given the free farm power regime and tendency for over-pumping, this results in negative externalities in terms of high well failure rate (90%) and increasing cost of groundwater which will be prohibitive for agriculture production.

One area of interest will be how to use the treated domestic waste water directly for irrigation or through recharging groundwater aquifers. Given the quantum of domestic waste water generated in urban areas is as high as 67 million m<sup>3</sup> (Mm<sup>3</sup>) in Coimbatore and 39 Mm<sup>3</sup> in Tirupur districts, it is possible to focus future investments in waste water treatment processes. ITP studies on the prevalence of waste water irrigation in Gujarat (Palrecha et al. 2012), Maharashtra (Palrecha et al. 2016), Karnataka (Gupta et al. 2016) and Tamil Nadu (Leaf Society 2016) found that more than 50,000 hectares are already being irrigated by farmers using untreated municipal waste water. Regarding demand management measures, use of drip irrigation is common but a major challenge of inadequate water supplies from bore wells remains. As a result, sub-optimal level of irrigation water application was observed. Overall, most of the farmers growing perennial crops indicated that they will reduce the area by 20 to 30% by cutting the old trees and will start diversifying their farming activities.

Given the scope for expanding micro irrigation, continuing public support for the wider adoption and promotion of micro irrigation technologies is warranted. Financial institutions may be geared up to offer special loans for the installation of drip and sprinkler irrigation. Also special purpose vehicles like GGRC models can be introduced at state level for effective spread of MI (Palanisami and Suresh Kumar, 2017).

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