# Exploring The Farm Level Irrigation Innovations to Cope Water Scarcity in Kerala

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## ABSTRACT

*Though Kerala is considered as a water rich state, the data on well water levels shows that the depth from ground to well water level is increasing across the state. Management of declining groundwater resources includes improving resource availability and practicing optimum use thorugh increasing access of resources. A field level study was conducted in a water scarce region of Kerala state (Chittur Block) to understand the long term and short term strategies by farmers to adjust with groundwater scarcity. The measures to improve resource availability include enhancing extraction and adopting water conservation measures. Some of the adaptation strategies like digging of new bore wells are not ecologically sustainable whereas measures like installation of drip irrigation system are capital intensive. Adoption of low cost conservation measures like mulching, taking water harvesting pits and coconut husk burial were limited among the sample farms. There could be wide promotion of conservation measures with monetary support and awareness creation. Considering common pool natural resource status of groundwater, conservation measures could be treated as ecosystem services and monitory support for them could be a policy option.*

**Key words:** *Water scarcity; Adaptation strategies; Irrigation innovation; Conservation measures; Awareness creation;*

In the context of global warming and resultant climate change phenomena, water scarcity is predicted to be the worst in arid and semi-arid tropical region (*IPCC, 2014*) and populous countries like India (*Kumar et al., 2005*). Groundwater resource of India is alarmingly declining due to excessive extraction (*Tiwari et al., 2009; Rodell et al., 2009* and *Shah, 2009*). Irrigation sector being the major consumer, farmers have effected behavioural changes in the management of water resources. Adaptation usually refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity (*Smit and Wandel, 2006*). Adaptation strategies are influenced by resource status, awareness and extent of scarcity and include macro (policy) level and micro (individual) level actions (*Mendelsohn, 2000*). Micro-level adaptations are practiced by individual farmers in their own farms. In the context of imminent groundwater scarcity, scientific validation of micro-level adaptation strategies could improve efficiency of such measures. Feasibility analysis of such adaptation measures can identify sustainable ones to frame policies to support their implementation while the opposite ones have to be discouraged. A micro-level study among farmers in Chittoor block of Palakkad district in Kerala was conducted to understand the farm level adaptation innovations in irrigation sector.

## METHODOLOGY

The secondary data were generated with the help of the statistics on irrigated area and level of water scarcity is drawn from sources like Department of Economics and Statistics, Kerala and Central Ground Water Board (CGWB). The primary data were collected from the farmers of Chittur CD Block of Palakkad district in Kerala. Chittur block was purposively selected as the block in the state was categorized as 'Overexploited' based on the stage of groundwater development. The blocks with groundwater extraction rate more than the annually replenishable resource availability is classified as 'Overexploited' (*CGWB, 2007*). Climate of the region is similar to rain shadow region of Tamil Nadu, with mean annual rainfall of 1758 mm (*CGWB, 2007*). Well failures and deterioration of well water quality are common problems in the region. On an average, the well water level in the region is declining at a rate of 0.4 m/year (*CGWB, 2007*). During 2000-2004, the Block was declared as draught affected. Though groundwater development is restricted in the region, number of abstraction structures including private bore wells is on the increasing trend.

The study area includes water scarce regions of the Block (Kozhinjampara, Eruthenpathy, Vatakarapathy and Perumatty Grama Panchayats). An exploratory study was conducted among 30 irrigated farms which were randomly selected from the list available at the respective *Krishi Bhavans*. Primary data were gathered through personal interview method using pre-tested structured interview schedule and direct observations. Farm level data on groundwater resource use pattern, irrigation practices, crops cultivated and management practices were analysed to know the changes due to water scarcity over a period of 15 years (2000 to 2015).

## RESULTS AND DISCUSSION

Kerala has been considered as a high rain fall region with rich water resources. The average rainfall of the state is 2943 mm/year, but with high variability (*Rao, 2008*). Surface water comprising rivers and fresh water lakes is the major source of water in the state (*Lathika, 2010*). Kerala is blessed with crisscross connection of 44 rivers, but most of them are small rivers and only four are classified as medium rivers. All rivers in the state are rain-fed, which means that Kerala is heavily dependent on the monsoon. The per capita water availability of the state (1248 $m^3$/person/year) is less than many of the dry regions like Rajasthan (1829 $m^3$/person/year) and it is declining over the years (*Devi et al., 2015*) as the population increases. Water requirement of 1700 $m^3$/capita/year is the threshold level accepted by Central Water Commission, India (*CWC, 2005*).

The figures of the water availability in Kerala prepared by several agencies are not converging. As per the estimates of the state Public Works Department (1974), all 44 rivers together yield 77.9 $km^3$ of water, of which about 70.2 $km^3$ is available in the state, with a total utilizable water yield of 42.7 $km^3$. According to Central Water Commission data, the water from rivers has decreased to 57.63 $km^3$. *Lathika (2010)* estimated that the replenishable water resource of the state as 70.17 $km^3$, of which about 42.67 $km^3$ could be put to beneficial uses (Table1). Major share of this (34.77 $km^3$) is surface flow and the remaining (7.90 $km^3$) is replenishable ground flow.

Major share of water use (72%) is in agricultural sector, followed by industrial (24%) and domestic (4%) sectors. Although the figures for the annual water balance indicate a surplus of about 8.5 $km^3$, the state faces acute water stress during summer months amounting to 7.1 $km^3$. This indicates that the summer period receives only about 15 per cent of the annual water, whereas the demand during this period is as high as 75 per cent of the annual requirement (*GOK, 2013*). The total water demand during the summer months is about 21.5 $km^3$, whereas the available supply is only 14.3 $km^3$, posting a deficit of about 7.1 $km^3$, even after accounting for 5.5 $km^3$ of surface water available in dams.

Despite high rainfall, the water retention capacity in Kerala is very low, due to the peculiarities of soil, high gradient, land-use changes and socio-economic aspects. Run-off losses are very high (40%). The surface runoff and ground-water recharge are lower than other states like Tamil Nadu and Rajasthan. Hence, though the rainfall is high, the annual surface water and

**Table1. Source wise supply and sector wise use of fresh water resource in Kerala**

| Source | Source wise supply ($km^3$) | | Sector wise use ($km^3$) | | |
|---|---|---|---|---|---|
| | Quantity supplied ($km^3$) | % of total | Sector | Quantity used ($km^3$) | %of total |
| Surface water | 34.77 | 81 | Agriculture | 19.2 | 72 |
| | | | Domestic | 1.1 | 4 |
| Groundwater | 7.90 | 19 | Industry | 6.4 | 24 |
| Total | 42.67 | 100 | Total | 26.7 | 100 |

(*Source: Compiled from Lathika, 2010 and GOK, 2013*)

**Table 2. Source wise net irrigated area and crop wise gross irrigated area in Kerala (2013)** (*Source: GOK, 2014*)

| Crop | Crop wise gross irrigated area | | Source wise net irrigated area | | |
|---|---|---|---|---|---|
| | Gross irrigated area (ha) | % | Source | Net irrigated area (ha) | % |
| Paddy | 154029 | 33 | Canals | 83175 | 21 |
| Coconut | 166380 | 36 | Tank | 43558 | 11 |
| Banana | 46312 | 10 | Wells | 154485 | 39 |
| Arecanut | 34482 | 7 | Private ponds | 42857 | 11 |
| Other crops | 67117 | 14 | Other sources | 71793 | 18 |
| Total | 468320 | 100 | Total | 395868 | 100 |

groundwater potential is very low (*Rao, 2008*)**.** Even though the groundwater development status of the state is estimated as 47 per cent, majority of the wells in the state are getting dried during summer months.

As per the national water policy, irrigation water assumes priority next only to drinking water. As per the assessment of the Directorate of Economics and Statistics-Kerala, net irrigated area and gross irrigated area of the state are 3.96 lakh ha and 4.58 lakh ha respectively (Table 2). Wells are major source (39%) of irrigation followed by canals (21%) and tanks (11%).

Among the crops irrigated, coconut occupies major share (1.66 lakh ha) followed by paddy (1.5 lakh ha) and banana (0.46 lakh ha) (*GOK, 2014*). Out of 3.96 lakh ha of net irrigated area, 1.5 lakh ha is irrigated using water from wells. The state could achieve only a marginal increase in the net and gross irrigated area over the years. Presently 17.67 per cent of gross cropped area is under irrigation whereas 19.34 per cent of net sown area has irrigation facility. There was slight decline in the net irrigated area in the year 2012-13 compared to previous year. Gross irrigated area also decreased by 6.7 per cent during the same period. The irrigation efficiency of the state (20%) is less than the national average of 30 per cent (*GOK, 2014*). A major share (50%) of irrigation water is supplied from groundwater resources (*GOK, 2014*). The ground-water potential of Kerala is very low as compared to that of many other states in the country due to the physiographic reasons like elevation (*CGWB, 2007*).

Increased dependence on well water is resulting in declining of water level in wells. Kerala is one of the states with high well density in the country. The well density of the state varies from 200/km$^2$ in coastal regions through 150/ km$^2$ in midland to 50/km$^2$ in high lands (*GOK, 2014*). CGWB (Central Ground Water Board) is maintaining nearly one thousand observational wells (941 as of 2015) in the state for monitoring water level. Analysis of the data on well water level observations of CGWB, showed that the number of wells having deeper levels of water table is increasing over the years (Table 3). Wells, wells with water level 5-10 meter below ground level was 33 per cent during 2010-11which rose to 43 per cent during 2013-14. Similarly, the proportion of wells with water level 10-20 mbgl has increased from 7 per cent to 13 per cent. Correspondingly, the proportion of wells with <2 mbgl and 2-5 mbgl has declined.

**Table 3. Distribution of CGWB observational wells in Kerala based on water level during 2010-11 and 2013-14**

| Wells with water level (mbgl) | Percentage of wells | |
|---|---|---|
| | During 2010-11 | During 2013-14 |
| <2 | 26 | 11 |
| 2-5 | 33 | 32 |
| 5-10 | 33 | 43 |
| 10-20 | 7 | 13 |
| >20 | 1 | 1 |
| Total | 100 | 100 |

(*Source: Compiled from CGWB, 2011 and CGWB, 2014*)

*Coping and adaptation innovations:* The strategies to manage water scarcity in the study area were categorized into two broad types viz., those measures which could improve the resource availability (supply) and those which could reduce the demand for water (judicious use) (Table 4). The first category includes exploration of groundwater through digging new bore wells and intensive extraction through compressor cum motors which were effective in low yielding wells. Water conservation activities like taking storage pits to reduce run-off and mulching the field with coconut leaves and coconut husk burial were also adopted. The measures to reduce demand for water include adoption of improved irrigation methods like drip irrigation, shifting from water intensive crops to other crops and shifting to dairy farming. Summer fallowing and abandoning cultivation were also noticed.

**Table 4. Farm level strategies to manage groundwater scarcity and their adoption level (%)**

| Measures for improving availability of groundwater | | Measures for reducing demand for water | |
|---|---|---|---|
| Measures | Adoption (%) | Measures | Adoption level (%) |
| Digging new bore wells | 40 | Summer fallowing | 66 |
| Intensive extraction with moter compressor | 33 | Adopting drip irrigation | 53 |
| Mulching | 10 | Crop shifting | 30 |
| Taking water harvesting pits | 10 | Shifting to animal husbandry | 10 |
| Coconut husk burial | 7 | Abandoning cultivation | 7 |

*Strategies for improving supply of groundwater*

*Digging new wells :* Open wells are the major source of irrigation in Kerala, including the study area. But, consequent to the water table decline, open wells are becoming defunct. Out of the 33 existing open wells, majority (55%) were reported as completely dry during previous summer season. Deepening of open wells is not generally adopted and the farmers started exploring deeper sources, shifting to bore wells. The tendency gained momentum corresponding to the water table decline and the bore well density dug after 2000 is reported as 90 per km$^2$ (Table 5). The well depth also increased correspondingly by 70 per cent. The average depth of wells dug before 2000 was 93 m which has increased to 158 m. But, *CGWB (2007)* suggests maximum feasible groundwater depth in the region as only 200 m. So the strategy of digging more and more bore wells and deepening is not ecologically sustainable. This obviously will lead to further lowering of groundwater table. In Northern parts of the country excessive groundwater extraction has resulted in an alarming situation of water scarcity (*Tiwari et al., 2009*).

**Table 5. Particulars of bore wells among the sample farms**

| Particulars | Mean value |
|---|---|
| No. of bore wells dug after 2000 (no./km$^2$) | 90 |
| Average depth of bore wells (m) | |
| dug before 2000 | 93 |
| dug after 2000 | 158 |
| Percentage increase in well depth | 69 |
| Cost of drilling new bore well (Rs./no.) | 76200 |
| Cost as share of gross farm income (%) | 37.33 |

The economic burden due to these adaptation strategies was also correspondingly high. The cost of digging one new bore well was Rs. 33000 including water lifting mechanism during 2000, which has increased to Rs. 76200 during 2015 indicating 130 per cent increase. On an average, 37.33 per cent of gross farm income was diverted for digging one bore well. The risk associated was also reported to be very high as failed attempts are becoming more frequent.

*Intensive extraction technology:* The yield of the bore wells is also reported to be declining over the years and the farmers further increase their investment for adapting to alternate extraction technologies. Most of the farms (63%) are using compressor cum motor which is suitable for low yielding wells. The cost is around Rs. 25000/- per one compressor cum motor. The pumping from such bore wells are done throughout the day and water is collected in the defunct open wells in the farms, utilising them as storage structure. Subsequently, water is pumped from the open wells for irrigation, making the level of energy consumption double. The present irrigation electricity subsidy policy (fully subsidized) is favouring this method. There are similar reports of intensive groundwater extraction from regions like Punjab and Haryana facilitated by free electricity supply (*Jeevandas et al., 2008*). The groundwater irrigated area is in stagnation in northern plains of the country due to the resource limitations (*Vaidyanathan, 2013*). Thus, extensive extraction strategy cannot be a policy option in the long run. Moreover, social cost of free electricity and environmental damages are also having to be considered. Groundwater pumping with electricity and diesel accounts for an estimated 16-25 million mt of carbon emission, *ie.*, 4-6 per cent of India's total emissions (*Shah, 2009*).

Water conservation measures like taking conservation pits, mulching the field and burial of coconut husk are effective for in-situ water conservation. Some of the farmers are adopting these methods (water conservation pits – 17 per cent farms, mulching with coconut leaves – 17 per cent farms and coconut husk burial – 10 per cent farms). On an average 10 pits were taken per hectare, incurring a cost of Rs. 20000 (cost incurred per pit is Rs. 2000/-). These measures are helping to improve water availability in the long run. But the farmers' awareness about these conservation measures was very low. There should be awareness creation programmes among farmers to disseminate the long term benefits of in-situ water conservation.

*Demand management strategies:*

*Crop shifting :* The soil type in the study area is mainly black cotton soil and the major crops in the area has been irrigated crops like sugarcane and vegetables (Table 6). Consequent to continuous rainfall deficit from 2002 to 2005 there was steep fall in the production of sugarcane. This led to closure of the sole sugarcane processing factory at Chittur (2002, 2003 and 2004 declared as draught years (*CGWB, 2007*). Gradually farmers shifted to crops like coconut and mango which is grown mainly as rain-fed crops. Currently, coconut is the major crop occupying about 70 per cent of garden land area. The average age of coconut plants in the area is 14 years, reflecting the relatively new plantation. Crop diversity in the garden land decreased with more and more seasonal crops being replaced by coconut. Apart from water scarcity (the major reason), high labour cost, price fluctuations and production uncertainties are also cited as reasons for shift in cropping pattern. Upland paddy cultivation was practiced by some 14 per cent farmers. Presently there is no upland paddy farming the area. Uncertainty about water availability and fear of resultant crop failure was the cited reason to this shift.

**Table 6. Cropping pattern changes in garden land during 2000 - 2015**

| Major crops | Percentage of cropped area | |
|---|---|---|
| | (During 2000) | (During 2015) |
| Coconut | 39.4 | 70.4 |
| Sugarcane | 20.4 | 0.0 |
| Vegetables | 10.1 | 6.5 |
| Banana | 5.0 | 8.0 |
| Fodder grass | 1.2 | 10.9 |
| Paddy | 13.9 | 0.0 |
| Other annual crops | 7.6 | 2.0 |
| Other crops | 2.4 | 2.2 |
| Total | 100.0 | 100.0 |

Area under fodder crops has increased during this period as a major intercrop in coconut gardens. This increased area under fodder crops can be linked with adaptation strategy of shifting to cattle rearing. The average number of cattle per farm was decreased from four to three due to labour scarcity and low profitability. However, farms with severe water scarcity were abandoning crop cultivation and they were making their livelihood by cattle rearing. In order to reduce market dependence for feed, such household have started raising fodder crops as intercrop in coconut garden.

*Water use efficient technologies :* Flood/basin irrigation has been the most popular method of irrigation in Kerala , which is very poor in efficiency (20%) and has high transmission losses. Presently, about 57 per cent of farms have shifted to drip irrigation covering around 55 percentage of garden land area (Table 7). This shift has helped them for either bringing in more area under irrigation or improving the water availability for the existing crops. The capital cost of installation of drip system was about Rs. 80000/ha. There is 50 per cent subsidy on capital cost with 35 per cent central and 15 per cent state government contribution.

**Table 7. Adoption of drip irrigation among sample farmers in the study area**

| Particulars | Value |
|---|---|
| Farms adopted drip irrigation (%) | 57 |
| Average garden land area (ha) | 1.7 |
| Share of garden land area under drip irrigation (%) | 55 |
| Cost of drip irrigation (Rs./ha) | 79830 |
| Gross farm income (Rs./ha) | 120000 |
| Cost as share of gross farm income/ha (%) | 66.66 |

*Kumar (2012)* studied the comparative water use efficiency among drip adopted and non-adopted banana plantation in Tamil Nadu and reported that drip irrigated farms have better water use efficiency and higher yield. Financial constraint was the major reason for non-adoption in the remaining areas. Delay in getting subsidy and higher cost of installation charged by the government approved agencies compared to local agencies were other constraints pointed out by farmers in installation of drip irrigation.

The farm level strategies in water management often resolve around the scientific information and awareness on the problem. However, the respondents in this, considered water scarcity as a macro-level problem and expected the state to take the initiative .This highlight the need for farm level programme on water literacy. At the same time the role of state is also underlines for macro management. Mapping of aquifers and estimating water resource available in aquifers is necessary for water budgeting and planning. Local governments can judiciously distribute the renewable groundwater among different sectors and stakeholders. Aquifer based common pool resource approach and participatory management strategies are the key elements to be included in combating water scarcity in India (*Kulkerniet al., 2015*)

## CONCLUSION

Considering imminent water scarcity, ensuring availability of irrigation water is a must for sustainability of the economy and food safety. In the context of declining groundwater resource, adoption of strategies to improve the availability and utilization efficiency is indispensable. Groundwater is a common pool natural resource with scope for enhancing its availability through improved recharge. Farmers can improve the recharge through adopting conservation measures and improved irrigation methods. Lack of proper awareness is a major constraint faced by farmers in adoption of these measures. Policy support is essential for feasible conservation measures and efficient utilization measures. Groundwater enhancement has to be considered as an ecosystem service and therefore monetary support could improve their micro-level adoption.

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