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POLICY BRIEF - 36

Investments on Groundwater Conserving Technologies and its Implications for Policy in Semi-Arid Regions of Karnataka

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Introduction

Karnataka, a typical semiarid state relies heavily on groundwater for agriculture and domestic uses and it is one of the most water starved states in India. In areas where there is no assured source of surface irrigation, the demand for groundwater irrigation is spiralling manifold, while supply is diminishing due to its overexploitation. Thus, there has been an intense pressure on groundwater extraction leading to unsustainable exploitation. Groundwater remains a critical and fast depleting resource especially in the eastern and central dry zones of the state (Santhosh et al 2013). Since imposing the market-based instruments and institutional approaches to bring sustainable use of groundwater are infeasible from the view point of political economy, however, the individual farmers have technological options to use water sustainably. Many farmers are investing on innovative irrigation technologies such as 1) micro irrigation (MI), 2) piped irrigation, 3) MI with plastic mulching, 4) pond lining with plastic film to store water as demand management measures, while supply management through groundwater recharge is neglected. However, at macro level recharging groundwater through filling tanks with urban sewage water is progressing in eastern dry zone through the efforts of GOK.

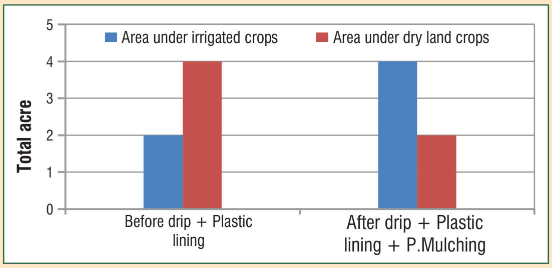
Focus: The focus of this brief is to evaluate the investments on demand management strategies on groundwater conservation and use pattern. Using partial budgeting technique, the economic worthiness of incremental changes in cost and revenue associated with the adoption of these technologies is evaluated. The required data has been generated through case studies and reviews.

In Karnataka, the Central and Eastern Agro-Climatic Zones are too much groundwater dependent, where groundwater scarcity has emerged on a large scale due to its over-mining through deeper bore-wells. In response to this, there has been an increasing trend in the investment on improved water storage structures, micro-irrigation and plastic mulching. Due to failure of wells and low discharge of water in the bore-wells, farmers are turning towards adopting water efficient technologies, as investing on drilling deeper bore-wells involve high risk of striking water (Kiran Kumar, 2013). In this regard, a modest attempt is made to evaluate the incremental changes on three scenarios of technologies used by the farmers through case studies in Chintamani Taluk of Chikballapur district under Eastern Dry Zone.

Scenario-I. Investing on Micro Irrigation

This case study pertains to a typical groundwater starved hard-rock area of Chintamani Taluk of Chikballapur district. The Kurtahalli village comprising more than 100 households depends on bore-well irrigation for agriculture. The selected farmer owns 6 acres of land facing acute shortage of groundwater for irrigation due to failure of bore-wells. Out of the 4 bore-wells, one is functional with a depth of 1300 ft discharging water about 1.2 inches or 1200 gallons/hr and another three bore-wells are defunct. Hence, the farmer introduced micro irrigation along with other changes to cope with water scarcity. Before introducing the changes on the farm, over 66 % of the area was under dry land crops (food crops like finger millet, perennial crops like mango and coconut) and 34% under irrigated crops like vegetables and coconut. But, after introducing Micro Irrigation (MI) along with plastic lined technologies, the irrigated area increased substantially (Fig-1).

Fig-1. Changes in Irrigated Area Before and After Introduction of Drip + Plastic lining +Plastic mulching



Source: Computed from the case study data

Since tomato is highly profitable cash crop in the area, farmers are making smart investments on drip and other technologies to maximise profit. The farmer has incurred an amount of Rs 52000/acre towards installation of drip for tomato without subsidy (Table-1). Generally, the cost of drip irrigation varies with spacing followed and the quality of material used. Out of the total investment, the field unit components of drip accounts for major share of total investment (94 %). The economic worthiness of incremental changes due to introduction of drip is evaluated using the partial budgeting approach.

Marginal approach

The capital investments on drip is amortized to arrive at the annual cost of irrigation considering life span of drip system as 5 years with 5 % interest rate as the opportunity cost of capital. The yield difference before and after drip irrigation is considered for computing the incremental returns due to drip irrigation (table-2). The debit side reflects the incremental or added cost due to drip irrigation and decrease in return if any, while the credit side reflects the reduction in cost and incremental returns due to drip irrigation. The amortised/apportioned cost is the additional cost of drip per year hence it is divided for two crops in a year.

In addition, the operational and maintenance cost plus the cost incurred to produce extra output due to drip is added to get a

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Table-1: Particulars of Investment on Drip irrigation Unit – A case of Tomato Crop (Rs)

Particulars	Cost incurred/acre	Remarks
Head unit components	8500.00 (6)	Filters, inlet and outlet, pressure gauze, control valve, butterfly valve, air release valve, bypass tea and GI fittings
Field Unit components including transport plus GST @ 9 %	43500.00 (94)	Main line, sub-main and laterals -PVC pipes, PVC ball valve, PVC flush valve, LLDPE plain lateral, emitters, PVC fittings and accessories
Total investment	**52000.00 (100)**	
Apportioned/Amortized cost /year considering life span of 5 years for drip system@ 5 % interest rate/annum	12010.00	
Operational and Maintenance expenditure/annum	3500.00	
Cost of drip irrigation/year	15510.00	
Cost of Drip irrigation/crop	7755.00	Considering two crops per year

Source: Computed from the case study data, 2020. The figures in the parenthesis indicates percentage to the total

Table-2. Evaluation of incremental changes with Drip irrigation for tomato crop

Debit	Amount (Rs)	Credit (Rs)	Amount (Rs)
Added cost due to drip (Apportioned cost of drip/ crop) including maintenance cost	7755=00	**Reduction in cost due to drip:** Reduction in labour cost on irrigation and weeding (30 man days/ Ac @ 350/md)	10500.00
Increased cost of harvesting (Due to improved yield on account of drip)	5000=00		
Decrease in returns	**Nil**	**Increase in returns due to drip:** a). Increase in productivity of15 Qtls/Ac @ 1200/Qtl b). Additional income from increased area under cultivation due to savings in water (one acre coconut with a net income of Rs. 34000)	18000.00 34000.00
Total: A	**12755.00**	**B**	**62500.00**
Net change B-A = 49745.00			
Incremental cost Benefit Ratio	**1:4.90**		
Sensitivity analysis: Upon fall in returns by 25 % (ICBR)	**1: 3.68**		

Source: Computed from the case study data

total cost, which is around Rs. 12755.0/acre. Similarly, on credit side, there is saving cost on labour towards weeding and irrigating the crop, which is around Rs.10500. In addition, the productivity of tomato increased by 15 quintals compared to without drip irrigation. Drip irrigation also enabled to save water and with saved water farmer could maintain another acre of coconut garden generating an additional income of Rs 34000/acre (considering difference between with and without irrigation). Thus, it is noteworthy that the sum of incremental returns realised was Rs. 62500/acre/crop on account of drip irrigation outweighing the additional cost of 12755.0 as reflected by net change (B-A) resulting a net gain of Rs.47995.

The incremental cost benefit ratio (ICBR) of 1: 4.9 indicates that for every rupee invested on drip irrigation generated an incremental return of Rs 4.9 (table-2). This undeniably proves that the investment on drip irrigation is economically worthy. Studies indicated that efficient irrigation enables farmer i) use of less water to produce more output, ii) irrigating more area with the saved water iii) generating more surplus value with less water (IFC, 2014). Further, it must be noted that capital invested on drip irrigation could be recovered within a season or at the most within a year considering additional income from two crops of tomato. With subsidy from the Government, farmers can recover their investment on drip within a season. The sensitivity analysis reiterates that in the event of drop in returns by 25 %, the incremental cost benefit ratio still >3, implying the marginal changes are remunerative and economically worthy.

Scenario II: Plastic lined Farm Pond as an improved storage structure

Construction of on-farm groundwater storage structures is one of the coping mechanisms to address ;1) vagaries of electricity supply to the agricultural sector especially during summer for pumping groundwater and 2) low discharge of water from the bore-wells where it is not possible to irrigate continuously unless it is stored and pumped again with pressure especially for micro-irrigation. Since water yield of the bore-well is very low, the farmers have converted the farm ponds into intermediate storage tanks. To prevent seepage loss and depletion of water in the pond, plastic lining is done. This involves treating the farm pond by installing impervious material as plastic film so that water could be stored for a longer period (http://www.ncpahindia.com/articles/article21.pdf).This practice reduces seepage losses and enables to store water for long period. Secondly, it facilitates harvesting and storing rain water. On an average, farmers expend an amount of Rs 90,000 on the farm pond with a depth of 3.5 M having a dimension of 18 X 18 M. Around 50 % of the amount is towards earthwork and 33 % is on HDPE plastic film (table-3). The annual amortised cost is computed by amortising total investment on the farm pond with plastic lining considering an average lifespan of 6 years with an interest rate of 5 %.

Table-3 Farm ponds as improved storage structure

Pond dimension	18 M X 18 M
Depth	3.5 M
Capacity to store water	1134 Cum
Cost of excavation	45000
HDPE Plastic film	30000
Civil works- Anchoring and jointing	15000
Total cost	90000
Apportioned cost/year	17730
Apportioned cost/crop	8865

Source: Computed from the case study data

The additional cost per crop worked out be around Rs 8865 as against an additional return (realised from half an acre of beans plus fish rearing from the pond) of Rs 30000.0 resulting a net gain of Rs. 21435 (table-4). Thus, the intervention of plastic lined farm pond is proved to be beneficial. It is striking to note that the incremental cost to benefit ratio is > 2 indicating its economic worthiness. Even by ignoring the income from fish rearing in the pond, still the ICBR is lucrative as indicated in the sensitivity analysis.

Scenario- III. Plastic mulching

Plastic mulching is commonly practiced for high value crops like tomato, capsicum, cauliflower, cabbage and other vegetables. Plastic mulch enables to reduce non-beneficial evaporation loss of surface water and thereby number of irrigations can be reduced. It also suppresses weeds growth and thus saving cost on labour towards weeding and also reduces nutrient loss.

The additional cost of introducing plastic mulch and the additional returns realised is provided in the table-5. Plastic mulch (HDPE sheet) lifespan is around 1-2 years depending on the intensity of use. Hence, the cost is apportioned accordingly and added to the operational and maintenance expenditure that include labour cost towards spreading and anchoring the sheet in the plots plus making planting holes at regular interval depending on spacing of the plants. The debit side display an additional cost of Rs. 12000/crop as against Rs 35800/crop on credit side, which include the savings cost on weeding, fertilisers and water and also the value of additional output. Thus, the net gain on account of introducing plastic mulch is to the tune of Rs. 23800.0 per crop with an incremental cost benefit ratio of Rs. 1: 2.98, indicating the plastic mulching practice is highly beneficial in terms of returns to investment. Even, if there is a drop in the output price by 25 %, still it is economical as indicated by the sensitivity analysis.

Water use efficiency across different technologies

Precise application of water through drip irrigation makes irrigation more efficient than flow method of irrigation where water is scarce. It also reduces water loss through evaporation and runoff. The water applied for tomato crop under bore-well and drip irrigation is calculated using standard procedure (Kiran Kumar, 2013). The results reveal that the drip irrigation consumes about 27 percent less water compared to flow irrigation, drip plus plastic mulch consumes 32 % less water and drip plus plastic mulch plus plastic lined pond system consume about 44 % percent less water compared to flow irrigation (fig-1). Thus overall, with improved technology 44 % of water could be saved. But this saved water is diverted to expand area under irrigation and intensified production. As evident from the figure-1, the area irrigated increased significantly from 34 % to 66 % after drip plus plastic mulching. Though farmers benefit from this technology at individual level, but not contributed towards conservation of water at community level. In this regard, the studies indicated that due to water saving investments, water consumption reduced significantly, but the saved water is diverted and depleted particularly when land is not limited. If land is limited, water depletion doesn't occur (Berbel and Mateos 2014, Kabbur et al 2020).

Scenario IV: Government Initiatives towards groundwater recharge

The KC Valley project is supplying Bangalore city treated wastewater into the dried up irrigation tanks of Kolar and Chikballapur districts for groundwater recharge. This is a unique project from the GOK towards rejuvenating the minor irrigation tanks which are seldom filled with rainwater due to incessant droughts. Under this scheme, the Kuratahally minor irrigation tank is one of the beneficiaries and it is treated as percolation tank. The tank located in the downstream received water through gravity flow from the chain of upper tanks and it was filled in April 2020. Before letting water, the tank was desilted from the local community with support from Shri Kshethra Dharmasthala Rural Development Project (SKDRDP).

There are >300 wells in the proximity of the tank and about > 60 % of them were failed. Currently, the wells located in proximity of tanks are being benefited. Functioning of failed wells is also evident in the close proximity of tank. However, wells distributed far away from the tank are yet to reap the benefit, as it takes time to recharge.

Economic benefits

Under different methods of irrigation technologies, the productivity of tomato increased ranging from 17 to 33 % reflecting improvement in agronomic water use efficiency in tomato production. In addition, there is saving of labor used where drip irrigation is the mode of water application.

Further, drip irrigation enables application of nutrients precisely at the root zone in the drippers and thus saving in fertilisers. Drip irrigation also reduced the weed growth and also number of man-days required to irrigate the land. Labour

Table-4: Incremental changes due to introduction of on-farm storage structure with plastic lining

Sl No	Debit	Amount (Rs)	Credit (Rs)	Amount (Rs)
1. a)	**Added cost due to plastic lined pond**(Apportioned cost of farm pond/crop considering two crops in a year)	8865	**Reduction in cost due to pond:**	-
b)	**O and M cost**	Nil		-
2.	**Decrease in returns**	**Nil**	**Increase in returns due to farm pond:** a) Additional income from increased area under irrigation due to storing water with required discharge of water to operate drip optimally (half acre French beans with a net income of Rs. 20000) b) additional income from fish rearing (50 kgs @120/kg)	24000=00 6000=00
	Total: A	**8865**	**B**	**30000=00**
	Net change B-A = 21135			
	Incremental cost Benefit Ratio	**1:3.4**		
	Sensitivity analysis: Without income from fish (ICBR)	**1:2.3**		

Source: Computed from the case study data

Table-5. Incremental changes due to introduction of plastic mulching

Sl No	Debit	Amount (Rs)	Credit (Rs)	Amount (Rs)
1. a)	**Added cost due to plastic mulching** (Initial investment) Plastic mulch (Covering 60 % of the area) 7 rolls @ 1800/Roll **Apportioned cost of plastic sheet/crop considering two crops in a year**	12600.00 6300=00	**Reduction in cost due to plastic mulch** Savings in fertiliser (20 %) Saving in labour on weeding (15 %) Saving in number of irrigations: 2 irrigations (cost of buying water for 2 irrigations)	2800=00 6000=00 30000=00
b)	**O and M cost-** labour cost towards spreading &anchoring the plastic sheet Extra cost on harvesting and marketing for 2 tonnes	2200=00 3500=00		
2.	**Decrease in returns**	**Nil**	**Increase in returns due to plastic mulching:** a) Additional income: (2 tonnes of tomatoes @ 12/kg)	24000=00
	Total: A (a+b+c)	**12000=00**	**B**	**35800=00**
	Net change B-A = 23800			
	Incremental cost Benefit Ratio	**1:2.98**		
	Sensitivity analysis: Upon fall in output price by 25 % (ICBR)	**1:2.5**		

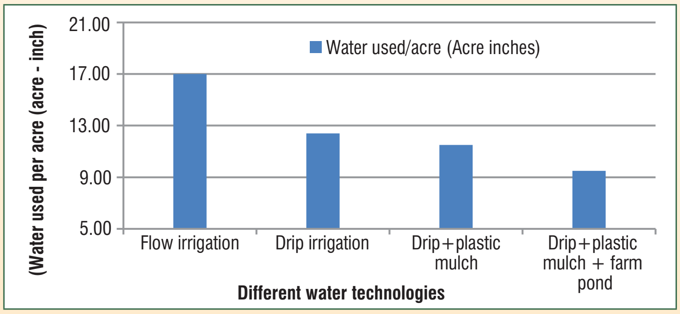
Source: Computed from the case study data requirement is also reduced by 20 - 30 % under drip method compared to flow method of irrigation.

Table-6 : Water use efficiency of different innovative irrigation technologies

Particulars	Water used/ acre (Acre inches)	Savings in water (%) compare to control	Productivity Qtls/acre	WUE (kgs/ac. inch of water)	Irrigation percentage
Flow- irrigation without drip	17.0	-	150	8.8	34
With drip irrigation	12.4	27	175 (17)	13.3	
Drip + plastic mulch	11.5	32	195 (30)	16.9	
Drip + plasticmulch + plastic lined farm pond	9.5	44	200 (33)	21.0	66

Note: Figures in parenthesis indicates % increase in productivity and water use efficiency

Fig-2. Water used/acre (Acre inches)



Source: Computed from the case study data

According to FICC&I, the potential benefits in terms of water saving ranged from 30 to 100%, while water use efficiency varied between 15 to 70 % and fertiliser use efficiency in terms of reduced cost on fertilizers is around 30 %. In case of farm pond lined with Plastic film, the percolation loss of water could be minimized up to 100 %. Thus, drip irrigation and groundwater are appearing as an indispensable technology-natural resource complement. The improved irrigation technologies enable to save water, augmenting productivity and income.

Conclusions

Farmers are investing on demand management measures like drip irrigation, plus plastic mulching, plus constructing farm ponds with plastic lining. As a result, water consumption reduced significantly, but the saved water is diverted towards expanding irrigated area. The results have amply proved that farmers adopting drip irrigation plus other efficient irrigation practices have proved their economic worthiness by adjusting with the available groundwater yield, when compared with farmers who risked by drilling additional wells / or by re-boring their existing irrigation wells with huge amount to augment groundwater supply. Thus the key economic message is that it would be wise on the part of the farmers to resort to water use efficient technologies rather than investing on additional source of groundwater, which is not only risky to strike at but also risky in its sustenance.

Policy recommendations

- Need appropriate policies that promote efficient water application tools for conserving and boosting agricultural productivity.
- Sustainable management of groundwater requires investments not only in the groundwater sector, but also in the cross-sectors like land and energy management.
- The land management involves laser levelling, mulching and altering crop pattern to suit less irrigation along with precision technologies like Micro-irrigation, soil moisture sensors and tensio-meter based irrigation scheduling which need to be promoted and incentivized as best bet water saving technologies.
- The energy management measures such as improving efficiency of irrigation pump-sets and solarising irrigation pump-sets of the farmers, as this could reduce not only electricity consumption but also carbon emissions.
- Strengthening groundwater irrigation research and outreach to deliver the appropriate technical services and capacity building of farmers along with water accounting procedures need to be initiated.
- Government initiative of groundwater recharge with urban wastewater through KC Valley project is in right direction and will greatly benefit farmers in boosting agricultural productivity. However, the environmental concerns and impacts need to be studied.
- Effective use of plastics including use, reuse and recycle is vital. Users of the plastic-based technologies in irrigating crops need to be educated relating to safe disposal/recycling of the plastic material after completing its life span.

Tomato crop with drip plus plastic mulching to conserve moisture and control weeds

Farm pond lined with plastic film to store water. Kuratahalli minor irrigation tank filled with treated urban waste water from K C Valley project for recharging groundwater

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