Indian J. Dryland Agric. Res. & Dev. 2013 28(1) : 38-42

Economic Evaluation of Lined Farm Pond for Supplemental Irrigation to FCV Tobacco in Southern Andhra Pradesh

M. Osman[1], R. Sreenivaslu[2], L.K. Prasad[2], K.V. Rao[1], A.R. Panda[2] and Shaik Haffis[1]

[1]*Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500 059, Andhra Pradesh*
[2]*Central Tobacco Research Institute, Regional Station, Kandukur, Prakasam-523 105, Andhra Pradesh*

Email: mdosman@crida.in

ABSTRACT: The study was conducted to know the response of flue cured Virginia tobacco to one supplemental irrigation using rainwater harvested in lined farm pond having a capacity of 640 m^3 and donor area of 2.0 ha. Cured leaf yield of FCV tobacco improved between 20 and 31% during the period of 6 years (2003-04 to 2008-09). An additional average net income of ₹ 10,565/ ha was accrued from improvement in leaf yield with one supplemental irrigation over control (no irrigation). Discounted cash flow model was employed for measuring the present worth of the pond. Between the two irrigation methods followed for recycling water from the pond, the sprinkler method of irrigation (at 25 mm depth of water) fared better than furrow method (at 40 mm depth of water). Sprinkler method registered higher net present values (NPVs): ₹ 40,044, ₹ 1,62,862 and ₹ 3,51,285; higher benefit-cost ratios (BCRs): 1.30, 1.93 and 2.47; and internal rate of return (IRRs): 24, 29 and 30% at 10, 20 and 40 years of expected lifespan of farm pond, respectively and took less payback period (PBP) of 7 years for recovering the investment made. While in case of furrow method of irrigation, the PBP was 11 years and that of NPV at different scenarios (expected lifespan of 10, 20 and 40 years) was ₹ - 8,105, ₹ 68,999 and ₹ 1,87,289; BCRs: 0.93, 1.48 and 2.02; and IRRs: 10, 20 and 23%, respectively.

Key words: Rainwater harvesting, farm pond, supplemental irrigation, FCV tobacco

India has prime share of resources in the world, yet 1,150 km^3 of its precipitation still goes as runoff to the seas annually in the form of "rejected recharge" (INCID, 1999). As such, water has become a scarce resource and the amount of water available as runoff is not fully tapped in general and rainfed areas in particular. Rainfed regions often experience both drought and flood, and land degradation is high due to rainwater induced soil erosion. These areas exhibit low rainwater use efficiency due to low investments on conservation measures and lack of appropriate policies (Rockstrom *et al*., 2007). Rainwater harvesting and re-use is the need of the hour as it can contribute significantly in reducing soil and nutrient losses and increasing of rainwater productivity. Development of a micro-level rainwater harvesting model on individual holdings can pay many dividends (Barron *et al*., 1999; Gunnell and Krishnamurthy, 2003). *Ex-situ* rainwater harvesting through farm ponds and supplemental irrigation in the rainfed regions is one of the most important proactive measures for drought proofing and enhancing productivity. Supplemental irrigation is found to increase the grain yield of different crops ranging from 23% in case of sorghum to 345% in chickpea (Singh *et al*., 1999). Similarly, under rainfed condition, supplemental irrigation improves the yield of crops from 18 to 80% depending upon the stage of crop growth (Wani *et al.,* 2008).

In many parts of the World, increasing stress is being placed on rainwater harvesting and recycling. In the monsoonal regions of India, this approach holds good as major chunk of the total rainfall is received within hundred hours giving little time to infiltrate (Keller *et al*., 2000) and mostly goes as runoff. Southern region of Andhra Pradesh is characterized by hot dry sub-humid ecosystem with predominance of red loams (Alfisols) and is prone to both droughts and floods due to depressions in the Bay of Bengal. The frequency of droughts and floods is showing an increasing trend with changing climatic scenario (Ramakrishna, 2007).

Rainfed coastal areas of Andhra Pradesh though blessed with sufficient groundwater but the water is not fit for irrigation due to presence of high amount of chlorides (200-1500 ppm). Any excessive withdrawal may further aggravate the situation due to ingress of seawater into coastal aquifers. Use of poor quality ground water for irrigation affects not only the quality of tobacco in the short run but also soil health in the long run. Keeping in view the twin constraints of erratic rainfall with prolonged dry spells and poor quality of groundwater, an attempt was made to package the farm pond technology using lined pond for supplemental irrigation to FCV tobacco at Regional Station of Central Tobacco Research Institute (CTRI), Kandukur in Prakasam district of Andhra Pradesh.

Materials and Methods

The soils of the study site are Alfisols characterized by red sandy loams, neutral in reaction, low to medium in fertility status, moderately well drained with adequate water holding capacity and low to medium in cation exchange capacity with more than 75% base saturation. The clay minerals are Quartzite and Kaolinite. Quartz is predominant in silt fraction of the soil (Table 1).

Data were collected for the present study in respect of one time investment made on construction of lined pond (base year, 2003), cost of supplemental irrigation and also yield of cured leaf FCV tobacco *versus* control (rainfed) for 6 years (2003–04 to 2008-09) at CTRI Regional Station, Kandukur in Prakasam district of Andhra Pradesh. The farm pond with dimensions of 16 m x 16 m top, 8 m x 8 m bottom to a depth 4 m (1:1 slope) was dug and lined {brick in cement mortar (1:6), plastered} with an investment of ₹ 1,00,000 in 2003. The total volume of the pond was 640 m^3 with a catchment area of 2.0 ha. An upper limit of lifespan of farm pond as 40 years was considered for economic evaluation of farm pond. Annual total cost incurred and annual gross benefit derived by recycling harvested water from the pond were used for estimating discounted cash flow and worth of pond. The cost of construction of pond was considered as non-recurring while cost of supplemental irrigation including additional labour required for harvest and curing as recurring variable for the study period of 10, 20 and 40 years. Additional gross returns accrued (irrigated) annually over control (rainfed) served as the annual gross benefit derived from the pond. The methodology adopted by Gittinger (1972) was followed for determining internal rate of return (IRR), benefit-cost ratio (BCR), net present value (NPV) and payback period (PBP) after discounting the total cost and gross benefit at 12% for different periods of expected lifespan. However, the intangible benefits of the farm pond were not considered.

Table 1 : Soil physical properties in the study area

Soil physical parameters	Constituents	
Soil texture	Sandy loam	
Bulk density (g/cc)	1.55	
Soil moisture constant at soil depth : 0-30 cm		
1/3rd bar (%)	17-21	
15 bar (%)	08-11	
Textural analysis	Soil depth	
	0-22.5 cm	22.5 – 45 cm
Coarse sand (%)	35	25
Fine sand (%)	33	30
Silt (%)	6	10
Clay (%)	27	35
Clay minerals	Quartzite, Kaolinite	

The data were projected year-wise for total cost (cost of supplemental irrigation and additional labour) incurred and gross benefit derived for two different levels of area under cultivation of FCV tobacco viz. 1.13 ha (at 40 mm depth of water) and 1.8 ha (at 25 mm depth of water) from the 7th year onwards up to 40 years were fed in the model of discounted cash flow for estimating present worth of the pond. To workout projected total cost incurred, an assumption of 10% annual rate of inflation while for projected gross benefit, an average of 25% improvement in yield and an average rise of 10% in market price of cured leaf were considered.

The above economic indicators were worked out using the formulae given below:

$$BCR = \left(\sum_{t=1}^{n} \frac{B_n}{(1+i)^n}\right) / \left(\sum_{t=1}^{n} \frac{C_n}{(1+i)^n}\right) \quad \text{..................(1)}$$

$$NPV = \sum_{t=1}^{n} \frac{B_n - C_n}{(1+i)^n} \quad \text{.. (2)}$$

$$IRR = \sum_{t=1}^{n} \frac{B_n - C_n}{(1+i)^n} = 0 \quad \text{.................................. (3)}$$

Where, B_n = Benefits accrued in each year; C_n = Costs incurred in each year; n = Number of years; i = Discount rate

Payback period (PBP) is the time (no. of years) required for the present value of gross benefit accrued to equal or just cross the present value of total cost incurred implying that the farmers or donor agencies are able to recover their investment made on the lined farm pond.

Results and Discussion

Water budgeting, yield and crop performance

The water stored in the lined pond was used for irrigation when the dry spell exceeded 15 days during active vegetative phase. The pond got filled by the end of October by receiving inflows from the catchment area of 2.0 ha. The water available (447 m^3) for irrigation after accounting evaporation losses was found sufficient to irrigate 1.8 ha at 25 mm depth once with sprinkler irrigation (Table 2). The pond capacity of 640 m^3 was found to be ideal with a catchment (donor) area of 2.0 ha for irrigating 1.0 ha of command (recipient) area by flood and 1.13 ha through furrow method of irrigation.

Benefits of supplemental irrigation in terms of increasing and stabilizing crop productivity have been impressive in drought affected rainfed areas of Prakasam district. The additional yield of cured leaf on an average was 22% higher than control (rainfed), which was 221 kg/ha (average of 6 years) and yield increase ranged between 20 and 31% (Table 3). The results reported in the present study are in confirmation with the findings noticed by Pathak and Laryea (1990); Jenson *et al.,* (2003) and Hatibu (2003).

Table 2 : Water budgeting of lined farm pond

Particulars	Magnitude
Full capacity of farm pond by October end (m^3)	640
Catchment area (ha)	2.0
Water loss by evaporation from October to December (m^3)	193
Water available for irrigation (m^3)	447
Water requirement for one irrigation for one hectare at 25 mm depth for sprinkler method of irrigation (m^3)	250
Area irrigated with available water (ha)	1.8

Economic viability of farm pond

Although cost of pond was high as the lining occupied a lion's share (70%) of the total cost but still it is a cheaper option than providing irrigation through canal system costing more than ₹ 200,000/ha (fixed cost) excluding recurring expenditure. Lined farm ponds are suitable for small farmers owning 2.0 ha of land in moist semi-arid areas receiving more than 750 mm of annual rainfall as the pond occupies small area of the farm (1.3%) but there is substantial increase in yield and income. The market price of tobacco cured leaves registered an increasing trend and varied from ₹ 34 to ₹ 97/kg during the study period (2003-09), thus yielding an additional net income ranging between ₹ 7145 and ₹ 15940/ha (Table 3).

In the present study, two methods of supplemental irrigation were followed viz. sprinkler and furrow method and the water was applied to a depth of 25 mm and 40 mm, respectively. Economic evaluation of lined pond revealed that the production of cured leaf tobacco took lesser payback period (7 years) in case of sprinkler method of irrigation than furrow methods (11 years) for recovering the investment made. The payback period has considered only the tangible benefits of lined pond but there are many intangible benefits like change in micro-climate and capturing of soil and nutrients, etc.

Table 3 : Impact of one supplemental irrigation on yield and returns from FCV tobacco

Parameter	Year					
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Yield - control (kg/ha)	1147	942	1003	983	943	1090
Yield - irrigated (kg/ha)	1416	1238	1249	1213	1183	1311
Additional yield (kg/ha)	269	296	246	230	240	221
Improvement in yield (%)	23	31	25	23	25	20
Rate per kg leaf (₹)	34	35	42	54	84	97
Gross returns accrued from irrigation (₹/ha)	9145	10360	10330	12420	20160	21440
Gross cost of irrigation and additional labour (₹/ha)	2000	2250	2600	3100	5000	5500
Net returns accrued from irrigation (₹/ha)	7145	8110	7730	9320	15160	15940

Table 4 : Economic analysis of lined farm pond under different life periods

Depth of water/ economic indicators	Area under irrigation (ha)	Expected lifespan of farm pond (years)		
		10	20	40
25 mm (sprinkler)	1.80			
PBP (yrs)		7		
NPV (₹)		40,044	1,62,862	3,51,285
BCR		1.30	1.93	2.47
IRR (%)		24	29	30
40 mm (furrow)	1.13			
PBP (yrs)		11		
NPV (₹)		- 8,105	68,999	1,87,289
BCR		0.93	1.48	2.02
IRR (%)		10	20	23

PBP, NPV and BCR were calculated at 12% discount rate; PBP = Payback period; NPV = Net present value; BCR = Benefit-cost ratio; IRR = Internal rate of return; Catchment area = 2.0 ha

Net present values (NPV) of pond were higher in sprinkler irrigation system of ₹ 40,044, ₹ 1,62,862 and ₹ 3,51,285 at 10, 20 and 40 years of its expected lifespan than furrow method (₹ - 8,105, ₹ 68,999 and ₹ 1,87,289, respectively). Table 4 shows that the BCRs in both sprinkler and furrow method of irrigation, on overall basis, were found to be more than unity at 12% discount rate at different scenarios 10, 20 and 40 years of expected lifespan except at 10 years lifespan in case of furrow method of irrigation where it was less than unity (i.e., 0.93). As expected, higher BCRs, were recorded in the sprinkler method of irrigation viz. 1.30, 1.93 and 2.47 at the expected lifespan of 10,20 and 40 years, respectively than that of furrow method (0.93, 1.48 and 2.02, respectively). Similar BCRs were achieved in an evaluation study of farm ponds and ranged between 1.85 and 1.96 making the farm ponds a viable proposition (Singh and Khan, 1999). Ngigi *et al*. (2005) and Fox and Rockstrom (2000) concluded that the supplemental irrigation using farm ponds was an economically viable option for improving livelihoods of small farmers.

IRR of farm pond was worked out to be higher (24, 29 and 30% at 10, 20 and 40 years of its expected lifespan, respectively) in the sprinkler irrigation system than that of furrow method (10, 20 and 23%, respectively). This indicates that at a discount rate of 24, 29 and 30% under different scenarios cited above in the sprinkler system of irrigation, the farm pond(s) just break even.

Conclusion

The rainwater harvesting and recycling using farm pond lined with brick and cement mortar was found suitable for providing supplemental irrigation with good quality water to tobacco in rainfed areas having light textured soils. The technology is suitable for small farmers having two hectares of land holding and can gain up to 30% additional net income. The payback period is short even after discounting the cost and returns at 12%. Thus, the usefulness of lined pond in mitigating drought is indisputable and can contribute to climate change adaptation.

References

Barron J, Rockstrom K and Gichuki F. 1999. Rainwater management for dry spell mitigation in semi-arid Kenya. East African Agriculture and Forestry Journal, 65(1): 57-69.

Fox P and Rockstrom J. 2000. Water harvesting for supplemental irrigation of cereal crops to overcome intra-seasonal dry spells in the Sahel. Physics and Chemistry of the Earth, Part B Hydrology, Oceans and Atmosphere, 25(3): 289-296.

Gunnell Y and Krishnamurthy A. 2003. Past and present status of run-off harvesting systems in dryland peninsular India; a critical review. Ambio, 32(4): 320-323.

Gittinger JP. 1972. Economic Analysis of Agricultural Projects, John Hopkins University Press, London.

Hatibu N. 2003. Rainwater management strategies for improving water availability and productivity in semi-arid and arid area. In: *Issues of Water Management in Agriculture; Compilation* *of Essays, Comprehensive Assessment of Water Management in Agriculture*. International Water Management Institute (IWMI), Colombo, Sri Lanka, http://www.iwmi.org/assessment%20.

INCID. 1999. Water for food and rural development 2025, Indian National Committee on Irrigation and Drainage (INCID), Paper presented at the PODIUM workshop, Central Water Commission, New Delhi, India, 15-16, December 1999.

Jenson JR, Bernhard RH, Hansen S, McDonagh J, Moberg JP, Nielsen NE and Nordbo E. 2003. Productivity in maize based cropping systems under various soil-water-nutrient management strategies in a semi-arid Alfisol environment in East Africa. Agricultural Water Management, 59: 217-273.

Keller A, Sakthivadivel R and David Seckler. 2000. Water scarcity and the role of storage in development. Research Report -39, International Water Management Institute, Colombo, Sri Lanka.

Ngigi SN, Savenije HHG, Thome JN, Rockstrom J and Penning de Vries FWT. 2005. Agro-hydrological evaluation of on-farm rainwater storage systems for supplementary irrigation in Laikipia district of Kenya, Agricultural Water Management, 73(1): 21-41.

Pathak P and Laryea KB. 1990. Prospects of water harvesting and its utilization for agriculture in the semi-arid tropics. In: *Proceedings of Symposium of the SADCC (Southern African Development Coordination Conference)*, 8-10 October 1990, Land and Water Management Research Program, Gaborone, Botswana. pp 266-278.

Rockstrom J, Hatibu N, Oweis TY and Wani SP. 2007. Managing water in agriculture. In: *Water for Food, Water for Life: a Comprehensive Assessment of Water Management in Agriculture* (D Molden, Ed.), International Water Management Institute (IWMI), Colombo, Sri Lanka. pp 315-352.

Ramakrishna YS. 2007. Observed Impacts on Agriculture in recent past. Paper presented in National Seminar on Climate Change – Impacts on Indian Agriculture, 12-13 October, 2007, New Delhi.

Singh RP and Khan MA. 1999. Rainwater management: water harvesting and its efficient utilization. In: *Fifty Years of Dryland Agricultural Research in India* (HP Singh, YS Ramakrishna and B Venkateswaralu, Eds.), Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, India. pp 301-313.

Singh SR, Chaudhary TN, Bhatta RK, Bhatnagar PR, Saha B and Patil NG. 1999. Irrigation water management. In: *Fifty Years of Natural Resource Management Research in India* (GB Singh and BR Sharma, Eds.), Central Soil Salinity Research Institute (CSSRI), Karnal, India. pp 40-48.

Wani SP, Joshi PK, Raju KV, Sreedevi TK, Mike Wilson, Amita Shah, Diwakar PG, Palanisami K, Marimuthu S, Ramakrishna YS, Meenakshi Sundaram SS and Marcella D'Souza. 2008. Community watershed as a growth engine for development of dryland areas – Executive Summary. A Comprehensive Assessment of Watershed Programmes in India, ICRISAT, Patancheru, India. 28 p.

Received : January 2013; Accepted : April 2013