Improving water use efficiency by integrating fish culture and irrigation in coconut based farming system: A case study in Kasaragod District of Kerala (India)

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Abstract: The crop production in the district of Kasaragod in Kerala State (India) is characterized by low input-low yield concept and rain-fed agriculture. A field study was conducted in Western Ghat region of the district to develop a suitable rainwater harvesting system adoptable to hilly terrains and to test its efficacy for improving the use efficiency of the harvested water by its multiple uses. The cost-benefit analysis of the water harvesting system was also carried out to find out its affordability to farmers. The water harvesting system has been developed by integrating three components: (i) improving the productivity of coconut and component crops in the cropping units (ii) developing multiple water use systems, and (iii) the conjunctive use of the harvested water along with other surface and groundwater resources. Based on the estimated annual costs and returns, the Benefit -Cost ratio was found to be 1.69 and all other financial viability criteria (IRR and NPV) were also found favourable for investment on a lined water harvesting tank integrated with a micro-irrigation system and fish farming. The study suggested that the rainwater harvesting could be implemented as a viable alternative to conventional water supply or on-farm irrigation projects considering the fact that any land anywhere can be used to harvest rainwater. Further, the water use efficiency can be improved through effective harvesting and subsequent multiple uses of stored water.

Keywords: rainwater harvesting, water use efficiency, plastic lined tank, seepage loss, fish culture, financial viability
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1 Introduction

Kerala is probably one among the few states in India blessed with monsoon twice a year with an average annual rainfall of 3 000 mm. But all this does not result in the perennial availability of water in the state. The effective management of water resources which are distributed unevenly both spatially and temporally, and its efficient and judicious management holds the key to solve the paradoxical problem of the frequent occurrence of floods and droughts in the region.

The development of water sources must be within the capacity of nature to replenish and to sustain. If this is not done, costly mistakes can occur with serious consequences. In view of all these considerations, now there is a paradigm shift among scientists, policy makers and farmers to develop and adopt low cost sustainable rain water harvesting technologies.

Being a high rainfall region, Kerala has great potential to harvest rainwater by various means. Though many such technically feasible water harvesting technologies are available, economical non-viability of the same prevents many farmers from adopting these techniques. In this context, a field study was conducted in the Western Ghat region of Northern Kerala to develop

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a suitable rainwater harvesting system adaptable to hilly terrains and to test its efficacy for improving the water use efficiency by multiple use of the water. The cost-benefit analysis of the water harvesting system was also carried out to find out its affordability to farmers.

The universal value of perennial water collected on-farm through *in situ* water harvesting measures to enhance productivity and reduce drought related loss has been generally underestimated. Water bodies, both community and household, have traditionally served a variety of functions in rural areas including livestock and fish production. Maintaining or enhancing the multiple uses of water bodies may be the cornerstone of wider adoption of fish production[1]. Irrigation of high-value vegetable and fruit crops planted around farm ponds have greater impacts on household food security and income along with the fish produced.

The raising of livestock in association with coconut is a well established practice in Kerala State. The rationale for this practice is that the same land could be simultaneously and profitably utilised to produce different crops and livestock enterprises, so that the productivity of the land is increased. The practice minimizes resource demand and encourages efficient resource use, especially in the low levels of resource endowments. However, fish culture in the coconut garden is not very common mainly because of the lack of perennial water source. Improving the use efficiency of harvested water is the best solution to make it more economic. Rainwater is presently considered as an important input factor for healthy and productive watershed ecosystems and irrigated agriculture[2]. Though many such technically feasible water harvesting technologies are available, economical non-viability of the same prevents many farmers from adopting these techniques.

In the present study, apart from developing a cost-effective rainwater harvesting system, various means of improving the water use efficiency such as (i) improving the water use efficiency of coconut and component crops in the cropping units (ii) developing multiple water use systems (iii) conjunctive use of multiple water sources are analyzed.

The region loses the lion share of the rainwater through runoff and in this context, the rainwater harvesting assumes great significance. It can be implemented as a viable alternative to conventional water supply schemes considering the fact that any land anywhere can be used to harvest rainwater. Rainwater harvesting is in reality extending the fruits of the monsoon based on the principle of catching the water where it falls. It is considered to be an ideal solution for water problems where there is inadequate groundwater supply or where surface resources are either not available or insufficient. The Millennium Development Goals of the United Nations[3] stress on rainwater harvesting as an effective measure to ensure environmental sustainability. Previous studies showed that subsistence agriculture in hilly region could be successfully transformed into a profit earning enterprise by tapping and utilizing rainwater[4]. Venketaswarulu[5] suggested that farm ponds in watershed areas help harvest both surface and sub-surface runoff from upper reaches. When rainwater harvesting at the household or community level enables rain-fed farms to access a source of supplementary irrigation, the economic security also improves. Jugale[6] reported that the adoption of rainwater harvesting technologies in drought prone areas of Maharashtra helped to enhance the growth of animal husbandry, farm employment, and improve the living standards, income and output levels of farmers other than ensure perennial availability of water. Based on the physiographic classification of the region[7], the homestead farming system was recommended with a large number of components like perennials, food and fodder crops, livestock, fishery, poultry, apiary etc. A study conducted in Nigeria on economic analysis of homestead fish production suggested that the production curve of homestead fish farmer is quadratic in nature and policy variables such as pond size, fingerlings, labor that influence the aquaculture revenue should be strengthened for sustainable fish production[8].

2 Materials and methods

The study was conducted in the agricultural field of an innovative farmer, located in North-Eastern part of

Kerala State (India) that receives an average annual rainfall of 3 500 mm. In spite of receiving a large amount of rainfall, the locality experiences severe scarcity of water during summer months[9]. This is mainly because of the uneven rainfall distribution pattern and huge runoff due to inclined topography. The rainfall data of the locality, depicted in the Figure 1, show the skewed distribution pattern of the much centralized rainfall. Most of the rainwater has been lost as surface runoff due to undulating topography and high intensity downpour. These factors coupled with low water holding capacity of the lateritic soil prevailing in this region results in moisture stress after the withdrawal of monsoon.

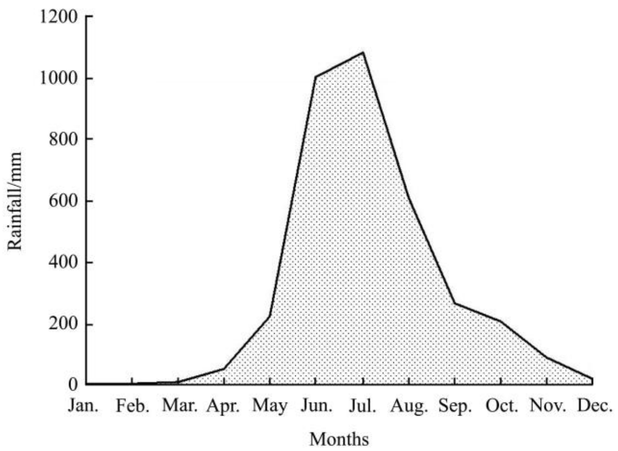

Figure 1 Rainfall distribution pattern of Kasaragod District, Kerala, India

Though coconut (*Cocos Nucifera*) was the main crop on the 2.0 ha farm, other high value crops like vanilla (*Vanilla Fragrans)*, arecanut (*Areca catechu*), pepper (*Piper nigrum*), and vegetables were also being cultivated in the interspaces of coconut. A natural spring that yields water up to December and an open well that provides water up to March were the major water sources and the garden was irrigated manually using a hose pipe. In absence of a sustainable source to fetch water for life saving irrigation to the crops during summer months (March- May), severe crop losses were observed during the drought period and it was estimated that the crop loss occurred to vanilla alone was about 1 quintal of green vanilla beans. The approximate loss calculated as per the local rates prevailed during the period under study (on an average at Rs.100/kg) was around Rs.1.5 lakhs.

Rainwater harvesting, irrespective of the technology used, essentially means harvesting and storing water in days of abundance, for use in lean days. In this context, it was decided to tackle the problem by constructing a large scale rain water harvesting tank. The direct rainwater, roof water or runoff can be harvested using eco-friendly low-cost technologies such as Ultraviolet (UV) resistant plastic lined ponds, ferro-cement tanks, etc. and used for multiple purposes[10]. In the present case, a UV resistant plastic lined rainwater harvesting tank was planned and designed.

The rainwater harvesting tank was constructed during the months of September-November 2004 on the agricultural farm under study, which is located at Rajapuram Village in Kasaragod District (Kerala) at 12°429'0 N, 75°4'0 E. As the first step, a demand and supply analysis of the on-farm water availability and irrigation requirement was carried out and based on it the optimum size and dimensions of the tank were finalized. The tank was constructed by digging out soil by means of earth moving machinery and the sides were stabilized subsequently by way of stone pitching. The tank was further lined with cross laminated multi-layered UV resistant plastic sheets for large scale harvesting of rainwater and runoff and to hinder seepage losses.

2.1 Calculation of demand

The water requirement for two hectares of the cultivated land was calculated based on the water requirement of crops grown as shown below:

Daily irrigation requirement for 140 coconut palms at 40 L/day/palm = 5600 L

Daily irrigation requirement for 260 arecanut palms at 20 L/day/palm = 5200 L

Daily irrigation requirement for vanilla garden through 30 emitters at 70 L/emitter/day = 2100 L

Therefore, total daily irrigation requirement = 12900 L

As a normal practice, the irrigation is commenced in the month of January and continued till the onset of monsoon during the month of June. The yearly irrigation requirement was calculated assuming that the crops are irrigated daily for about 150 days annually.

Hence, the annual water requirement = 12 900 ×150 = 1 935 000 L = 1 935 m^3

Taking into consideration of getting an average amount of 323 mm of rainfall during the lean period in approximately 5 to 10 rainy days, which amounts to about 9% of the total, the annual water requirement can be reduced to 1 806 m^3. The figure was arrived by reducing the water requirements for 10 rainy days, for which irrigation is not required, from the total annual water requirement.

2.2 Design of pond

It was estimated from the demand analysis that a tank which can hold around 1 800 m^3 of water was required for providing irrigation during the summer season. It was approximated that the contribution of rainwater to the pond from summer showers would approximately compensate the losses due direct evaporation from the pond during the period under consideration.

A trapezoidal shaped storage tank with the following specifications was constructed by excavating soil and dumping the excavated soil at the four sides of the tank (Figures 2 and 3).

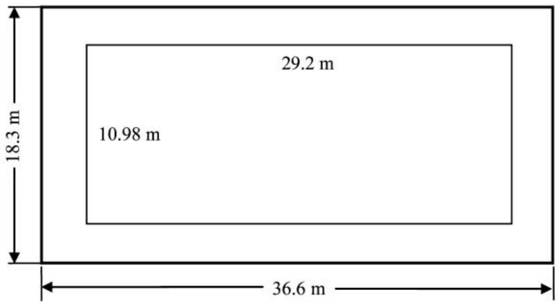

Figure 2 Plan of the trapezoidal water harvesting tank

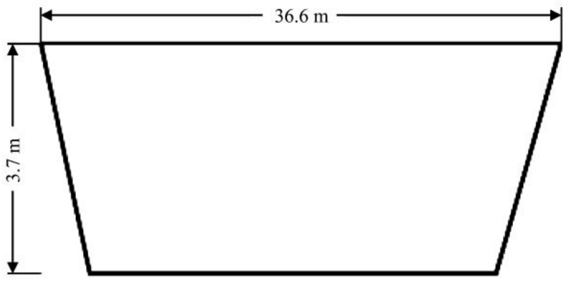

Figure 3 Side view of the water harvesting tank

A trench of 50 cm depth and 50 cm width was taken all around the pond to anchor the sheet.

Top length (L_t) = 36.60 m

Top width (W_t) = 18.30 m

Depth(D) = 4.00 m

Free board = 0.30 m

Bottom length (L_b) = 29.20 m

Bottom width (W_b) = 10.98 m

Side slope (z) = 1:1

The wetted perimeter $P = W_b + 2D$ (Ǿ + cot Ǿ)

i.e., $P = 10.98 + 2 \times 3.7\ (0.785 + \cot 45) = 24.19$ m^2

The volume of the tank is calculated using the following formula:

i.e. Carrying capacity of trapezoidal tank $V = L_bW_bD + (L_b + W_b)\,zD^2 + 4/3z^2D^3$

i.e. $V = (29.20 \times 10.98 \times 3.70) + (29.20 + 10.98)\ 1 \times 3.70^2 + 4/3 \times 1^2 \times 3.70^3 = 1803.88$ m^3

That means the tank can hold 1.8 million litres of water. However, it was observed that a considerable amount of water was lost by deep percolation and seepage because of the porous lateritic soil. The seepage and percolation losses were hindered by lining the tank using a 200 GSM uv resistant cross laminated polyethylene film commonly known as *Silpaulin*.

The sheet was made into the shape of the pond with exact dimensions by the process of thermal welding. After the thermal welding, the welded multi-layered plastic sheets, which were transformed into a single unit with the similar shape and size of the pond, were inserted into the pond. All the four sides of the sheet were buried in the trench taken on the side bund and were riveted at the corners with iron pegs. The trench was then refilled with soil (Figure 4). The two sides of the tank that were above the ground surface were further stabilized with rubble pitching and vegetative fencing. Subsequently the pond was completely covered with fishing net/shade net to prevent birds from catching fishes and also to prevent the dried leaves falling from the nearby trees.

Figure 4 Overview of the pond covered with fishing net/shade net

The inflow to the pond is from two different sources - a natural seasonal spring flowing down from the hilltop (Figure 5) and the direct precipitation. The average rate of flow of the spring was measured as 3 m^3/h and it was observed that in normal rainfall years the spring will last only for 6 months.

Figure 5 Inflow to the Silpolin lined spring-fed pond

2.3 Water balance study

Both the inflow to the pond and outflow from the pond were observed to study the water balance of the plastic lined dugout pond.

Storage of water in the pond + spill over water = (Inflow to the pond as direct precipitation/ annum + Contribution to the pond by the natural spring) - (Evaporation losses+ Irrigation requirement)

Inflow to the pond as direct precipitation/annum = Surface area of the pond × annual rainfall = 36.6 m × 18.3 m × 3.5 m = 2344.23 m^3

Contribution to the pond by the natural spring = 180 days × 3 m^3/h ×24 h = 12960 m^3

Total annual inflow to the pond = 15 304.23 m^3

Evaporation losses at 120 cm annually = 803.736 m^3

Annual irrigation requirement = 1 935 m^3.

Hence, storage of water in the pond + spill over water = 12565.494 m^3

Since the pond can store only 1 803.88 m^3 of water, the rest 10 761.614 m^3 of water was allowed to spill over from the pond. A major portion of the spilled-over water had been diverted for groundwater recharge through contour trenches.

3 Results and discussion

3.1 Development of water harvesting system

It was observed that the construction of a dugout pond and lining it with strong and durable cross laminated plastic sheets for harvesting rain and/or spring water has two advantages, which are effective storage of harvested water by hindering seepage losses and low capital investment per litre of collected water.

3.1.1 Effective storage of harvested water by preventing seepage losses

The seepage studies on a nearby farm pond with similar soil characteristics were carried out for analyzing the effect of lining. Daily observations on water depth, evaporation and rainfall were taken in respect of water saving efficiency. The storage behavior of the pond showed an average rate of seepage/ percolation loss up to 0.11 m^3/ m^2 wetted perimeter/day. Therefore, the total annual seepage loss expected from the constructed pond = 24.19 m^2 × 0.11 × 365 = 971.23 m^3. Since the dugout-cum-embankment type unlined ponds had high rate of seepage and percolation, they could not hold water during the crucial dry season. However, the seepage/ percolation from the tank after lining was observed to be negligible. The storage hydrographs of the unlined and lined ponds (Figure 6) clearly shows the increase in water saving efficiency of the pond after lining in terms of both quantity and duration of storage.

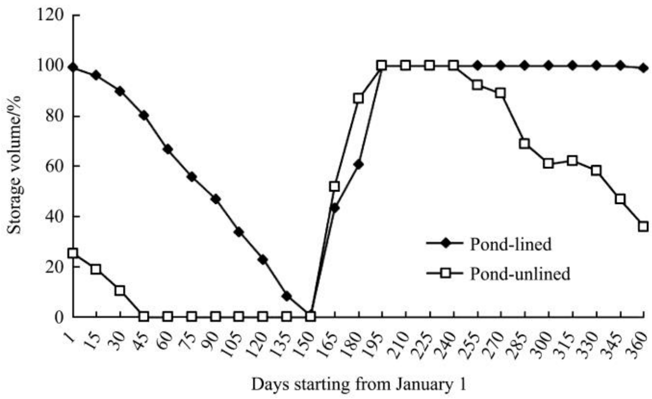

Figure 6 Storage hydrograph of UV resistant plastic lined pond

3.1.2 Low investment per litre of harvested water

Cost of construction of the water harvesting structure including excavation, rubble pitching, lining and other finishing works was Rs.180 686.00 as per the rates prevailing during the season under study. In terms of cost per m^3 of storage capacity, this would be Rs. 98.50 (Table 1).

It was observed that the cost/litre of collected rain water/spring water in UV resistant plastic sheets was significantly less compared to other methods as shown in Table 2.

Table 1 Financial analysis of costs involved in construction of plastic lined pond (as per the prevailing rates during the year 2004; Exchange rate in October, 2013: 1US $= 61.55 INR)

Sl. No.	Items	Quantity	Rate per unit (Rs.)	Amount (Rs.)
1.	Earth work in excavation of pond			
	(a) Ordinary soil of pond bed	1 105.68 m^3	39 per m^3	43 121.50
	(b) Hard rock of pond bed	698.2 m^3	70 per m^3	48 874.00
2.	Smoothening and dressing of soil bed	672.412 m^2	3.50 / m^2	2 353.44
3.	Fine sand cushioning	96.18 m^3	286 / m^3	27 508.85
4.	UV resistant thermal welded plastic sheet 200 GSM (Silpaulin)	672.412 m^2	65/ m^2	43 706.78
	HDPE Sheet in bottom for extra protection	320.616 m^2	35/ m^2	11 221.56
5.	Laying and fixing of Silpaulin film	6 man days	Rs 150 per man day	900.00
6.	Miscellaneous expenditure			3 000.00
	Total amount	Rs.180 686.13 say **Rs.180 686.00**		
	Cost per m^3 of storage capacity of the pond	**Rs. 98.50**		

Table 2 Cost per unit volume of harvested water for different water harvesting structures (Exchange rate in October, 2013: 1US $= 61.55 INR)

Sl. No.	Material	Cost/litre in Rs.
1.	Concrete	4.00 - 5.00
2.	Brick masonry	3.00 - 4.00
3.	Ferro-cement	1.50 - 2.00
4.	Fibre-glass	4.00 - 5.00
5.	Clay (partial seepage)	0.05 - 0.10
6.	UV resistant plastic (silpaulin)	0.095 - 0.20

Moreover, the studies suggested that these technologies are sustainable, locally adoptable, cost-effective, applicable and affordable to the farmers. Saha et al.[11] reported that the lining of the water harvesting tank with 250 μm low density polyethylene (LDPE) black agri-film involved an expenditure of ₹140 m^{-3} during the first year, which came down to ₹46 m^{-3} of stored water during the third year. However, the material used *i.e.* LDPE black agri-film is non *uv* resistant, which restricts its durability under the tropical humid climate. Whereas it is reported that the multi layered plastic sheets like *silpaulin* or nylon are cross laminated in structure and UV resistant in nature and therefore having high durability and strength[12].

3.2 Improving the farming system

The development of a technically feasible perennial water source also made feasible the multiple uses of water other than irrigation and in turn helped to enhance the use efficiency of harvested water. Subsequently an innovative farming system had been developed by integrating three aspects viz., (i) improving the use efficiency of harvested water, (ii) developing multiple water use systems, and (iii) cultivating high value crops using the harvested water.

3.3 Improving the productivity of coconut and component crops

Basin irrigation using a hosepipe connected to a centrifugal pump driven by a diesel or electric engine is the common method employed by farmers for irrigating coconut and other component crops. The basin irrigation requires more water and labour compared to micro-irrigation. After developing a permanent and continuous water source in the form of a water-harvesting tank, a drip irrigation system was installed in the farm mainly for crops like coconut and arecanut. It was observed that 40% of the irrigation water could be saved by using the new system of irrigation.

While providing irrigation, vanilla (orchid species) stem and leaves also should get wet; this would in turn enhance the plant growth and yield. Therefore, irrigation was given to vanilla plants using micro-jets attached to the lateral, which was laid at a height of 2 m above ground level by means of iron wires. The fine spray of water coming from the micro-jets not only wet the leaves and stem, but also created a microclimate favorable to vanilla. Gravitational force was employed to direct water from the tank, which was located at a higher elevation, for irrigating the palms through drip system, while a 2 HP electric centrifugal pump was used for the micro-jets as it requires higher head to produce fine spray. The water spilling over the tank was directed to contour trenches for groundwater recharging.

Creation of *in-situ* structures for this purpose are well demonstrated under undulating topography and steep hill sides of other high rainfall zones of India by many non-government development organizations[13,14]. Verma[15] reported increase of field crop productivity from 62.42% in case of paddy to 250.26% in linseed due to irrigation with harvested rain water along with application of farm yard manure to crops in a hill farming system.

3.4 Developing multiple water use systems

Intensive freshwater aquaculture in the storage tank was a relatively simple component the farmer integrated with irrigation to make it a multiple water use system. The aquaculture unit required substantial volume of water but actually consumed very little of that volume. By linking enterprises, the farmer could use the output water from the aquaculture directly as irrigation water. The nutrients (particularly N and P) in the output water were effectively utilised by the irrigated crop, partially substituting for the costly chemical fertilisers. In contrast, if each of the above enterprises were operated in isolation, the total volume of water extracted from the natural environment would be much higher, and the first enterprise (aquaculture) would require a separate strategy for disposal of the biological waste.

The African catfish *(Clarias gariepinus)* was grown in the constructed tank. This particular fish was selected mainly because it takes air from atmosphere. Since there was facility neither to circulate water nor to provide aeration, the water gets dirty very fast. This particular variety of fish was found to be very adaptable under these circumstances. Direct selling strategy was adopted for marketing the harvested fishes and was found to be very effective.

Nutrient-rich water from the fishpond was used to irrigate the crops through gravity-operated micro irrigation system. The fertilizer use could also be reduced by applying nutrient-rich water from fishpond for irrigation.

3.5 Cultivating high value crops

In order to make the irrigated agriculture a profitable venture, high value crops that grow better under filtered sunlight were introduced. After the introduction of continuous irrigation, more intercrops such as pepper, beetle vine and banana were established in the garden. Moreover, *Salvinia cuculata*, an aquatic weed plant, was introduced as a cover crop in the tank to control evaporation. This when harvested was utilized to provide mulch for coconut and arecanut palms.

3.6 Impact of technology

The study revealed that the innovative approach to harvest and store rainwater in large quantity and its subsequent use for irrigation has the following visible impacts.

3.6.1 Increase in production and productivity

The area under Vanilla cultivation could be increased to 1 ha area from 0.4 ha due to assured irrigation water supply during summer months. The availability of water throughout the year helped provide assured irrigation in the entire garden through micro irrigation and maintain a better microclimate.

The observations showed that the average productivity of coconut palm had been increased from 50 coconuts/ palm to 90 coconuts/ palm over a period of five years. During the same period the arecanut yield was increased from 1.6 kg dried nuts/ palm to 2.2 kg dried nuts/ palm.

The increase in the production of coconut palms could be attributed to the newly introduced soil and water management practices such as mulching the palm basins with dried *Salvenia* and consistent irrigation to the palms using the nutrient rich water from the tank.

3.6.2 Fish farming

The fish culture was adopted in the pond as a subsidiary enterprise by introducing 6 000 fingerlings of the variety African catfish. An amount of Rs.41 500.00 (Table 3) was spent annually towards the capital and maintenance costs, whereas the returns through the sale of fishes fetched an earning of Rs.90 000.00 per year.

3.6.3 Production of effective mulch

It has been unequivocally accepted that soil mulching has several advantages such as the increase in moisture retention and the improvement in other soil conditions. Water hyacinth and *salvinia* are considered better mulches among various organic mulches including leaf mould, rice husk, saw dust etc.[16]. In the present case study, the dried *Salvania* plants, which were grown as cover crop in the pond, mixed with fish waste and fish feeds served as an effective mulch and manure.

3.6.4 Economic analysis of rainwater harvesting tank

Previous studies suggested that ornamental fish culture in large tanks are financially and economically viable and investment friendly[17]. In the present study, it has been estimated that a sum of Rs.248 386 was required as capital cost to establish a *uv* resistant plastic lined water harvesting tank integrated with micro-irrigation system and fishery unit (Table 3). The major cost component in initial investment was construction and lining of tank and installation of micro-irrigation system (Table 3).

Table 3 Details of fixed and variable costs and returns of the integrated water harvesting system
(Exchange rate in October, 2013: 1 US $ = 61.55 INR)

Sl.No.	Particulars	Amount (Rs.)
Expenditure incurred (2006-07 prices in Kerala)		
I. Initial Investment (fixed costs)		
1.	Rental value of land (670 sq.m at Rs.10/sq.m)	6 700.00
2.	Initial investment for constructing RWH tank	180 686.00
3.	Initial investment for installing micro-sprinkler system	37 000.00
4.	Electric pump set (2 HP)	8 000.00
5.	Balance	7 000.00
6.	Net, bucket	4 000.00
7.	Glass wares	5 000.00
	Total	248 386.00
II. Annual Costs (variable costs) (as per 2006-07 prices in Kerala)		
1.	Cost of Brood fish	6 000.00
2.	Feed	16 000.00
3.	Chemicals, medicine, polythene, bags	3 000.00
4.	Electricity and maintenance	3 000.00
5.	Labour charges (Rs. 125 / man-day)	12 500.00
6.	Miscellaneous	1 000.00
	Total	41 500.00
III. Returns		
1.	Sale of fish	90 000.00
2.	Reduction in labour charges (used for irrigation/ fetching water (per annum) = 200 man days/year at Rs.125/manday)	25 000.00
3.	Reduction in crop (Vanilla) loss (previously 100 kg /year lost due to water at Rs.200/kg)	20 000.00
4.	Enhanced coconut yield from 50 to 90 nuts per palm for 140 coconut palms at Rs.6/nut)	33 600.00
5	Enhanced yield of 260 arecanut palms from 1.6 kg dried nuts/ palm to 2.2 kg dried nuts/ palm at Rs.70/ kg)	10 920.00
6	Reduction in fertilizer application (previously 1 kg/plant organic fertilizer was applied. This reduced to 0.5 kg/plant. Supplemented by additional application of *salvinia* enriched with fish meal)	4 500.00
	Total	184 020.00

Note: Income from component crops such as banana, beetle vine and vegetables were not included since the same was not cultivated systematically and the produce was mainly consumed by the farmer.

The major variable cost components were cost of labour, feed, fingerlings, plant/ fish protection, polythene bags and charges for electricity and maintenance and other miscellaneous costs. For the first year, as depicted in Table 3, it was estimated to be Rs.41 500, but in the subsequent years it was found to be a little less as the amount spent on the purchase of fingerlings was less.

Based on the estimated annual costs and returns, the Benefit-Cost ratio was found to be 1.69, which is well acceptable. Other financial viability criteria (IRR and NPV) were also found favourable for investment on plastic lined water harvesting tank integrated with micro-irrigation system and fish farming (Table 4). The analysis indicated that the establishment of such an integrated system was not only financially viable but a highly attractive proposition also for the low cost harvesting and effective use of rainwater/runoff. Some assumptions were also made in consultation with fishery scientists and the farmer.

Table 4 Financial viability of establishing a plastic lined water harvesting tank
(Exchange rate in October, 2013: 1 US $ = 61.55 INR)

Sl.No.	Investment criteria	Value
1.	Net present value (NPV, in INR)	341 265.55
2.	Internal rate of return (IRR, in %)	46
3.	Benefit-Cost ratio(BCR)	1.75

4 Conclusions

The farmers and local communities identified rainwater harvesting as a workable technology option for providing a dependable source of drinking as well as irrigation water and also for preserving the vital ground water reserves. More farmers need to be educated further on the problems crippling the conventional sources and the need for the “shift”.

In the present study, the Rain Water Harvesting initiative of an innovative farmer in N-E Kerala was investigated. The field experience in mitigating the ill effects of drought and providing security against future droughts were brought together apart from exploring out new avenues for profitable agriculture through integrated fish farming. The financial analysis indicated that such an integrated system is not only financially and economically viable to the farmer but leads them to a sustainable farming approach. Based on the estimated annual costs and returns, all the financial viability criteria (IRR, NPV and BCR) were found favourable for investment on a plastic lined water harvesting tank integrated with a micro-irrigation system and fish farming. The approach to harvest rainfall in bulk quantity, as explained in this paper, for drought proofing with generation of additional income through integrated farming could be considered as a model and more locally adaptable and sustainable on-farm technologies of such type should be identified and explored.

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