Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2023, Volume 36, Issue 1, Page 105-113

Financial analysis and biological yield assessment of traditional Aquaforestry system: A case study from Lakhimpur district, Assam

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ARTICLE INFO

Article history:
Received: 16 September, 2022
Revision: 23 January, 2023
Accepted: 13 April, 2023

Key words: *Aquaforestry, Biological yield, NPW, BCR, IRR, Payback Period*

DOI: 10.56678/iahf-2023.36.01.14

ABSTRACT

Financial analysis and biological yield assessment of traditional Aquaforestry system were done in the Lakhimpur district, Assam from December 2021 to April 2022. The study was conducted through a questionnaire survey and informal interviews. The dominant occupation of Aquaforestry farmers was farming with 70.77% and the average landholding of the farmers was 1.43 ha. The average fodder and fuelwood consumption per household per day was 22.33 kg and 3.06kg, respectively. The highest biological yield was reported from marginal farmers with 2.52 quintals per annum. The Net Present Worth (NPW) was found highest in semi-medium farmers with Rs. 2,08,553 followed by small and marginal farmers with Rs. 1,69,913 and Rs. 1,31,370 respectively. The highest Benefit-Cost Ratio was found in semi-medium farmers with 2.91:1 followed by marginal farmers with 2.7:1 and small farmers 2.58:1. The highest Internal Rate of Return (IRR) was found in semi-medium farmers with 86.73%, followed by small farmers and marginal farmers. The Payback Period (PBP) was lowest in semi-medium farmers i.e., 2.21 years followed by semi-medium and small farmers.

1. Introduction

Aquaforestry is an integral part of the traditional agroforestry system in India. It is a practice that links trees with aquaculture. This is a system whereby trees or woody perennials are planted in or by water bodies such that the leaves of the trees are used as forage for fish (Nair 1991). Worldwide, Aquaforestry is practised by many ethnic communities in many other countries viz., Turkey (Ozden and Tolunay 2020), Nigeria (Ariwaoda *et al.* 2007), Southwest Nigeria (Akinwalere *et al.* 2017), etc. There are many plants parts used as potential feed for fish such as seed of *Sterculia setigera* (Adelakun *et al.* 2014), pod of *Samanea saman* (Rath *et al.* 2014), seed of *Gleditsia triacanthos* (Buyukcapar *et al.* 2012), leaves of *Moringa oleifera* (Yuangsoi and Masumoto, 2012), etc.

In India, agroforestry has been traditionally practised by ethnic communities such as the agri-silviculture system, Agri-silvi-horticulture system, Agri-horticulture system, Aquaforestry, etc. by Assamese and Nyishi communities of Assam and Arunachal Pradesh, respectively (Tanjang *et al.* 2009), ethnic community of Orissa (Singh *et al.* 2011), Nyishi tribe of Arunachal Pradesh (Pangging and Singh 2015), etc. Of these, Aquaforestry is one of the important agroforestry systems which has been traditionally practised since time immemorial in various states such as Arunachal Pradesh, Assam, etc. (Pangging and Singh 2015, Dabral and Baithuri 2007).

A perusal of the literature reveals that there were few studies conducted on the economic and financial analyses of Aquaforestry in Assam till date (Dabral and Baithuri 2007). The present study not only reports the socio-economic condition of Aquaforestry but also evaluates the biological yield and financial analysis. With this perspective, the study on "*Financial analysis and biological yield assessment of traditional Aquaforestry system: A case study from Lakhimpur district, Assam"* was taken up with the following objectives such as documentation of the socio-economic conditions of the farmers adopting aquaforestry; studying the biological yield of the Aquaforestry; financial analyses of Aquaforestry through calculation of Net present worth (NPW), Cost-Benefit Ratio, Internal rate of return (IRR) and Payback Period (PBP).

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2. Study area

The study was carried out in six selected villages viz., *No. 1 Borbali, No. 2 Borbali, Pathali Pahar, Rajbari, No. 1 Jokai Paluwa,* and *No. 1 Motia* of the Lakhimpur district in Assam, India. The headquarter of the district is North Lakhimpur and the district lies between 26°48'N to 27°53'N and 93°42' E to 94°20' E.

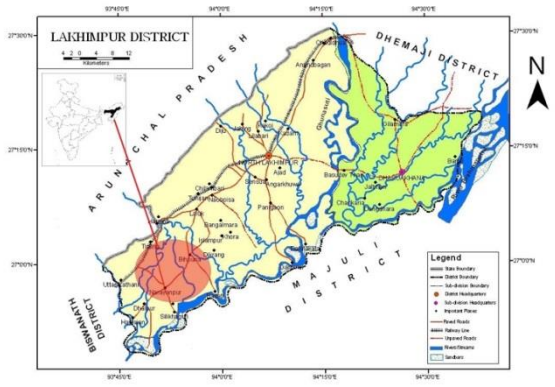

Figure 1. Map of the study site. (*Source: lakhimpur.nic.in)*

3. Material and Methods

The study was carried out through a questionnaire survey and informal interviews by adopting random sampling wherein 20 households were surveyed. The study was conducted from six selected villages viz., *No 1 Borbali, No 2 Borbali, Pathali Pahar, Rajbari, No 1 Jokai Paluwa, and No 1 Motia.* Of these, Rajbari Gaon had the highest population i.e., 1493 with 325 household units. The size of the aquaforestry area, location, information on the rearing of fish, and the types of trees grown were recorded during the field visits.

The socio-economic condition of farmers was recorded through a questionnaire survey and informal interviews. The farmers were categorised based on operational land holding (Anon. 2019)

Marginal farmer	:	>1ha
Small farmer	:	1-2 ha
Semi-medium farmer	:	2-4 ha
Medium farmer	:	4-10 ha and
Large farmer	:	>10 ha

The biological yield of the aquaforestry system was evaluated for each farmer category by incorporating all yield obtained from trees such as fruits, leaf fodder (LF), fuelwood (FW), construction (Const.) etc. The biological yield of horticultural and silvicultural crops were estimated by multiplying average number of trees with yield (kg) and the benefit was obtained from biological yield by multiplying the total yield (kg) with the market price (Rs. per kg). The fixed costs and operational costs were used for calculating the total costs whereas total net benefit was obtained by subtracting the total cost from the total benefit. The year of initial investment for construction of pond was different for each farmer however value of money was brought to the base year i.e., 2010.

The following formula is used:

$FV=PV\times(1+i)^n$, where:

- FV: Future value
- PV: Present value
- i: Interest rate
- n: Number of times the interest is compounded (years)

The average life period of the pond was considered 40 years and the rate of interest was 15%. In the financial analysis, Benefit: Cost ratio (B: C ratio), Net Present Worth (NPW), Internal Rate of Return (IRR) and Payback Period (PBP) were used. The discount rate of 15% was used for financial analysis wherein present cost and present benefit were calculated by multiplying the discount factor with cost and benefit, respectively. In the calculation, 2010 was considered as the base year where the total cost and benefit from 1-11 years were worked out. For the rest of 12-39 years, total cost and benefit were calculated by averaging the total cost and benefit from 1-11 years.

The Net Present Worth is the difference between the present worth of benefits and the present worth of costs.

The following are formula used:

Present worth benefits $= \sum_{i=1}^{n} \frac{B_t}{(1+r)^t}$;

Present worth costs $= \sum_{i=1}^{n} \frac{C_t}{(1+r)^t}$

Where n =life period of the pond in years, B_t=Benefits for the year t, C_t=Costs for the year t, r = Rate of discount.

Payback period (PBP) is the time period needed to recover an initial investment.

Payback period =E + $\frac{B}{C}$ where,

E= The year preceding immediately to recovery year

B= The amount left for recovering

C= Cash inflow in the final recovery year

Note: Cumulative cash inflows must be calculated prior to use these values

Internal Rate of Return (IRR) is the discount rate when the Net Present Value (NPV) =0.

IRR= Lower Discount rate + Difference between higher and lower discount rate x NPV of project lower Discount rate/ (Absolute difference of NPV of two discount rate).

4. Results and discussion

In the traditional aquaforestry system, farming was the dominant occupation in all farmer categories ranging from 60% to 85.71%. The nuclear family was the dominant family type, and the highest average family size was found in the small farmers with 7 members, followed by marginal and semi-medium farmers (Table 1).

Table 1. The occupation of aquaforestry farmers and family structure.

Farmer category	Occupation		Family structure		Average family size
	Farming	Business	Nuclear	Joint	
Marginal	60%	40%	80%	20%	5±1.85
Small	85.71%	14.28%	75%	25%	7±4.14
Semi-medium	66.6%	33.3%	71.42%	28.58%	6±2
Overall	**70.77%**	**29.19%**	**75.50%**	**24.50%**	**6**

The highest landholding was found in semi-medium farmers with 2.61ha followed by small farmers and marginal farmers. The average landholding of farmers was 1.43ha. The male and female ratio was highest in marginal farmers with 1:0.961 and the literacy rate was comparatively low in all the categories of farmers (Table 2).

Table 2. Education status, land holding, male and female ratio, and land: man ratio.

Farmer category	Average land holding	Literacy rate	Male and female ratio	Land: man ratio
Marginal	0.34	50%	1:0.961	0.06
Small	1.36	37.5%	1:0.71	0.19
Semi-medium	2.61	50%	1:0.7	0.43

The highest fodder requirement was found in semi-medium farmers with 41.25 kg per Household (HH) per day, followed by small farmers and marginal farmers. The highest fuel wood consumption per HH per day was found in small families with 3.78 kg per HH, followed by the marginal farmer and semi-medium farmer (Table 3).

Table 3. ACU, fuelwood, and fodder requirements

Farmer category	No. of household	Total ACU	Fodder requirement per HH per day (kg)	Fuelwood Consumption per HH per day (kg)
Marginal	10	2.24	6.27	2.7
Small	7	4.87	19.48	3.78
Semi-medium	3	4.42	41.25	2.6
Average			**22.33**	**3.06**

Table 4. Size of aquaforestry

Farmer category	Size of aquaforestry (m^2± SD)
Marginal	249±181
Small	535±440
Semi-medium	416±200

Table 5. Fixed Capital cost

Items	Fixed capital cost (Rs.)		
	Marginal	Small	Semi-medium
Initial investment for the construction of pond at base year.	24,586	37,000	30,947
Cost of tree plantation including pit preparation and seedlings	1,695	800	567
Fishing gear (nylon net), *Jakoi* and *Khaloi,* etc.	2,000	2,000	2,000
Total initial investment	**28,281**	**39,800**	**33,514**

Table 6. Operational cost at present year

Items	Operational cost (Rs.)		
	Marginal farmer	Small farmer	Semi-medium farmer
Cost of fingerling @ Rs. 4 $seed^{-1}$	2,500	3,500	4,500
Cost of Supplementary feeds; 50 kg (Marginal), 70kg (Small) and 100kg (semi-medium). @ Rs.30 kg^{-1}	1,500	2,100	3,000
Cost of labour charge for harvesting of fish; 3 mandays (Marginal), 4 mandays (Small) and 5 mandays (semi-medium) . @ Rs. 300 day^{-1}	900	1,200	1,500
Irrigation @Rs. 0.80 $plant^{-1}$ $year^{-1}$. (5 irrigations)	115	60	30
Input value of labour for harvesting and maintenance of trees; 3 mandays (Marginal), 2 mandays (Small) and 2 mandays (semi-medium) @ Rs. 200 day^{-1}	600	400	400
Cost for leasing of land @ Rs. 225 per $100\ m^2$	570	1,200	936
Depreciation @ 2.5%	707	995	838
Miscellaneous costs	141	200	130
Total Cost (Rs.)	**7,033**	**9,655**	**11,334**

Table 7. Biological yield of aquaforestry in marginal farmers category.

Components	Name of the species	Fruits production $tree^{-1}$(kg)	No. of tree ± SD HH^{-1}	Average Yield (Kg)			Goss benefit per HH (Rs.)
				Fruits	Fodder		
a) Fruit tree	*Areca catechu*	8	10.6±4.8	84.8	-		6,784
	Musa spp.	7	7.1±9.2	49.7	3		2,385
	Cocos nucifera	65	0.4±0.7	26	-		1,040
	Mangifera indica	20	0.6±0.9	12	-		960
	Ziziphus spp.	30	0.1±0.3	3	-		200
	Artocarpus heterophyllus	100	0.3±0.48	30	-		600
	Citrus maxima	75	0.1±0.3	7.5	-		375
	Carica papaya	15	0.2±0.6	3	-		90
Sub-total				**219**			12,434
				FW.	**Fruit**	**Const.**	
b) Forest tree	*Bambusa tulda*		11±13.9	10	-	20	300
	Archidendron bigeminum		0.3±0.9	-	-	-	-
	Gmelina arborea		1±1.7	3	-	-	50
	Ficus religiosa		0.2±0.6	-	-	-	-
	Alstonia scholaris		0.1±0.3	-	-	-	-
Sub-total				**33**			350
c) Fish	*Cyprinus carpio*		Fish (no.)				
	Ctenopharyngodon idella						
	Labeo rohita						
	Catla catla		312.5	**187.5**			30,000
	Probarbus jullieni						
	Hypophthalmichthys molitrix						
Total							**42,784**

FW = Fuelwood, HH=Household, Const.= Construction.

Gross income from fish, horticultural and silvicultural component = Rs. 42,784
Operational cost = Rs. 7,033
Net income (Total Gross income – Total operational costs) = Rs. 35,751

The average biological yield of horticultural & silvicultural crops and fishes in aquaforestry of marginal farmers category was 2.52 quintals per household and 1.87 quintals per household, respectively (Table 7).

Table 8. Present worth of costs and benefits of aquaforestry in marginal farmers category.

Year	Cost (Rs.)	Benefit (Rs.)	Discount factor@15%	Present worth cost (Rs.)	Present worth benefit (Rs.)	Present worth of Net Cash flow (Rs.)
0	28,281	0	1.00	28,281	0	-28,281
1	7,240	24,000	0.87	6,296	20,870	14,574
2	7,240	24,000	0.76	5,474	18,147	12,673
3	7,240	24,000	0.66	4,760	15,780	11,020
4	7,240	24,000	0.57	4,139	13,722	9,583
5	7,490	35,060	0.50	3,724	17,431	13,707
6	7,490	35,060	0.43	3,238	15,157	11,919
7	7,740	38,060	0.38	2,910	14,308	11,398
8	7,990	45,784	0.33	2,612	14,967	12,355
9	7,990	45,784	0.28	2,271	13,015	10,743
10	6,400	33,904	0.25	1,582	8,381	6,799
11	**7,033**	42,784	0.21	1,512	9,196	7,684
12-39	7,372	33,858	*	*	*	*
Total				77,152	2,08,522	1,31,370
Net Present Worth @ 15%						**1,31,370**
BCR Ratio @ 15%						**2.70**
IRR%						**65.31**
Payback Period (Years)						**2.68**

* Series of data from 12-39 years

(b) Small farmers.

Table 9. Biological yield of aquaforestry in small farmers category.

Components	Name of the species	Fruits produce tree^{-1}(kg)	No of tree HH^{1}	Average Yield (kg)			Gross Benefit per HH (Rs.)
				Fruits	Fodder		
a) Fruit tree	*Areca catechu*	8	8.28±4.9	66.24	-		5,300
	Musa spp.	7	3±3	21	1		1,050
	Mangifera indica	20	0.85±1.8	17	-		1,360
	Syzygium cumini	15	0.14±0.3	2.1	-		126
Sub-total				107.34			7,836
				LF.	FW	Const.	
b) Forest tree	*Bambusa tulda*		4.28±11.3	-	5	10	150
	Gmelina arborea		0.14±0.3	-	-	-	-
	Ficus religiosa		0.14±0.3	-	-	-	-
	Neolamarckia cadamba		0.71±1.8	-	-	-	-
Sub-total				15			150

c) Fish	*Cyprinus carpio* *Ctenopharyngodon idella* *Labeo rohita* *Catla catla* *Probarbus jullieni* *Hypophthalmichthys molitrix*		Fish (no.) 437.5	262.5	42,000
Total					**49,986**

FW =Fuelwood, HH=Household, LF= Leaf fodder, Const.= Construction.

Gross income from fish, horticultural and silvicultural component = Rs. 49,986
Operational cost = Rs. 9,655
Net income (Total Gross income – Total operational costs) = Rs. 40,331

The average biological yield of horticultural & silvicultural crops and fishes in aquaforestry of small farmers category was 1.22 quintals per household and 2.62 quintals per household, respectively (Table 9).

Table 10. Present worth of costs and benefits of aquaforestry in small farmers category.

Year	Cost (Rs.)	Benefit (Rs.)	Discount factor@15%	Present worth cost (Rs.)	Present worth benefit (Rs.)	Present worth of Net Cash flow (Rs.)
0	39,800	0	1.00	39,800	0	-39,800
1	10,150	36,000	0.87	8,826	31,304	22,478
2	10,150	36,000	0.76	7,675	27,221	19,546
3	10,150	36,000	0.66	6,674	23,671	16,997
4	10,150	36,000	0.57	5,803	20,583	14,780
5	10,400	45,240	0.50	5,171	22,492	17,322
6	10,400	45,240	0.43	4,496	19,559	15,062
7	10,650	48,240	0.38	4,004	18,135	14,131
8	10,900	52,986	0.33	3,563	17,321	13,758
9	10,900	52,986	0.28	3,098	15,062	11,963
10	8,400	40,986	0.25	2,076	10,131	8,055
11	9,655	49,986	0.21	2,075	10,744	8,669
12-39	10,173	43,606	*	*	*	*
Total				1,07,548	2,77,461	1,69,913
Net Present Worth @15%						**1,69,913**
BCR @15%						**2.58**
IRR%						**68.20**
Payback Period (Years) **2.53**						

* Series of data from 12-39 years

(c) Semi-medium farmers.

Table 11. Biological yield of aquaforestry in semi-medium farmers category.

Components	Name of the species	Fruits produce tree^{-1}(kg)	No of tree HH^{-1}	Average Yield (kg.)			Goss benefit per HH (Rs.)
				Fruit	Fodder		
a) Fruit tree	*Areca catechu*	8	4.66±2.3	37.28	-		2,982
	Musa spp.	7	3±3	21	1		1,050
	Cocos nucifera	67	0.33±0.57	22.11	-		884
	Carica papaya	15	0.33±0.57	4.95	-		148
Sub-total				86.34			5,064
				LF	FW	Const.	
b) Forest tree	*Gmelina arborea*		0.33±0.57	-	-	-	-
	Albizia lebbeck		0.33±0.57	-	-	-	-
	Lagerstroemia speciosa		1±1.7	-	-	10	100
Sub-total				10			100
c) Fish spp.	*Cyprinus carpio*		Fish (No.)	Fish (Kg)			
	Ctenopharyngodon idella						
	Labeo rohita						
	Catla catla						
	Probarbus jullieni		563	337.5			54,000
	Hypophthalmichthys molitrix						
Total							**59,164**

FW =Fuelwood, HH=Household, LF= Leaf fodder, Const.= Construction.

Gross income from fish, horticultural and silvicultural component = Rs. 59,164

Operational cost = Rs. 11,334

Net income (Total Gross income – Total operational costs) = Rs. 47,830

The average biological yield of horticultural & silvicultural crops and fishes in aquaforestry of semi-medium farmers category was 0.96 quintals per household and 3.37quintals per household, respectively (Table 11). The Benefit-Cost ratio was highest in semi-medium farmers i.e., 2.91, followed by small farmers (2.70) and small farmers (2.58) (Table no. 8, 10 and 12). However, Dabral *et al.* (2017) reported B:C ratio of water harvesting ponds between 1.5 to 2.93.

The highest Internal Rate of Return (IRR) was reported from semi-medium farmers i.e., 86.73%, followed by small farmers (68.20%) and marginal farmers (65.31%). Whereas the lowest Payback period (PBP) was found in the small farmer category i.e., 2.21 years, followed by small farmers (2.53 years) and marginal farmers (2.68 years) (Tables no. 8, 10 and 12).

5. Conclusions

From the present study, it can be concluded that aquaforestry is an important traditional agroforestry system of Assam that gives valuable resources to farmers such as fishes, fuelwoods, fodders and fruits. The financial analysis of aquaforestry w.r.t. three farmers categories based on their landholding was studied and found that NPW, Benefit-cost ratio, internal rate of return and payback period of aquaforestry were feasible and profitable. Thus, aquaforestry can be considered as a profitable sustainable land-use system and has the potential to improve the socio-economic condition of agroforestry farmers.

6. Acknowledgements

The authors would like to thank the aquaforestry owners of Lakhimpur district, Assam for their cooperation in completing the research work on traditional aquaforestry system.

Table 12. Present worth of costs and benefits of aquaforestry in semi-medium farmers category.

Year	Cost (Rs.)	Benefit (Rs.)	Discount factor @ 15%	Present worth cost (Rs.)	Present worth benefit (Rs.)	Present worth of Net Cash flow (Rs.)
0	33,514	0	1.000	33,514	0	-33,514
1	11,290	39,000	0.870	9,817	33,913	24,096
2	11,290	39,000	0.756	8,537	29,490	20,953
3	11,290	39,000	0.658	7,423	25,643	18,220
4	11,290	39,000	0.572	6,455	22,298	15,843
5	11,540	54,670	0.497	5,737	27,181	21,443
6	11,540	54,670	0.432	4,989	23,635	18,646
7	11,790	57,670	0.376	4,432	21,680	17,248
8	12,040	62,164	0.327	3,936	20,322	16,386
9	12,040	62,164	0.284	3,423	17,671	14,248
10	10,740	50,164	0.247	2,655	12,400	9,745
11	11,334	59,164	0.215	2,436	12,717	10,281
12-39	11,471	50,606	*	*	*	*
Total				1,09,464	3,18017	2,08,396
Net Present Worth @15%					**2,08,553**	
BCR @15%					**2.91**	
IRR% **86.73**						
Payback Period (Years) **2.21**						

* Series of data from 12-39 years

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