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Feasibility study and carrying capacity of Lake Batur ecosystem to preserve tilapia fish farming in Bali, Indonesia

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Abstract. *Budiasa IW, Santosa IGN, Ambarawati IGAA, Suada IK, Sunarta IN, Shchegolkova N. 2018. Feasibility study and carrying capacity of Lake Batur ecosystem to preserve tilapia fish farming in Bali, Indonesia. Biodiversitas 19: 563-570.* Lake Batur in Bangli District was potential for fishery development up to 5% of the total water area. Currently the lake area used for fishery was only 6.28 ha, leaving the area up to 77.07 ha potential for fishery development. Tilapia (*Oreochromis niloticus*) was the most abundant fish in the lake. This research aimed to evaluate the financial feasibility of tilapia fish farming with Floating Net Cages (FNC) technology within the lake and to assess its carrying capacity for the tilapia aquaculture. Discounted investment criteria were used to test farm survey data from 30 tilapia fish growers at top three villages which had the largest number of FNC. Six water samples were taken using deep water sampler at three sampling points were analyzed to see a number water chemistry and physics condition. The results showed that economic life of a FNC was financially feasible as indicated by the positive Net Present Value (NPV), Internal Rate of Return (IRR) was greater than 9% and Net Benefit Cost Ratio (Net B/C) was greater than one; and however the water quality as indicated by value of TDS, NO_2, BOD, Total-P, NH_3, and P-PO_4 exceeded the maximum limit of water quality criteria class II based on Government of Indonesia Regulation No. 82/2001. Thus, FNC should not be more expanded within the lake due to water pollution of the lake.

Keywords: Financial feasibility, fish diversity, floating net cages, Lake Batur, water pollution

INTRODUCTION

Water resources of the Bali Island are composed of surface water (rivers, canals, and lakes) and groundwater (Budiasa et al. 2018). Lake Batur located within UNESCO Batur Global Geopark resort in Kintamani Sub-district, Bangli District, Bali Province, Indonesia has been decided as tourism destination with natural panorama. Based on Regional Regulation of Bangli District No 9 in 2013 about Zoning Plan of Bangli District, it consists of 1,667 ha surface water area and 102 ha supporting area. It has 70 m in depth, water volume approximately 815,580,000 m^3, and shoreline as long as 21.4 Km. In reality, the water of Lake Batur provides several benefits such as domestic water supply, water transportation, irrigation of intensive horticulture farming, agro-tourism development, and aquaculture by floating net cages technology. Aquaculture as a newly emerged food production sector has being subjected to an increased level of public scrutiny, and one of the most contentious aspects has been its impacts on biodiversity (De Silva 2012). So far cage fish farming is not allowed by law in the Tanzanian waters of Lake Victoria on the fear of environmental pollution and other associated ecological effects (Kashindye et al. 2015).

Based on the zoning plan, about five percent of the lake water might potentially be allocated for fishery development with Floating Net Cages (FNC) technology. FNC for fishery development or Cage culture of fish is one of the proven methods of aquaculture (Devi et al. 2017). Tilapia in net cages was also grown at a tropical reservoir in Brazil (Roriz 2017). Integrated floating cage aquageoponics system (IFCAS) was another innovation in fish and vegetable production for shaded ponds in Bangladesh. It was financially feasible indicated by benefit-cost ratio of IFCAS was greater than one (Haque et al. 2015).

Since 1997, a two-year pilot project of tilapia fish (*Oreochromis niloticus*) farm by CV Prima with farm size of 192 m^2 (12 plots of FNC) had accelerated the local fish farming at Lake Batur. During this study only 6.28 ha of the lake area was used for FNC, hence there should be still vast area potential for the expansion of FNC within the lake. In addition, there were 184 groups of tilapia fish (*O. niloticus*) farmers with 3,924 total number of FNC with 16 m^2 average plot size. However, 26 units of FNC consisted of 350 plots were inactive due to some constraints faced by the local fish growers. The active fish growers were 2,398 managed 3,574 plots of FNC.

The diverse economic activities inside and around the lake were potential to cause water pollution and sedimentation. Hasim et al (2017) showed that among eight physical-chemical parameters there were only two of them categorized as suitable and only 8.03 ha (0.36%) was suitable, while 2,195.57 (99.64%) was unsuitable for environmentally friendly fish farming development in Lake Limboto, Gorontalo, Indonesia. In addition, the water pollution and sedimentation were arise because of development of floating net-cages business which exceeds the carrying capacity of Jatiluhur Reservoir (Simangunsong and Hidayat 2017). Based on Bali Agreement for Sustainable Lake Management formulated on National Conference of Lake Indonesia I in 2009, Lake Batur was included as one of the 15 national priority lakes with critical degradation level would be the restoration targets (Suwanto et al. 2011).

Head of Bangli District in 2017 stated that Lake Batur resort needed strategic policy and programs for sustainable fishery development based on integrated zone plan of Lake Batur ecosystem. Head of Animal Husbandry and Fishery Office Bangli District promoted tilapia fish (*O. niloticus*) as the common commodity which was considered very potential for the fishery development within the lake. However a number of questions might be raised, i.e., (i) was the tilapia fish farming with FNC technology at Lake Batur financially feasible? (ii) did the carrying capacity of Lake Batur ecosystem appropriate for further expanding the fishery development? Thus, the aims of this study were to evaluate the financial feasibility of tilapia fish farming with FNC technology within the lake and to assess the lake carrying capacity for developing aquaculture including tilapia fish farming.

MATERIALS AND METHODS

Study area

The study location was Lake Batur, Kintamani Sub-district, Bangli District, Bali Island, Indonesia (Figure 1). The selection of this lake was due to (i) 5% of its water is potential for fishery development with FNC technology based on the Zone Plan of Bangli District 2013-2033 and General Plan of Investment of Bangli District 2016-2025, (ii) no proper study to had been carried out to see the feasibility of the lake both economically and environmentally to be developed for FNC fisheries.

Procedures

Survey method

A survey method was used to collect data about tilapia fish farming. This survey used a structured questionnaire to collect data from 30 tilapia fish growers who were selected based on the largest number of FNC plot owners in the top three villages (Kedisan, Batur Tengah, and Songan B).

In each village, 10 fish growers were selected. The questionnaire consisted questions about the economic life of FNC owners, amount of investment, annual operation cost, fish farm productivity, and the profit per unit FNC.

Water quality sampling and laboratory test

Water quality can be assessed by various parameters such as BOD, temperature, electrical conductivity, nitrate, phosphorus, potassium, dissolved oxygen, etc (Bhateria and Jain 2016). To analyze the Lake Batur water quality, six water samples were taken at two water depths, 0.5 m and 50 m from the water surface at three sampling sites, i.e., WSP1 (08^{0}16'38.5"S-115^{0}23'30.9"E), WSP2 (08^{0}15'43.9"S-115^{0}24'17.2"E) and WSP3 (08^{0}15'43.9"S-115^{0}24'17.2"E). The water samples were taken on September 24th, 2017 using deep water sampler and brought to the laboratory on the following day. Selected physical, organic and inorganic chemical, and microbiological parameters were analysed and compared to national water quality standard class II based on Government Regulation No. 82, 2001 and regional water quality standard based on Governor Regulation of Bali Province number 16, 2016.

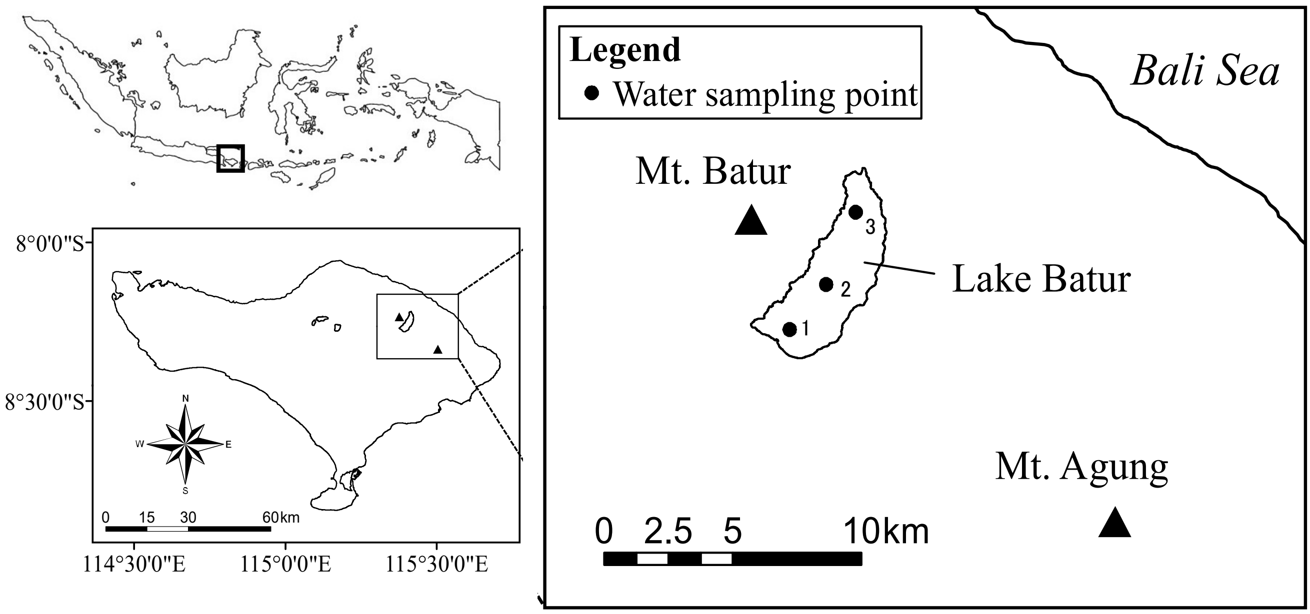

Figure 1. Study location andwater sampling points at theLake Batur, Bali, Indonesia. Point: 1 (08^{o}16'38.5"S-115^{o}23'30.9"E), 2 (08^{o}15'43.9"S-115^{o}24'17.2"E), and 3 (08^{o}14'16.2"S-115^{o}24'55.1"E)

Data analysis

Data from fish farm survey were quantitatively analyzed using *Benefit-Cost Analysis.* Discounted investment criteria such as Net Present Value, Internal Rate of Return, dan Net Benefit Cost Ratio (Sarma 2010) were used for the analysis of implementation.

The carrying capacity of Lake Batur ecosystem was analyzed using descriptive qualitative analysis. Results from the laboratory test on selected physical, organic and inorganic chemical, and microbiological parameters were compared to the national and regional water quality standard class II.

RESULTS AND DISCUSSION

Result

Data about the area, land use, and number of households in each village connected to the Lake Batur ecosystem are presented in Table 1. Number of local people from the 11 villages relied their life on the Lake Batur ecosystem is shown in Table 2. The villages around the Lake Batur were Terunyan, Abang Songan, Abang Batudinding, Suter, Buahan, Kedisan, Batur Tengah, Batur Selatan, Batur Utara, Songan A, and Songan B.

Based on the Zone Plan of Bangli District 2013-2033 that fishery development at Lake Batur was permitted up to 5% (83.35 ha) of the total area of Lake Batur water body, and the existing fish farm was only 0.38% (6.28 ha). Hence, it up to 77.07 ha of the water area was potential for expansion of the fishery development. However, out of 3,924 FNC plots,8.92% (350 plots)were inactive. Based on 30 samples of tilapia fish farming system with FNC technology at Lake Batur, the average number of FNC plot was 33.2 whereas a standard FNC has 9 plots (Table 3.).Thus, in average economic scale of fish farming was interconnected 3 unit FNCs, making the total plot would be 33 plots (Figure 2).

Table 1. Area, land use, and number of household within selected village nearest to the Lake Batur ecosystem, Bali, Indonesia (BPS 2017)

Village	Area (km^2)	Land use (Ha)				Number of households
		Plantation	Dryland food farming	Housing	Other	
Terunyan	19.63	115	972	36	840	807
Abang Songan	7.08	94	911	15	412	376
Abang Batudinding	14.33	77	312	10	310	761
Suter	12.56	71	296	17	872	876
Buahan	14.23	25	528	17	853	423
Kedisan	11.75	6	737	23	408	690
Batur Tengah	4.74	210	215	14	35	862
Batur Selatan	13.86	100	360	22	905	1,792
Batur Utara	3.36	0	167	9	160	506
Songan A	17.01	60	1,321	44	276	1,852
Songan B	11.88	65	700	95	328	2,576
Total	130.43	823	6,519	302	5,399	11,521

Table 2. Number of groups, number of group member, and number of FNC plot at Lake Batur, Bali, Indonesia

Village	FNC Group			Active Member			FNC Plot		
	Active	Inactive	Total	M	F	Total	Active	Inactive	Total
Terunyan	16	-	16	262	40	302	404	-	404
Abang Songan	6	-	6	66	14	80	84	-	84
Abang Batudinding	12	-	12	126	38	164	188	-	188
Suter	1	-	1	10	3	13	29	-	29
Buahan	14	-	14	148	34	182	219	-	219
Kedisan	26	-	26	216	125	141	452	-	452
Batur Tengah	18	4	22	222	79	301	868	47	915
Batur Selatan	11	1	12	101	52	153	231	20	251
Batur Utara	3	-	3	30	9	39	81	-	81
Songan A	15	2	17	172	54	226	252	18	270
Songan B	36	19	55	517	80	597	766	265	1.031
Total	158	26	184	1,870	528	2,398	3,574	350	3,924
Total FNC size (m^2)							57,184	5,600	62,784
Average number of FNC plot per group (plot)							22.62	13.46	21.33
Average FNC size per group (m^2)							361.92	215.38	341.22

Source: Data base of fishery group in Bangli District 2017

Table 3. Characteristics of tilapia fish farming system at Lake Batur, Bali, Indonesia

Village	Group Name	Year establish	Head group name	Member		Plot Number	Production		
				M	F		Total (Kg)	Period (month)	Kg/ plot
Kedisan	Mina Sandan	2012	Km Sukawan Adi	10	3	9	2,000	6	222.22
	Mulya Kedisan Sari	2012	I Kt Mawan	10	3	9	2,000	6	222.22
	Makmur Lestari	2012	I Wayan Sudana	10	3	9	2,000	6	222.22
	Seked Sari	2012	I Ngh Dester	10	3	90	27,000	6	300.00
	Werda Tani	2011	I Wayan Teka	9	4	9	2,000	6	222.22
	Mina Kedisan	2012	I Ketut Wijaya	10	3	9	2,000	6	222.22
	Mina Jati sari	2012	Ni Wayan Muliasih	10	3	9	2,000	6	222.22
	Mina Segara Madu	2012	I Ketut Wirnayasa	8	5	9	2,000	6	222.22
	Mina Abadi	2014	I Wayan Burat	9	4	42	12,600	6	300.00
	Bina Bersama	2014	I Kmg Arimbawa	14	2	20	4,000	6	200.00
Batur Tengah	Werdi Guna	2004	I Jero Ardana	13	-	30	6,000	6	200.00
	Dwi Segara	2007	I Kmg Arta	13	-	72	14,400	6	200.00
	Mina Kencana	2006	I Wayan Sokal	13	-	288	86,400	6	300.00
	Mina Juet Sari	2011	Wayan Sugandi	13	-	9	2,000	6	222.22
	Harapan Maju	2011	I Wayan Sudarba	13	-	9	2,000	6	222.22
	Mina Swadiri	2011	I Wayan Widiarta	13	-	9	2,000	6	222.22
	Budha Kerti	2011	Md Dedi Suriawan	13	-	9	2,000	6	222.22
	Mina Lestari	2011	I Ngh Lanus	13	-	36	7,200	6	200.00
	Arum Telaga sari	2012	I Ketut Necayana	13	-	12	2,400	6	200.00
	Mina Wantika	2013	Ni Wayan Suliastrini	13	-	18	3,600	6	200.00
Songan B	Bintang Danu	2006	I Gede Pt Ariadi	10	-	22	4,400	6	200.00
	Wana Sari Rahayu	2013	I Komang Arta	13	-	9	2,000	6	222.22
	Mina Ayu Werdi	2010	I Gede Kawi	10	-	18	3,600	6	200.00
	Sari Tirta Laksana	2004	I Wayan Arta	7	3	150	45,000	6	300.00
	Baruna Jaya	2011	I Kt Metu Kamajaya	10	-	45	9,000	6	200.00
	Nila Sari	2010	I Ngh Arto	10	-	9	2,000	6	222.22
	Merta Danu	2010	I Wayan Tarpedo	10	-	9	2,000	6	222.22
	Enggal Jaya	2011	I Gd Darta Wirawan	10	-	9	2,000	6	222.22
	Mina Danu	2011	Ni Wayan Nuriasih	10	-	9	2,000	6	222.22
	Manik Tirta Danu	2012	I Gede Medal	10	3	9	2,000	6	222.22
		Average		11	3.3	33.2		6	225.93

1	2	3
6	5	4
7	8	9

A standard FNC

1	2	3		1	2	3		1	2	3
6	5	4		6	5	4		6	5	4
7	8	9		7	8	9		7	8	9

Interconnected 3 FNCs

Figure 2. The illustration of plot number for a standard FNC and interconnected 3 FNCs

The average tilapia fish productivity over one growing cycle (6 months) was 225 kg/plot. A standard FNC had 9 plots with size 16 m^2 per plot. Total investment for constructing a standard FNC was IDR24,365,000 in the first year and IDR7,320,000 in the fourth year (Table 4).The fourth-year investment was intended to replace the floating bamboo (60%) which was used to last in three years, while the sunk bamboo could last up to seven years (Table 4.)

Operational cost of a standard FNC consisted of purchasing young fish, fish feed, medicine, and labor cost (Table 5 and Table 6). The young of tilapia fish ranged9-12cm in length was commonly used by local growers. Each plot of FNC needed approximately 2,000 young fish with average price of IDR400/fish. Two sinking feed brands, *i.e.*, Comfeed and Bintang were commonly used for feeding the fish and each FNC plot needed five packages of 50 kg each for one production cycle. The composition of fish feed was commonly 1:1 for Comfeed and Bintang. The price of the sinking feed wasIDR415,000/package at the local shops. However, a number of fish growers also used floating feed, Comfeed brand, priced IDR290,000 fora 30 kg package. The application of floating feed was physically 30% and financially 18% more efficient than of the sinking pellet.

Four months since the stocking time, the tilapia fish sized 3 to 4 individuals/kg were selectedly harvested and all fish were then collected at the end of the sixth month. In average, tilapia fish production was 225 kg plot with two price categories. About 50% of the fish was sold to a wholesaler, and the rest was sold to local retail sellers in Bangli District. The wholesaler price was IDR 18,000/kg tilapia fish with a minimum volume of one ton, while local buyers paid IDR23,000/kg as retail price. Hence, the expected revenue for each production cycle was IDR41,512,500 (Table 7) could the fish farmer harvested once in the first year and twice a year in the following years.

Table 4. Total investment for a standard FNC construction

Material	Volume	Unit	Price unit (IDR)	Total (IDR)
Bamboo	32	Stem	90,000	2,880,000
Styrofam	16	pieces	180,000	2,880,000
Net (1 inch)	1	pis	2,200,000	2,200,000
Net (1.5 inch)	2	pis	2,400,000	4,800,000
Rope (4 mm)	5	Roll	115,000	575,000
Rope (6mm)	2	Roll	165,000	330,000
Net worker	9	Plot	100,000	900,000
Bamboo worker	9	Plot	200,000	1,800,000
Manual boat	1	unit	5,000,000	5,000,000
Feed storage 2x1.5m^2	1	unit	3,000,000	3,000,000
Total Investment in the 1st year				24,365,000
Bamboo	18	Stem	90,000	1,620,000
Net worker	9	Plot	100,000	900,000
Bamboo worker	9	Plot	200,000	1,800,000
Feed storage 2x1.5m^2	1	unit	3,000,000	3,000,000
Total investment in the 4th year				7,320,000

Table 5. Operational cost of growing tilapia fish within a standard FNC by using sinking feed

Kind of input	Volume	Unit	Unit price (IDR)	Total (IDR)
Fish young 9-12 cm	18,000	tail	400	7,200,000
Sinking feed:				
Comfeed	22.5	zak (50 Kg)	415,000	9,337,500
Bintang	22.5	zak (50 Kg)	415,000	9,337,500
Medicine	2	sachet	45,000	90,000
Worker (labor)	6	month	1,500,000	9,000,000
Total				34,965,000

Table 6. Operational cost of growing tilapia fish within a standard FNC by using floating feed

Kind of Input	Volume	Unit	Unit price (IDR)	Total (IDR)
Fish young 9-12 cm	18,000	tail	400	7,200,000
Floating feed:				
Comfeed	52.5	zak (30 Kg)	290,000	15,225,000
Medicine	2	sachet	45,000	90,000
Worker (labor)	6	month	1,500,000	9,000,000
Total				31,515,000

Table 7. Expected revenue of one cycle tilapia fish farming within a standard FNC

Kind of product	Volume	Unit	Price unit (IDR)	Total (IDR)
Fresh Tilapia 3/4	1,012.5	Kg	23,000 (local market)	23,287,500
Fresh Tilapia 3/4	1,012.5	Kg	18,000 (wholesale)	18,225,000
Total				41,512,500

Table 11. Four scenarios of FNC-9 feasibility study

Scenario	NPV (000IDR)	IRR (%)	Net B/C	Decision
FNC-9-DF-WOF	15,573.95	30.48	1.88	Go project
FNC-9-DF-WF35M	13,823.40	73.92	4.10	Go project
FNC-9-FF-WOF	44,311.19	74.43	3.53	Go project
FNC-9-FF-WF32M	16,189.05	98.98	5.00	Go project

Based on the basic information in Table 4, Table 5, Table 6, and Table 7 four scenarios of financial feasibility were identified, namely (I) FNC-9-DF-WOF was growing tilapia fish of 9 FNC plots using sinking feed without financing (Table 8); (II) FNC-9-DF-WF35M was growing tilapia fish of 9 FNC plots using sinking feed with financing as much as IDR35 million (Table 9); (III) FNC-9-FF-WOFwas growing tilapia fish of 9 FNC plots using floating feed without financing, and (IV) FNC-9-FF-WF32Mwas growing tilapia fish of 9 FNC plots using floating feed with financing as much as IDR32 million. The difference between scenario I and scenario III was in operational expenditure while the difference between scenario II and scenario IV was in operational as well as the financing expenditure.

Discussion

Feasibility study of tilapia fish farming with FNC technology

By using discounted investment criteria such as NPV, IRR, and Net B/C at discount rate at 9% and economic life of FNC as long as 7 years, the application of sinking feed without financing into a standard FNC provided NPV as much as IDR15,573,950; IRR = 30.48% and Net B/C = 1.88 (Table 8 and Table 11). Then, with financing as much as IDR35 million for the second scenario, it provided NPV as much as IDR13,823,400; IRR = 73.92%; and Net B/C = 4.10 (Table 9 and Table 11). Furthermore, by applying floating feed without financing on the third scenario, it provided NPV = IDR44,311,190; IRR = 74.43% and Net B/C = 3.53. Finally, by financing as much as IDR32 million for implementing floating feed and other operating expenditure on the fourth scenario, it provides NPV = IDR16,189,050; IRR = 98.98%, and Net B/C = 5.00.Based on Table 11 it was found that the biggest NPV was using scenario 3 (FNC-9-FF-WOF) that implementing floating feed without financing into a standard FNC.

Carrying capacity of Lake Batur ecosystem to preserve fish diversity

The fish community within Lake Batur was dominated by introduced fish. All of the fish caught were introduced fish including *O. niloticus* (63.45%), 446 fish individuals and weighed 28.6 kg, followed by *O. mossambicus* (13.90%). In weight 82.66% of the fish, biomass was belonged to *O. niloticus*. The dominance of introduced fish in the lake Batur was probably due to the absence of endemic fish within in the lake (Sentosa and Wijaya 2012).

Table 8. Farm budget for growing tilapia fish within a standard FNC by using sinking feed without financing (000IDR)

Item	Year						
	1	2	3	4	5	6	7
Cash inflow							
Gross velue of production[a]	41,512.50	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00
Off-farm income	-	-	-	-	-	-	-
Incremental residual value[b]	-	-	-	-	-	-	-
Total inflow	41,512.50	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00
Cash outflow							
Investment	24,365.00	-	-	7,320.00	-	-	-
Operating expenditure	34,965.00	69,930.00	69,930.00	69,930.00	69,930.00	69,930.00	69,930.00
Incremental working capital[c]	10,489.50	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Total outflow	69,819.50	69,930.00	69,930.00	77,250.00	69,930.00	69,930.00	69,930.00
Net benefit before financing							
Total[d]	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Without project	-	-	-	-	-	-	-
Incremental	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Financing							
Loan receipts[e]	-	-	-	-	-	-	-
Debt service[f]	-	-	-	-	-	-	-
Net financing	-	-	-	-	-	-	-
Net benefit after financing							
Total[g]	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Without project	-	-	-	-	-	-	-
Incremental	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Cash position							
Net benefit after financing	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Less home consumed production[h]	1,080.00	2,160.00	2,160.00	2,160.00	2,160.00	2,160.00	2,160.00
Cash surplus (or deficit)	(29,387.00)	10,935.00	10,935.00	3,615.00	10,935.00	10,935.00	10,935.00
1/ (1+i)^t	0.9174	0.8417	0.7722	0.7084	0.6499	0.5963	0.5470
15,573.95	(25,969.72)	11,021.80	10,111.74	4,091.16	8,510.85	7,808.12	7,163.41

Note: a. From Table 7; b. Incremental residual value is accounted in the last year of the project, but in this case the incremental residual value of construction and equipment are assumed to be negligible since their value are too small; c. Taken to be 30 percent of the incremental operating expenditure in the following year; d. Total inflow less the total outflow; e. A loan received by fish grower from commercial banking as much as operating expenditure for a four-year period; f. Debt service includes principal and interest, and the annual interest rate is 9 percent; g. Total benefit before financing plus net financing; and h. It is assumed that the grower will consume approximately 60 Kg per one cycle of tilapia fish production with price IDR18,000/Kg.

Table 9. Farm budget for growing tilapia fish within a standard FNC by using drowning feed with financing as much as IDR35 million (000IDR)

Item	Year						
	1	2	3	4	5	6	7
Cash inflow							
Gross velue of production [a]	41,512.50	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00
Off-farm income	-	-	-	-	-	-	-
Incremental res. value [b]	-	-	-	-	-	-	-
Total inflow	41,512.50	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00	83,025.00
Cash outflow							
Investment	24,365.00	-	-	7,320.00	-	-	-
Operating expenditure	34,965.00	69,930.00	69,930.00	69,930.00	69,930.00	69,930.00	69,930.00
Incremental working capital [c]	10,489.50	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Total outflow	69,819.50	69,930.00	69,930.00	77,250.00	69,930.00	69,930.00	69,930.00
Net benefit before financing							
Total [d]	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Without project	-	-	-	-	-	-	-
Incremental	(28,307.00)	13,095.00	13,095.00	5,775.00	13,095.00	13,095.00	13,095.00
Financing							
Loan receipts [e]	35,000.00	-	-	-	-	-	-
Debt service [f]	10,451.72	10,451.72	10,451.72	10,451.72	-	-	-
Net financing	24,548.28	(10,451.72)	(10,451.72)	(10,451.72)	-	-	-
Net benefit after financing							
Total [g]	(3,758.72)	2,643.28	2,643.28	(4,676.72)	13,095.00	13,095.00	13,095.00
Without project	-	-	-	-	-	-	-
Incremental	(3,758.72)	2,643.28	2,643.28	(4,676.72)	13,095.00	13,095.00	13,095.00
Cash position							
Net benefit after financing	(3,758.72)	2,643.28	2,643.28	(4,676.72)	13,095.00	13,095.00	13,095.00
Less home consumed production [h]	1,080.00	2,160.00	2,160.00	2,160.00	2,160.00	2,160.00	2,160.00
Cash surplus (or deficit)	(4,838.72)	483.28	483.28	(6,836.72)	10,935.00	10,935.00	10,935.00
1/ (1+i)^t	0.9174	0.8417	0.7722	0.7084	0.6499	0.5963	0.5470
13,823.40	(3,448.36)	2,224.79	2,041.10	(3,313.10)	8,510.85	7,808.12	7,163.41

Note: From (a) to (h) are similar with Table 8.

Table 10. Water samples test results from Analytical Laboratory Udayana University, Bali, Indonesia

Indicator	Parameter	Unit	Class II	1/A	1/B	2/A	2/B	3/A	3/B	Remark
Physical	Temperature	^oC	Dev-3	24.00	24.00	24.50	24.50	25.00	25.00	Normal
	TDS	mg/L	1,000	**1,320**	**1,310**	**1,290**	**1,315**	**1,291**	**1,360**	**NAcc**
	TSS	mg/L	50	0.55	1.77	1.46	2.16	0.80	1.94	Acc
	Mercury	mg/L	0.002	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Acc
	Zinc	mg/L	0.05	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Acc
	NO_2 as N	mg/L	0.06	**1.13**	**0.02**	n.d.	n.d.	**1.13**	n.d.	**NAcc**
Inorganic chemical	pH	-	6-9	8.79	8.77	8.79	8.78	8.80	8.70	Acc
	BOD	mg/L	3	**7.09**	**5.10**	**6.39**	**4.03**	**5.72**	**5.03**	**NAcc**
	COD	mg/L	25	11.42	12.47	12.09	12.09	10.66	11.89	Acc
	Total phosphorus as P	mg/L	0.2	**2.67**	**1.64**	**1.50**	**0.43**	**4.11**	**2.60**	**NAcc**
	NO_3 as N	mg/L	10	0.29	0.20	0.59	0.21	0.15	0.26	Acc
	NH_3asN	mg/L	(-)	**0.82**	**0.72**	**0.62**	n.d.	**0.04**	**0.30**	**NAcc**
	Ntotal	mg/L	10	2.24	0.94	1.21	0.21	1.32	0.56	Acc
	P-PO_4	mg/L	0.05 (Ot) 0.15 (Mt) 0.2 (Et)	**0.29**	**0.20**	**0.59**	**0.21**	**0.15**	**0.26**	**NAcc**
Micro-biology	Total coliform	Number /100 mL	5,000	10	n.d.	n.d.	n.d.	n.d.	n.d.	Acc
Organic chemical	Oil and fat	ug/L	1,000	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Acc
	Phenol	ug/L	1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Acc

Note: 1, 2, 3areGPS-basedsampling point 1, 2, 3 respectively; A is 0.5m under water; B is 50m under water; Acc means acceptable; NAcc means not acceptable; and n.d. means not detected

Table 12. The composition of fish caught at Lake Batur, Bali, Indonesia based on survey in 2011 (Sentosa and Wijaya 2012)

Name	Scientific name	Length (cm)	Weight (g)	Individual number (n)	Biomass (g)
Tilapia	*Oreochromis niloticus*	7-31	62-588	283	23,637
Mujair	*Oreochromis mossambicus*	10.8-17.6	26.2-98.67	62	2,657
Nyalian Poleng	*Rasbora lateristriata*	4.6-13.3	1.3-31.77	53	554
Pedang	*Xiphophorus hellerii*	4.6-6.5	1.0-5.02	19	41
Seribu	*Poecilia reticulate*	4.5-6.2	1.0-3.08	6	10
Rasbora	*Rasbora* sp.	4.7-12.1	1.9-17.4	6	56
Nyalian Bali	*Puntius binotatus*	6.7-13.2	6.5-31.52	4	54
Red tilapia	*Oreochromis* sp.	12.9	44.52	1	45
Milkfish	*Chanos chanos*	51	950	1	950
Eel	*Monopterus albus*	38	128	1	128
Black louhan	*Amphilophus* sp.*1*	9.3-16	19.53-98	8	366
Red louhan	*Amphilophus* sp.*2*	11.5-15	28.00-68	2	96
	Total			446	28,593

Lake Batur was polluted by high TDS, NO_2, BOD, Total-P, NH_3, and P-PO_4. The high BOD values and relatively low values of the suspended matter content suggest that the organic matter available to bacteria was primarily in the dissolved form. The extremely high content of total phosphorus (more than 20 times the standard) and with such a high ratio of carbon, nitrogen, and phosphorus in water, was likely the cause of outbreaks of growth of cyanobacteria or heterotrophic bacteria. With their high growth, a sharp decrease in the dissolved oxygen content was frequently observed. A massive loss of fish in 2017 in this lake was suspected associated with the phenomenon of a sharp decrease in dissolved oxygen in the water. Thus, environmentally the water quality of Lake Batur is no longer able to receive more FNC. Even though just only one sample has very little number of total coliform. Gorlach-Lira et al (2013) reported that more samples within the site with FNC showed contaminated with *E. coli* and fecal streptococci than other sampling points.

The higher proportion of BOD compared to COD (53-62%)in the upper horizons, and 33-42% in the deep layers of water indicated that the content of the most toxic substances (not available for decomposition by microorganisms) was higher in the deeper water than near the water surface. This is an indirect confirmation that bottom sediments were highly toxic. The higher content of nitrite than nitrate in site 1 and 3, the northern and southern part of the lake, indicated that the nitrification process was higher in the upper layers. The results also suggest that the first phase of nitrification (from ammonium to nitrite) was higher than in the second phase (from nitrites to nitrates). This fact is often implied as an indication of presence of toxins in the water, since in the second-phase the bacteria are very sensitive to toxic substances. Thus, in addition to contamination from nutrients, it is very likely that toxic substances originated from the agricultural activities.

In conclusion, the present tilapia fish farming with FNC technology in Lake Batur is financially feasible as indicated by positive NPV, IRR is greater than 9%, and Net B/C is more than one, but the Lake Batur ecosystem is not able to support further expansion of the fishery due to the lake water pollution. Poor water quality for new aquaculture business can result in low profit, low product quality and potential human health risks (Devi et al. 2017). The poor water quality, in Lake Maninjau West Sumatera Province for example, was a major constraint to fish production (Syandri et al. 2017). Further study is required to find out the main source of water pollutants and alternative solutions to overcome it. A possible solution for the sustainable cage culture in Hungary and Romania, for example, is the combined pond (lake)-cage rearing method. The combined pond (lake)-cage rearing is an integrated system where cage culture is integrated with semi-intensive pond (lake) culture with feeding artificial diets in cages and without feeding and fertilizing in open ponds (lake) to utilize natural foods from cage wastes (Gál et al. 2011).

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