E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2023; 11(1): 101-108

www.fisheriesjournal.com
Received: 01-10-2022
Accepted: 03-11-2022

BK Baliarsingh
Department of Tribal Welfare, PN Complex, Gurkhabasti, Kunjaban, West Tripura, Tripura, India

Dipmala Ro
Department of Fishery, PN Complex, Gurkhabasti, Kunjaban, West Tripura, Tripura, India

KK Navaladi
MS Swaminathan Research Foundation, Jeypore, Koraput, Odisha, India

Corresponding Author:
BK Baliarsingh
Department of Tribal Welfare, PN Complex, Gurkhabasti, Kunjaban, West Tripura, Tripura, India

Water quality, yield and cost-benefit analysis of rain water ponds of Cuttack district: A comparison between Indian major carp and GIFT Tilapia

BK Baliarsingh, Dipmala Roy and KK Navaladi

DOI: https://doi.org/10.22271/fish.2023.v11.i1b.2767

Abstract
A comparative research study was executed to assess the production and cost-benefit return from Indian major carp (IMC) and GIFT tilapia, *Oreochromis niloticus*. The research study was operated with two individual tank size of 0.4 ha each (T1 & T2) for a period of 9-10 months from September, 2018 to June, 2019 with a selected farmer of Cuttack district, Odisha state. The present study focused on water quality parameters, production and cost-benefit analysis. An Interview with a pre-tested questionnaire was conducted for data collection during April 2020. In T1 & T2, the mean value of temperature varied 26.3±4.56 &27.7±6.5; pH 7.5±0.55 &7.5±0.35; DO 6.07±1.35 &5.3±0.51; Transparency 27.71±0.86 & 29.29± 0.81; Alkalinity 100.4±12.8 & 98.3±14.2 and Ammonia 0.55±0.05 &0.58±0.04 respectively. The study tanks were demonstrated by World fish through Dept. of fisheries, Govt. of Odisha sponsored project. In T1, advance fingerlings of *Catla catla* 9-12cm & 18-23g, *Labeo rohita* 10-12cm & 18-24g and *Cirrhinus mrigala* 8-11cm & 15-19g were stocked with density10,000/ha with catla, rohu & mrigala in the percentage ratio of 40:30:30 respectively on 3rd September 2018, whereas in T2, average size of GIFT mono-sex tilapia seed 6-7cm &7-9gm were stocked with density 16,000/ha on 15th September 2018. In T1 & T2 (>91 & 93.7%) the survival rate and the final harvest done in June 2019. The total harvest of 8457.5 kg/ha was done in T1; where as in T2, total harvest was 20,000kg/ha with cost benefit ratio of 0.81 in case of IMC poly-culture and 1.22 in case of GIFT mono-sex tilapia.

Keywords: GIFT mono-sex tilapia, carp poly-culture, water quality, production, cost-benefit analysis, Cuttack district

1. Introduction
The aquaculture production approximately 82 million tones with a value of $ 250 billion contributes 46% of the total global production about 179 million tones in 2018. The Indian contribution reached 8.61% to world aquaculture production (FAO, 2020) [1]. The importance of aquaculture can be seen in terms of its contribution to socio economic development (Haque *et al*., 2014; Chowdhury *et al*., 2017) [2, 3], nutrition supply (Thilsted *et al*., 2014) [4], employment generation, poverty alleviation (Sedhuraman, 2014; Karim *et al*., 2006) [5, 6] and foreign exchange earnings (Belton *et al*., 2011) [7] of the country.
The huge inland water bodies of India endowed with 1,95,210 kms of rivers and canals, estuaries 0.3 million ha, backwaters and lagoons 0.19 million ha, reservoirs 3.15 million ha, floodplain wetlands and ponds/tanks 2.41 million ha & 0.798 million ha respectively (Tamuli *et al*., 2017) [8]. The share of production of capture fishery from rivers and estuary is very less. The major contribution of inland capture fishery is from reservoirs and floodplain wetlands, whereas the major production contribution is from aquaculture sector (FAO, 2005) [9]. Fishery sector justified its contributions in generate foreign exchange, employment and helping in GDP growth. A research shows around 14.5 million people in India involved directly or indirectly in fishery sector. (Ayyappan, 2011) [10]. Aquaculture is the cost effective alternative to high cost fishing during energy crisis and expensive fishing. (Ayyappan & Jena, 2001; Ayyappan, 2004; Jana & Jena, 2004; Pillai & Katiha, 2004) [11, 12, 13, 14].
Odisha is considered as one of the major fish producing states of India, constituting of 30 administrative districts and it is situated in the eastern part of the country (Fig. 1).

The availability of aquatic resources in the state about 155,707 km^2 is comprising of tank/pond of 1.33 lakh hectare, reservoir of 2.00 lakh hectare, lake, floodplain wetlands, swamps with 1.8 lakh hectare and rivers and canals constituting 1.7 lakh hectare (GoI, 2017) [15]. In addition, the state possesses six major river systems *viz*. the Brahmani, Baitarini, Mahanadi, Subarnarekha, Budhabalanga and rushikulya (Baliarsingh *et al*., 2014) [16]. The contribution of fish production from the state 0.6MT to the total fish production of the country (GoI, 2018) [17], apart from that the state requires 50,000metric tones of fish, mitigate the demand of per capita requirement @ 15.38 kg (GoO, 2015) [18].

In recent time many more comparative research have been carried out in the field of fish culture (Saud BJ *et al*., 2013) [19]. The recent example was comparative experimental study of Tilapia and African catfish (Ibrahim *et al*., 2010) [20], Macrobrachiam rosenbergii (Goda *et al*., 2010; Asaduzzaman *et al*., 2009) [21, 22] and carp fish (Frei *et al*., 2007) [23]. The quick growth and maximum margin profit motivate the rural farmers to involve in Tilapia farming and get maximum of two yields per year (Hussain *et al*., 2000; Hussain *et al*., 2004) [24, 25]. Because of poor information and technical skill of farmers always affecting the production. Having some challenges, such as poor financial condition, farming information, knowledge on inflow-outflow relationship in aqua-farm lead them to lower outcome and unsatisfactory application the technology. Therefore, it is very important to highlight the essential accessories, inflow-outflow mechanism and its relationships. The above information always helps the farmers to maintain the farm in profitable way. Apart from this, farmers should know the input and output cost for the management point of view and performance as well.

The present study is carried out to comparison of IMC and GIFT Tilapia, which is consider for income generation through fish farming in Cuttack district, Odisha. Further, it provides the basic information about the input and output comparative cost structure to the farmer community.

2. Materials and Methods

2.1 Study area

The comparative research study was conducted in the year 2018-19 at Jodamu village, block Narasinghpur, Cuttack, Odisha in two individual seasonal pond which was situated side by side (T1 & T2) area of 0.4 ha each (Fig. 1) with the financial & technical assistant of state government tilapia project and Worldfish.

2.2 Overall district information

Cuttack district of Odisha is situated between 20°51′68’’N & 85°72′ 56”E (Fig. 1). The total of 3932 km2 geographical areas endowed with fisheries resources like reservoir and MIP 376.4 ha, swamp and Bheels 141.25 ha and pond and tank 2562.46 ha (Das *et al*., 2017) [26]. The district has a total of 22202 MT during 2018-19. (GOI, 2018) [17]. Rivers and Bheels are the major source of capture fisheries whereas ponds and tanks are the major source of aquaculture.

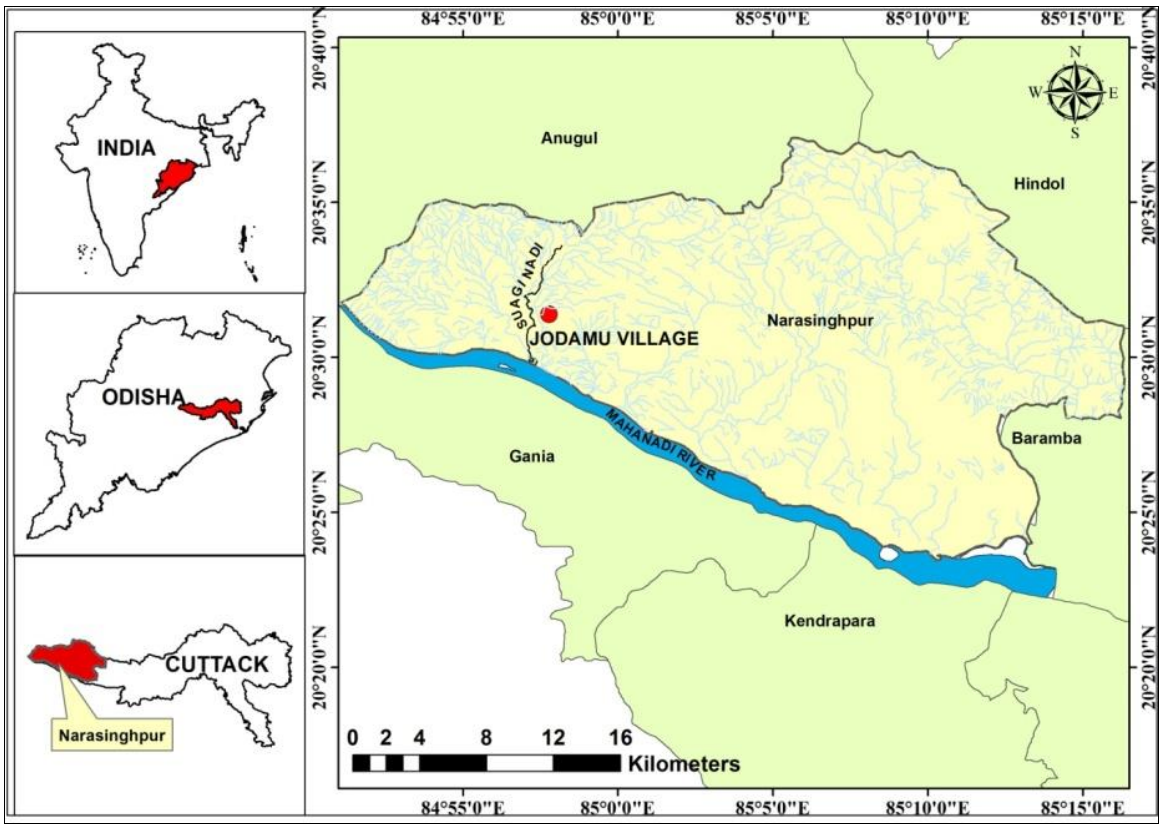

Fig 1: Location of the experimental side, Jodamu, Cuttack, Odisha

2.3 Research pond selection

Base line survey & Dept. of fishery in the concerned district was the main source for identification of suitable tank for the research. The criteria for the tank selection were the minimum resource availability for culture practice, farmer experience in fish farming, good water source and input availability. Two individual tanks situated side by side (T1 & T2) were selected for the comparative study at Jodumu village, under Narasinghpur block, Cuttack. The tank size was (0.4 ha) each tank for IMC polyculture (C. *catla, L. rohita* & *C. mrigala*) and GIFT mono-sex tilapia (*O. niloticus*) culture practice. Both the fish tanks were managed by farmer and all data

related to culture practice collected and documented in farm register by the farmer under the guidance of the project.

2.4 Bio-security procedure and license issue
In tank-2, GIFT mono-sex tilapia initiated in the year 2018. Under the scheme, 4 no. of happa and bio-security net were provided to the farmer. After the bio-security ensured, the farmer received the license from local district fishery office.

2.5 Preparation of fish tanks
As per the standard procedure, the fish tanks (T1 & T2) were eradicated of weeds and wild fishes in the ponds, clearing of dyke and testing of water-soil in the laboratory. The water samples were collected and tested in regular interval. The lime quantity in the ponds was @ 600-800 kg/ha, organic fertilization @ 400-600 kg/ha and inorganic fertilizer like Urea and SSP @ 40 and 20 kg/ha/yr. Yearly dose of fertilization like cow dung, urea and phosphate splitting into monthly dose.

2.6 Stocking and feeding
In Tank-1, advance fingerlings likes (*Catla catla* 9-12cm & 18-23g, *Labeo rohita* 10-12cm & 18-24g and *Cirrhinus mrigala* 8-11cm & 15-19g were stocked with density 10,000/ha and percentage of ratio catla: rohu: mrigala: 40: 30: 30 on 3rd September 2018, and Tank-2, advance fry (GIFT mono-sex tilapia 2-3 cm & 1-2g) was stocked on 15th September 2018, with the density 16000/ha. Initially the tilapia seeds were reared in happa for 30 days and after that it was released in the pond directly with the seed attaining the size (6-7 cm & 7-9g). Ground nut oil cake and rice bran approximately@1:1 ratio and starter-1(Company feed) were used as fish feed in tank-1 & 2, at initial stage. Including the supplementary feeding, there is fortnightly application of formulated slurry dose (GNOC @ 5kg, Soya power @ 2.5kg, Jiggery @ 25kg, Yeast @1kg, Rice bran @ 10kg and Curd @ 20 kg)was done in each pond for production and maintenance of the natural feed in the pond. After one month, floating feed was provided and sampling was done at regular intervals in order to observe the growth in terms of length and weight of the fish. Regular monitoring of water and health of fishes in both tanks was done. Fertilization, liming and fish feeding were regulated through regular monitoring.

2.7 Pond water parameters
Water parameters like temperature (0^{C}), dissolved oxygen (mg/l), total alkalinity (mg/l), Transparency (cm) and ammonium-N (mg/l), were analyzed in regular intervals (Table 1). The DO calculate through DO meter (YSI, Model-58, USA), pH calculate by pH meter and transparency of water were determined through Secchi Disc. Alkalinity and ammonia were determined by Ammonia/alkalinity testing Kit (APHA 1998) [27].

Table 1: Ranges and mean values (± SD) of water parameters in T1 &T2

Parameters	T1-IMC poly-culture			T2-GIFT tilapia mono-sex		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Temp (°C)	21.1	33	26.3±4.56	21.2	34.1	27.7±6.5
Transparency (cm)	24.33	35.67	27.71± 0.86	25.00	36.00	29.29± 0.81
DO (ppm)	4.3	7.5	6.07±1.35	4.5-	6.0	5.3±0.51
pH	7.0	8.4	7.5±0.55	6.0	8.0	7.5±0.35
Alkalinity mg/l	86.7	114.7	100.4±12.8	80.1	114.0	98.3±14.2
Ammonia mg/l	0.51	0.61	0.55±0.05	0.55	0.64	0.58±0.04

2.8 Fish harvest
The research tanks were harvested in the month of May-June-2019; fish growth were measured through length-weight measurement; survival rate was calculated based on total fish stocked; production data were compared between Tank-1 & 2 and the data is converted in to kg/ha/yr (Table 2).

Table 2: Fish stocking & production data-IMC poly-culture & GIFT Tilapia mono-sex culture in T1 & T2 (2018-19)

Tank No.	Pond Area (ha)	Stocking (no)	Date of Stocking	Types of fish Stocking	Growth estimate during stocking (August-2018)		Growth estimate during final harvest (May-June-2020)		Total production (kg)	FCR
					Length in (cm)	Weight (g)	Length in (cm)	Weight (g)	Weight in (kg)	
T1	0.4	4000	05.09.2020	*Catla*	9-12	18-23	28.3-39.6	980-1070	1682	1.7
				Rohu	10-12	18-24	28.0-41.3	700-750	880	
				Mrigala	8-11	15-19	29.4-37.6	680-720	821	
T2	0.4	6400	15.09.2020	GIFT tilapia (*O. niloticus*)	6-7	8-9	28.3-32.1	1333	8000	1.2

2.9 Economic analysis
Tank wise economic calculation was conducted for estimation of profit. The calculation based on the local fish price and market price of all input items. The costs of feed, seed, probiotics, limes, transport, etc. shown in (Table 3 & Fig. 2). In the cost table an additional 7.5% on total was included and not included the pond leasing amount. (ADCP, 1983). The net profit was calculated by subtracting the gross cost from the gross return per acre. The profit margin was also measured as a ratio of net benefit to gross cost.

Table 3: Comparision of operational cost, production and economic profit of IMC polyculture & GIFT mono-sex tilapia culture during 2018-19 at Jodamu village of district Ciuttack, Odisha

Parameters	T1-IMC culture (area-.4 ha)		T2-GIFT Tilapia culture (area-.4 ha)	
Operational Cost	**Expenditure (Rs/0.4ha/yr)**	**Expenditure (Rs/ha/yr)**	**Expenditure (Rs/0.4ha/yr)**	**Expenditure (Rs/ha/yr)**
I. Expenditure				
Watering/de-watering charges	3,000	7,500	3,000	7,500
Bleaching Powder 50kg@Rs30/kg	1,500	3,750	1,500	3,750
Organic Manure 1000kg@Rs 0.5/kg	500	1,250	500	1,250
DAP fertilizer 20kg@ 20/kg	400	1,000	400	1,000
Lime-800kg (IMC), 1000kg (GIFT tilapia) @ Rs 10/kg	8,000	20,000	10,000	25,000
GNOC-25kg (IMC), 42kg (GIFT tilapia) @ Rs 22/kg	550	1325	924	2310
Soyabin 21kg @Rs 30/kg	630	1,575	630	1,575
Curd 120 kg @ 40/kg	4800	12000	4800	12000
Yeast 5kg @ Rs 200/kg	1000	2500	1000	2500
Ricebran 80kg @ Rs 15.5/kg	1,240	3,100	1,240	3,100
Joggery-100kg (IMC), 208kg (GIFT tilapia) @ Rs 23/kg	2,300	5,750	4,784	11,960
IMC seed4000pc @ Rs 5/pc and GIFT seed cost 6400pc @ Rs 2/pc	20,000	50,000	12,800	32,000
IMC-F. Feed 5500kg @ Rs 40/kg and GIFT tilapia F. Feed 9800kg @ Rs 40/kg	2,20,000	5.50,000	3,92,000	9,80,000
Transport @ Rs10000/time	20,000	50,000	30,000	75,000
Man power for pond preparation, bio-security installation, Management, Feeding, netting, watch and ward, marketing etc. @ 200/man day (IMC & GIFT)	10,000	25,000	30,000	75,000
Miscellaneous expenditure (medicine, aeration, transaction and coordination)	5,000	12,500	10,000	25,000
Total expenditure	2,98,920	7,47,300	5,03,578	15,22,070
IMC poly-culture & GIFT mono-sex tilapia Production and economic profit (2018-19)				
II. Gross Income from GIFT tilapia	0.4 ha/yr	ha/yr	0.4 ha/yr	ha/yr
Total production (kg/yr)	3383	8457.5	8000	20000
IMC & GIFT Cost of fish @ Rs 160 & 140/kg (Rs)	5,41,280	13,53,300	11,20,000	28,00,000
Net income from fish (Gross income-expenditure) (Rs)	2,42,360	6,05,900	6,31,172	15,77,930
Return on expenditure (%)	81.07	0.81	125.33	103.67
Cost benefit ratio (C:B)	0.810	0.81	1.25	1.25

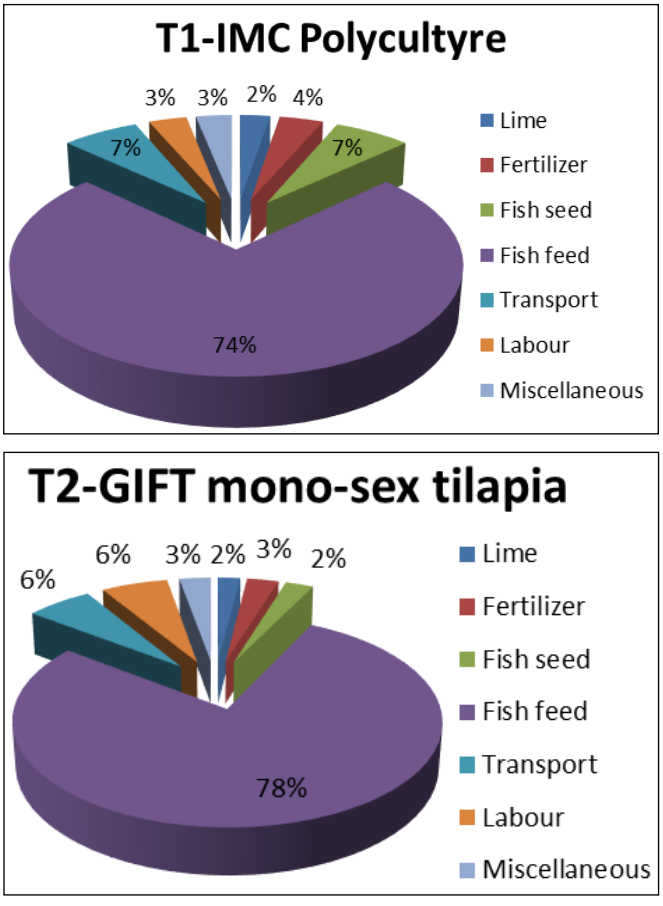

Fig 2: Average share of various cost in IMC poly-culture and GIFT mono-sex culture in T1 & T2 (2018-19)

3. Results and Discussion

3.1 Water parameters

The water quality parameters like pH, transparency, temperature, dissolved oxygen, alkalinity and ammonia in two tanks are mentioned in (Table 1). The water quality in T1 & T2 like pH values in both the pond were found to be alkaline and varied from 7.0 to 8.4 with mean limit of 7.5±0.55 and 7.5±0.35. Transparency varied from 24.33 to 36.00 cm with mean limit of 27.71±0.86 and 29.29±0.81 cm. Temperature varied from 21.1 to 34.1 °C with mean limit of 24.03±4.56 °C and 27.7±6.5 °C. Dissolved oxygen (DO) ranged from 4.3 to 7.5 mg/l with mean limit of 6.07±1.35 and 5.3±0.51 mg/l. Alkalinity in the pond varied from 80.1 to 114.7 mg/l with mean limit of 104.4±12.8 and 98.3±14.2 mg/l. while, the presence of ammonia varied from 0.51-0.64 mgL-1 with mean limit of 0.55±0.05 and 0.58±0.04 mg/l respectively.

The water temperature of both the tanks ranged minimum 21.1 to maximum 34.1 °C during the culture period. The temperature variation may be due to the weather condition of high sunshine and heavy rain. (Likongwe *et al.*, 1996) [29] reported that small water bodies follow the air temperature. For productivity water having level of dissolve oxygen should be the range in between 5.00 to 7.00 mg/l and below 5 mg/l always count for unproductive (Banerjee, 1967) [30]. The percentage of dissolve oxygen (DO) should be more than 5ppm for good fish production (Bhatnagar and Singh, 2010 and Bhatnagar *et al.*, 2004) [31, 32]. Also stated that the lower DO (2-3 ppm) has lethal effect on digestion and growth. The present study indicate the low concentration of DO in T1 & T2, this is because of early measurement of DO in T1 & T2 (8.00 am). Because of high tolerance to fluctuation of environment effect, Tilapia has no negative effect on growth and survivability. In the present study, pH ranged in between

7.3 to 8.4 in T1 and 6.5 to 8.5 in T2, as stated by (Swingle, 1969) [33] that pH should be in a range of 6.5 to 9.0 is suitable for pond fish culture. The recent study indicated that pH in both the tanks were suitable for fish culture (Michael, 1969 and DOF, 1996) [34, 35].

The transparency of water ranges 24.3 to 36.00 cm, which might be due to the turbidity and more plankton production. Similar range of transparency was recorded by (Latif *et al*., 1986; Wahab *et al*., 1995) [36, 37]. (Boyd, 1982) [38] stated that, the minimum and maximum range of transparency should be 15-40 cm are good for integrated fish farming and below 12 cm causes stress (Bhatnagar *et al*., 2004) [32]. The turbidity should be minimum 30 and maximum 80 cm is symbolized for fish health; the good productivity for aquaculture should be 30-40 cm in secchi disk as per the statement by (Santhosh and Singh, 2007) [39]. The present value indicates the permissible limit for aquaculture.

Alkalinity should be ideal between 75 to 200 mg L-1 as per (Wurts and Durborow, 1992) [40]. During the study period minimum and maximum range of alkalinity documented in between 80.1 to 114.7 mg/l. The content of ammonia should be less than 0.2 ml/l and not more than 0.1 ml/l for fish farming (Bhatnagar and Singh, 2010; Meade, 1985; Santhosh and Singh, 2007) [31, 42, 39]. The recommended ammonia concentration for aquaculture practices considered safe below 0.02 ppm (Swann, 1997) [41]. Present study indicates the permissible limit of water quality for aquaculture practice.

3.2 Growth and production

In T1 and T2, details of FCR, Initial and final weight of fish, survival rate and total production mentioned in (Table 2 & 4). In T1 and T2 the FCR was 1.7 and 1.2 respectively. In T1 & T2, there was a survival rate of 91% to 93.75% and the production was highest (3383 kg/ha/yr) and (8000 kg/ha/yr). The research study shows that, net return of 15,41, 055/ha/yr which was a highest production of Tilapia in T2 in compare to 6,05,900/ha/yr. The benefit cost ratio was 1.22 for Tilapia whereas .81 in T1 (Table 3 & 4). It was observed that, the Tilapia growth more that 38.8% in compare to IMC.

Results showed that the growth and production as well as initial and final length and weight summarized in (Table 2 & 4). In the present study, IMC poly-cultured and GIFT tilapia showed that the growth in T2 was comparatively higher than that of IMC poly-culture. Maximum number of GIFT tilapia male population found significant effect of production in earthen pond (Mair and Van Dam, 1996). Some of the collective points which was responsible for maximum growth, production and survivability of GIFT tilapia in comparison of IMC poly-culture; The initial period of 30 days happa rearing in the pond probably the main cause of higher survivability (Dan and Little, 2000a; normal growth in month of December to February where IMC was very slow growth (Cruz and Ridha, 1994; Crab *et al*., 2009) [46, 47, 48]; high range of cold tolerance (Behrends *et al*., 1983, Chaani *et al*., 2000, Frei *et al*., 2007 and Kolar *et al*., 2005) [49, 50, 23, 51], Size of seed (Hofer and Watts, 2002) [52]; Feeding and fertilization (Bhakta, 2003) [53]. All male population (Azaza *et al*., 2008 and Lovshin *et al*., 1990) [55, 45]. The optimum growth can influence by methyl testosterone, which is used for sex reversal to GIFT tilapia in compare to IMC. As per the statements (Kuwaye *et al*., 1993) [57] the methyl testosterone use for growth promoter in species of Oriochromis genus. As stated by (Dan and Little, 2000b) [58] the FCR for GIFT tilapia comparatively low compared to IMC poly-culture, further it would suggest that more research on the role of Curd, Yeast powder, Jiggery and Soya powder in preparation of slurry and its importance of natural food development and management in pond water.

Table 4: Growth and production of IMC poly-culture & GIFT mono-sex tilapia in T1 & T2 (2018-19)

Parameters	Growth-production data	
	T1	T2
Initial avg. weight (g)	19	8
Final avg. weight (g)	816	1333
Survival rate (%)	91	93.75
Production (kg/pond/9 months)	3383	8000
Total production (kg/ha/9 months)	8457.5	20000

4. Cost benefit analysis (CBA)

The present study showed high survival rates of 91 and 93.75% in (T1 & T2) and the survival rate was higher in case of GIFT tilapia documented by (Hossain *et al*., 2004) [59]. The BCR values found in T1 and T2 were 0.81 and 1.22 respectively. The total production of fishes in T1 & T2 were 8457.5 and 20000 kg/ha respectively. Because of the natural food availability and input of high quality supplementary feed may be responsible for higher side production in T2, also it is observed that, fortnightly application of curd, soya powder, jaggery, yeast and GNOC slurry during the study period, the similar kind of production have been observed by (Hossain *et al*., 2004 and Hossain, 2007) [59, 60]. As per the statement (Boyd, 1982) [38], only fertilization cannot responsible for fish growth without high quality supplementary feeding. (Gupta *et al*., 1991) [61] stated that, production of tilapia 3554.76 kg/ha with use of supplementary feed in compare with 1510.71 kg/ha in fertilized ponds. The cultural period and rearing seasonal periods along with factors can make the difference in production in the pond. The difference between net returns of GIFT tilapia and IMC was 160% more than of IMC net profit (Rahman *et al*., 2012) [43].

As per the statement by (De *et al*., 2012, Rahman *et al*., 2012) [62, 43] that intensive Carp and Tilapia culture feed was the highest cost item. In the present study the similar kind of observation found in both GIFT tilapia and IMC poly-culture. Followed by labor & transport cost (Boateng *et al*., 2013) [63]. The benefit cost ratio specify that IMC poly-culture was able to recover Rs. 0.81 in T1 whereas, GIFT tilapia mono-sex culture was get back a return of Rs. 1.22 per Rs. 1.0 investment which may be due to higher revenue with minimum production costs (Fig.2 & Table 3).

5. Conclusion

The cost benefit information worked out in the above described study would be profitable for the farmers both in domestic consumption as well as commercial tilapia farming system. It is also clear that both IMC poly-culture and GIFT mono-sex tilapia culture would be profitable. The study shows the net income in GIFT tilapia is more than double as compared to IMC poly-culture in same time period and the average cost of tilapia mono-sex culture was maximum due to supplementary feed cost. The study concludes that maximum profit, export value will encourage the tilapia farmers to continue their sustainable culture practices for domestic as well as commercial fish farming in Odisha. It is advisable for further improvement, farmers should be updated with latest technology, input-output cost management, high quality formulated and floating feed and continued quarantine and

tighter bio-security standards. The bumper production of GIFT tilapia was surprised the researcher and fish loving people. This raises the question whether the huge production of GIFT tilapia was really due to the efficient pond management practices adopted by the farmer (Mr. Karana) or due to the contribution by the curd, yeast, jiggery and soya powder which were added to the pond for the development of natural feed. Hence, further research should be conducted for this angle.

6. Acknowledgements

The authors acknowledge the State Government, Odisha for funding this GIFT tilapia project, the department of Fishery, Odisha and Worldfish jointly provide the technical support and implementation work for this project. Authors are also express their gratitude to the Block level officers, Village farmers and farm owner of Jodamu, Narasinghpur, Cuttack, Odisha, for nice coordination and conducting the research work in his ponds. Thanks to Dr. C. Vishnumurthy Mohan, Principal scientist & Director, Worldfish, India for his inspiration & encouragement.

7. References

1. FAO. The State of World Fisheries and Aquaculture. Sustainability in action. Rome; c2020. https://doi.org/10.4060/ca9229en
2. Haque MM, Little DC, Barman BK, Wahab MA, Telfer TC. Impacts of decentralized fish fingerling production in irrigated rice fields in Northwest Bangladesh. Aquaculture Research. 2014;45:655-674.
3. Chowdhury AH, Chowdhury FJ, Rahman L. Marketing System of Tilapia Fish in Some Selected Areas of Bangladesh. Imperial Journal of Interdisciplinary Research. 2017;3(1):447-452.
4. Thilsted SH, Wahab MA. Production and conservation of nutrient-rich small fish (SIS) in ponds and wetlands for nutrition security and livelihoods in South Asia. In: Proceedings of a World Bank/SAFANSI funded regional workshop on small fish and nutrition, Dhaka, Bangladesh; c2014. p. 47.
5. Sedhuraman V, Haq BMA, Kavitha P, Ahamed SA, Rao MV, Tiwary C, *et al*., Status on non-alien species SPF Pacific white shrimp Litopenaeus vannamei in India-An overview. Journal of Applied Science and Research. 2014;2(5):126-145.
6. Karim M, Ahmed M, Talukder RK, Taslim MA, Rahman HZ. Dynamic agribusiness-focused aquaculture for poverty reduction and economic growth in Bangladesh. The WorldFish Center discussion series no. 1. WorldFish Center, Penang; c2006.
7. Belton B, Karim M, Thilsted SH, Collis W, Phillips M. Review of aquaculture and fish consumption in Bangladesh. Food Nutr. Bull. 2011;21:482-487.
8. Tamuli AK, Borah S, Kapil DN. Economic analysis of fish farmer and in Kamrup district, Assam, India. Asian Journal of Agricultural Extension, Economics & Sociology. 2017;20(1):1-7.
9. FAO. National Aquaculture Sector Overview India. FAO, Rome; c2005. Available: http://www.fao.org/fishery/country sector/naso_india/en
10. Ayyappan S, Sugunan VV, Jena JK, Gopalakrishnan A. Indian Fisheries. In: Handbook of Fisheries and Aquaculture. DKMA, ICAR, New Delhi; c2011. p. 11-16.
11. Ayyappan S, Jena JK. Sustainable freshwater aquaculture in India. In: Sustainable Indian Fisheries (ed. Pandian TJ). National Academy of Agricultural Sciences, New Delhi; c2001. p. 88-131.
12. Ayyappan S. Enhancing global competition. Survey of Indian Agriculture. The Hindu; c2004. p. 97-100.
13. Jana RK, Jena JK. Overwhelming growth. Enhancing global competition. Survey of Indian Agriculture. The Hindu; c2004. p. 101-103.
14. Pillai NGK, Katiha PK. Evolution of Fisheries and Aquaculture in India. Central Marine Fisheries Research Institute, Kochi; c2004. p. 34.
15. GoI. Annual Report 2016-17, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Framers welfare, Govt. of India; c2017.
16. Baliarsingh BK, Kosygin L, Rout SD. Fish diversity and Physico-Chemical Characteristics of Rivers of Ganjam district, Odisha. Biological Forum-An International Journal; c2014. p. 13-18.
17. GoI. Handbook of Fisheries statistics, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Framers welfare, Govt. of India; c2018.
18. GoO. Odisha Fisheries Policy. Govt. of Odisha; c2015.
19. Saud BJ, Chetia M, Borah S, Ramteke KK, Kashyap D, Sharma P. Growth surveillance of Labeo rohita (hamilton, 1822) fingerlings fed on two formulated feeds. 2013;19(04):1085-88.
20. Ibrahim N, Naggar GE. Water quality, fish production and economics of Nile tilapia, Oreochromis niloticus and African catfish, Clarias gariepinus, monoculture and polycultures. Journal of the World Aquaculture Society. 2010;41(4):574-582.
21. Goda AMAS, Wafaa MIAH, Omar EA, El-Bermawey NM, Hebalah SMA. Influence of different dietary protein levels and feeding frequencies on growth performance and feed utilization of the Giant freshwater prawn, Macrobrachium rosenbergii with the Nile tilapia, Oreochromus niloticus in polyculture. Egyptian Journal of Aquatic Biology and Fisheries. 2010;14(2):53-67.
22. Asaduzzaman M, Wahab MA, Verdegem MCJ, Benerjee S, Akter T, Hasan MM, *et al*., Effects of addition of tilapia Oreochromis niloticus and substrates for periphyton developments on pond ecology and production in C/N-controlled freshwater prawn Macrobrachium rosenbergii farming systems. Aquaculture. 2009;287(3-4):371-380.
23. Frei M, Razzak MA, Hossain MM, Oehme M, Dewan S, Becker K. Performance of common carp, *Cyprinus carpio* L. and Nile tilapia, *Oreochromis niloticus* (L.) in integrated rice-fish culture in Bangladesh. Aquaculture. 2007;262(2-4):250-259.
24. Hussain MG, Kohinoor AHM, Islam MS, Hossain MA, Dey MM, Mazid MA. Growth and production performances of gift strain of Nile tilapia, *Oreochromis niloticus* L., in ponds and cages under different farming conditions in Bangladesh. Journal of the Aquaculture in the Tropics. 2000;15(3):273-280.
25. Hussain MA, Roy R, Rahmatullah SM, Kohinoor AHM. Effect of stocking density on the growth and survival of GIFT tilapia, (*Oreochromis niloticus*) fed on formulated diet. Journal of Agriculture and Rural Development. 2004;2(1):127-133.
26. Das BK, Chandra G, Meena DK, Kumari S, Koushlesh SK, Das AK, *et al*. Roadmap for Development of Inland

Open Water Fisheries in Eastern States of India. ICARCIFRI, Barrackpore; c2017. p. 68. ISSN 0970-616X
27. APHA. Standard Methods for the Examination of Water and Wastewater, 20th edition, APHA (American Public Health Association), Washington, USA; c1998.
28. ADCP. Fish feeds and feeding in developing countries. Aquaculture Development and Co-ordination Programme. ADCP/ REP/ 83/ 18. FAO; c1983. p. 97.
29. Likongwe JS, Stecko TD, Stauffer JR, Carline RF. Combined effects of water temperature and salinity on growth and feed utilization of juvenile Nile tilapia *Oreochromis niloticus* (Linneaus). Aquaculture. 1996;146:37-46.
30. Banerjee SM. Water quality and soil condition of fish ponds in some states of India in relation to fish production. Indian Journal of Fisheries. 1967;14:115-144.
31. Bhatnagar A, Singh G. Culture fisheries in village ponds: a multilocation study in Haryana, India. Agriculture and Biology Journal of North America. 2010;1(5):961-968.
32. Bhatnagar A, Jana SN, Garg SK, Patra BC, Singh G, Barman UK. Water quality management in aquaculture, In: Course Manual of summer school on development of sustainable aquaculture technology in fresh and saline waters, CCS Haryana Agricultural, Hisar (India); c2004. p. 203-210.
33. Swingle HS. Standardization of chemical analysis for waters and pond mud. FAO. Fisheries Research. 1969;4:397-421.
34. Michael RG. Seasonal trends in physico-chemical factors and plankton of a fresh water fish pond and their role in fish culture. Hydrobiology. 1969;33:144-160.
35. DOF. Matsha Pakkah Shankalan. Directorate of Fisheries, Bangladesh; c1996. p. 81.
36. Latif MA, Ali MM, Islam MA. A comparative physico-chemical study of a well-managed fishpond and a derelict pond. Bangladesh J Aquacult. 1986;6-7(1):71-78.
37. Wahab MA, Islam MT, Ahmed ZF, Hoq MS, Haque MA, Biswas BK. Effect of frequency of fertilization on the pond ecology and growth of fishes. BAU Res. Prog. 1995;9:410-419.
38. Boyd CE. Water quality Management for pond fish culure. Elsevier Science Publisher, The Netherlands; c1982. p. 318.
39. Santhosh B, Singh NP. Guidelines for water quality management for fish culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Publication No. 29; c2007.
40. Wurts WA, Durborow RM. Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds Southern Regional Aquaculture Center, SRAC Publication No. 464; c1992.
41. Swann LD. A Fish Farmer's Guide to Understanding Water Quality, Aquaculture Extension Illinois, Purdue University, Indiana Sea Grant Program Fact Sheet AS-503; c1997.
42. Meade JW. Allowable ammonia for fish culture, Progressive Fish culture. 1985;47:135-145.
43. Rahman MM, Shamsuzzaman MM, Mahmood M, Sarker S, Alam MD. Economics of Tilapia Culture in Watershed Pond in Bangladesh. Journal of Aquaculture Research and Development. 2012;7(4):367-377.
44. Mair GC, Van Dam AA. The effect of sex ratio at stocking on growth and recruitment in Nile Tilapia (Oreochromis niloticus) ponds. In: The International Symposium on Tilapia in Aquaculture, Pullin RSV, Lazard J, Legendre M, Amon Kothias JB and Pauly D. (eds.), ICLARM Conf; c1996. p. 100-107.
45. Lovshin LL, De-Silva AB, Cameiro-Sobrinho A, Melo FR. Effects of Oreochromies niloticus females on the growth and yield of male hybrids (O. niloticus female x *O. hormonrun* male) cultured in earthen ponds. Aquaculture. 1990;88:55-60.
46. Dan NC, Little DC. Over-wintering performance of Nile tilapia *Oreochromis niloticus* (L.) brood fish and seed of ambient temperatures in Northern Vietnam. Aquaculture Research. 2000a;31:485-493.
47. Cruz EM, Ridha M. Over-wintering tilapia, *Oreochromis spilurus* (Gunther), fingerlings using warm underground sea water. Aquaculture and Fishery Management. 1994;25:865-871.
48. Crab R, Kochva M, Verstraete W, Avnimelech Y. Bio-flocs technology application in over-wintering of tilapia. Aquacultural Engineering. 2009;40:105-112.
49. Behrends LL, Smitherman RO. Use of warm water effluents to induce winter spawning of tilapia in temperate climates. In: Proceedings of the First International Symposium on Tilapia in Aquaculrure, L. Fishelson and Z. Yaron (eds.), Tel Aviv, Israel; c1983. p. 446-454.
50. Chaani A, Gall GAE, Hulata G. Cold tolerance of tilapia species and hybrids. Aquaculture International. 2000;8:289-298.
51. Kolar CS, Chapman Jr. DC, Courtenay WR, Housel CM, Williams JD, Jennings DP. Asian carps of the Genus Hypophthalmichthys (Pisces, Cyprinidae)-A biological synopsis and environmental risk assessment. Report to US Fish and Wildlife Service per Interagency Agreement. 2005;94400:30-128.
52. Hofer SC, Watts SA. Cold tolerance in generally the mail tilapia (GMT registred), Oriochromis niloticus. World Aquaculture. 2002;33(2):19-23.
53. Bhakta JN. Fertilizer microbial interaction in waste water system, influence of fertilizer doze and stocking density of fish. Ph.D. Thesis, University of Kamlyani, India; c2003. p. 199.
54. Grag SK, Bhatnagar A. Effect of fertilization frequency on pond productivity and fish biomass in still water ponds stocked with *Cirrhinus mrigala* (Ham). Aquacul. Res. 2000;31:409-414.
55. Azaza MS, Dhraïef MN, Kraïem MM. Effects of water temperature on growth and sex ratio of juvenile Nile tilapia *Oreochromis niloticus* (Linnaeus) reared in geothermal waters in southern Tunisia. Journal of Thermal Biology. 2008;33:98-105.
56. Lovshin LL, Tave D, Lieutaud AO. Growth and yield of mixed-sex, young-ofthe-year *Oreochromis niloticus* raised at two densities in earthen ponds in Alabama, U.S.A. Aquaculture. 1990;89:21-26.
57. Kuwaye TT, Okimito DK, Shimoda SK, Howeiton RD, Hoa-Ren L, Pang PKT, Grau EG. Effect of 17α-methyl testosterone on the growth of euryhaline tilapia Oreochromis mossambicus, in fresh water and sea water. Aquaculture. 1993;113:137-157.
58. Dan NC, Little DC. The culture performance of mono sex and mixed sex new season and over-wintered fry in three strains of Nile tilapia (*Oreochromis niloticus*) in Northern Vietnam. Aquaculture. 2000b;184:221-231.

59. Hossain MA, Roy R, Rahmatullah SM, Kohinoor AHM. Effect of stocking density on the growth and survival of GIFT tilapia, (*Oreochromis niloticus*) fed on formulated diet. J Agric. Rural Dev. 2004;2(1):127-133.
60. Hossain MS. Evaluation of rice bran and wheat bran as a supplemental feed compared to a commercial feed for the monoculture of GIFT tilapia (*O. niloticus*) in ponds. M.S. Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymen Singh; c2007.
61. Gupta MV, Akhteruzzaman M, Kohinoor AHM, Shah MS. Nile tilapia (*Oreochromis niloticus*) culture under different feeding and fertilization regimes. In: Pullin RSV, Lazard J, Legendre M, Amon Kothias JB and Pauly D (eds). The Third International Symposium on Tilapia in Aquaculture. ICLARM Conf. Proc. c1991;41:500-504, 575.
62. De HK, Chattopadhyay DN, Radheshyam GS, Saha AK, Pal S, Satpapati TS. Strenthening the livelihoods of rural women through Polyculture of carps in seasonal ponds. Indian J Fish. 2012;59(3):137-141.
63. Boateng VF, Alhassan EH, Saahene Y, Nensom E, Abarike ED. Profitability Analysis of all-male Tilapia Farming in Sekyere South and Bosomtwe Districts of Ashanti Region. Agriculture and Biology Journal of North America. 2013;4(5):568-575.