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Inland Fisheries Production Condition with Production Unit-Wise Productivity and Production Growth Rate in Bangladesh

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ABSTRACT

In Bangladesh, 85% of fisheries yield comes from inland fisheries. There is an evident production gap between the inland capture and culture fisheries in sample data, but what is in population? The study evaluates the production gap between inland capture and culture fisheries by appropriate test statistics and traces the production share, productivity, yield area, and growth status of various production units of inland fisheries. The required data have been collected from the website of the department of fisheries of Bangladesh. To evaluate the production gap, the study relies on the Mann-Whitney-Wilcoxon U test. The P-value, 0.02272 < 0.05, suggested that there is a significant yield gap between the population of inland capture and culture fisheries in Bangladesh. Inland capture and culture controlled 82.06% and 17.94% of inland production area and 33.03% and 66.97% of production, respectively. The productivity of the inland culture fishery is 9.2 times higher than the inland capture. Rivers, floodplains, and ponds combinedly control 83.07% of the inland production area and 82.57% of the inland yield. To achieve the vision of Bangladesh, policymakers should make separate fishery policies for rivers, floodplains, and ponds. This study might be helpful to national and international bodies to understand the inland fisheries population and production units which might be helpful to restructure fisheries policy in Bangladesh

INTRODUCTION

Bangladesh is an agriculture-based developing country, and 40.6% of its labor force has employed in agriculture (Bangladesh Bureau of Statistics, 2018). In Bangladesh, the contribution of agriculture was 11.61% of the Gross Domestic Product (GDP) in 2021, while the fishery sub-sector was 2.54% (Manik, 2023). For subsistence, either full-time or part-time, at least 12% of the 165 million population of Bangladesh relies on fisheries and aquaculture (Department of Fisheries of Bangladesh, 2020). Although Bangladesh is developing, 24.3% and 12.9% of its population are suffering from poverty and extreme poverty, respectively (Bangladesh Bureau of Statistics, 2019).

At least 91% of the global aquaculture yield is grown by Asian states in 2017 (Tacon, 2020). Developing and climate change-hazardous countries like Bangladesh are combinedly supplying 90% of the world's aquaculture production (Islam et al., 2019). In the inland capture fishery segment, Bangladesh produced 1.22 million metric tons and held third place in the world in 2018, but it produced only 0.66 million metric tons of the marine fishery segment in the same year (Food and Agriculture Organization, 2020). Inland and marine fisheries production in Bangladesh was 85.26% and 14.74%, respectively, in 2021. Bangladesh is not having enough success extracting its marine resources, although it has vast marine area in the Bay of Bengal (Manik, 2022). The country's inland water bodies occupy nearly 45,000 km^2, approximately one-third of its total area (Bishwajit, 2014).

Because of socioeconomic and climate change reality at least one-third child in Bangladesh are bearing the problems of low growth rate, malnutrition, and an imbalanced diet (World Food Programme, 2016). Fish is one of the major sources of animal protein and other vitamins for the human body, so fisheries resources may help to achieve food security with a balanced diet in Bangladesh. In the regular diet, per capita, the fish intake requirement of Bangladesh is 60 g (Nahar et al., 2013). Daily, per capita, fish consumption in Bangladesh was 49.5 g in 2010 and 42.1 g in 2005 (Bangladesh Bureau of Statistics, 2010). For the first time in 2016, the country acquired its expected fish intake requirement in a regular diet, which was 62.6 g per capita per day (Bangladesh Bureau of Statistics, 2019). Due to geographic position and environment, in Bangladesh, fish is relatively obtainable and inexpensive than other animal protein sources like meat.

The vision of Bangladesh is to meet the animal protein demand, decrease poverty, and increase export income from fisheries resources (Ministry of Fisheries and Livestock, 2019). To acquire the vision, Bangladesh should increase its production in the future. The inland fisheries yield is 85% of the total yield in Bangladesh. The inland fisheries production trend from 2007 to 2019 shows there is a clear production gap between inland capture and inland culture (Jahid et al., 2021). This gap might be raised from the sample characteristics or other reasons. So, what about the population characteristics? Further, what is the production status of different inland production units? This study is conducted to address these questions. The study objectives are to evaluate the production gap between the inland capture and inland culture by using an appropriate statistical test and depict inland production unit-wise productivity and growth rate scenario. This study might be helpful for the policymakers of Bangladesh to make future fishery policies to achieve the vision. International communities like WorldFish may use this study to make new strategies.

METHODS

Required data for this study has been collected from the website[1] of the department of fisheries of the government of Bangladesh. There are 20 uploaded files on the website entitled "Yearbook of Fisheries Statistics of Bangladesh", and the year-wise inland capture and culture fisheries production data, FY 2001-02 to FY 2020-21, are collected from those files. The inland fishery in Bangladesh has 12 production units, whereas inland capture fishery covers five units, and inland culture fishery covers the rest seven units. Production units of inland capture are River, Sundarbans, Beel, Kaptai lake, and Floodplain, and the units of inland culture are Pond, Seasonal cultured waterbody, Baor, Shrimp farm, Carb production, Pen culture, and Cage culture. To depict production unit-wise productivity and growth rate, the study has collected data from FY 2019-20 to FY 2020-21 from the same website. For analytical purposes, the production of FY 2020-21 in the original data file has been considered as the production of 2021.

To evaluate the gap between the inland culture and the inland capture fisheries yield, either the parametric, student t-test, or the non-parametric, Mann-Whitney-Wilcoxon U (MWWU) test, might be a good option. Before performing the student t-test, one must check the normality assumption of the data set. If data do not follow the normality assumptions, the MWWU test should be used as an alternative to the student t-test (Gupta and Kapoor, 2004). If the sample size is less or equal to 20 and breaks the normality assumptions, the MWWU test shows more efficiency and strength than the student t-test (Fay and Proschan, 2010). The MWWU test is used as an alternative to the student t-test to evaluate the difference between the two samples (Manik et al., 2023). Because of the characteristics of the data, the research depends on the MWWU test rather than the student t-test.

RESULTS AND DISCUSSION

This study emphasizes only inland fisheries production because 85% of total production comes from this sector. Figure 1 shows the year-wise capture, culture, and total inland fisheries yield trend in Bangladesh from 2002 to 2021. In Bangladesh, in 2002, the total inland production was 14.8 hundred thousand metric tons, whereas capture and culture were 6.9 and 7.9 hundred thousand metric tons which were 46.7% and 53.3%, respectively. After 19 years, in 2021, the total inland yield turned to 39.4 hundred thousand metric tons, whereas capture turned to 13.0 hundred thousand metric tons, 33.0%, and culture turned to 26.4 hundred thousand metric tons, 67.0%. Although the two segments are increasing gradually, the increasing rate of the culture segment is much higher than the capture segment.

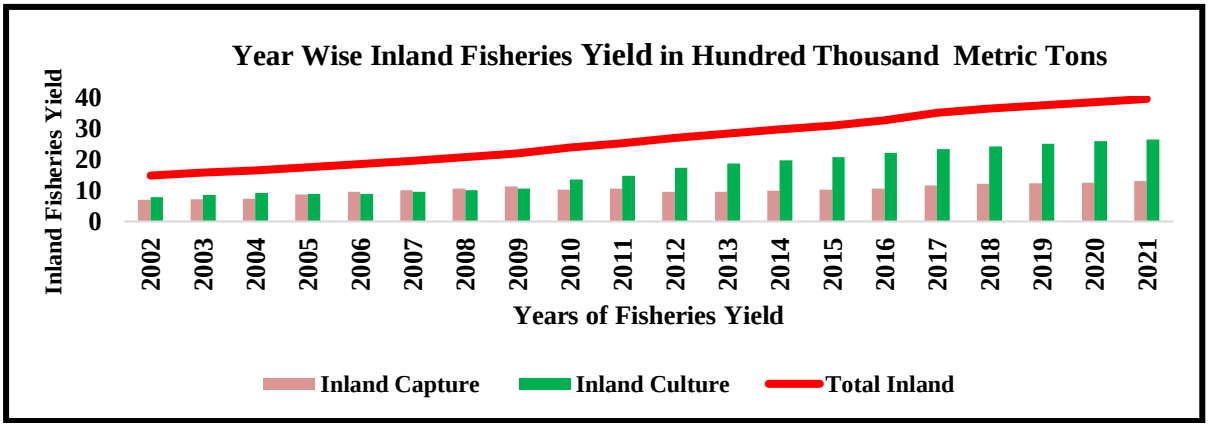

Figure 1. Inland Fisheries Production Trend in Bangladesh from 2002 to 2021

The production trend is presented in figure 1 based on the sample data, and a clear production gap between capture and culture is observed. This gap might be raised due to the sampling technique, sampling process, or any other reasons. To know the population distribution, one must perform an appropriate statistical test of the hypothesis based on the sample data, so the study performs an appropriate statistical test to infer the production gap of inland capture and culture fisheries production in Bangladesh.

To run the student t-test, the normality assumption of the data set must be checked. This study makes a histogram plot to check the normality assumption of data sets. The inland capture fisheries production violates the normality assumption due to the lack of bell shape among the different adjacent bars in the histogram plot in figure 2.

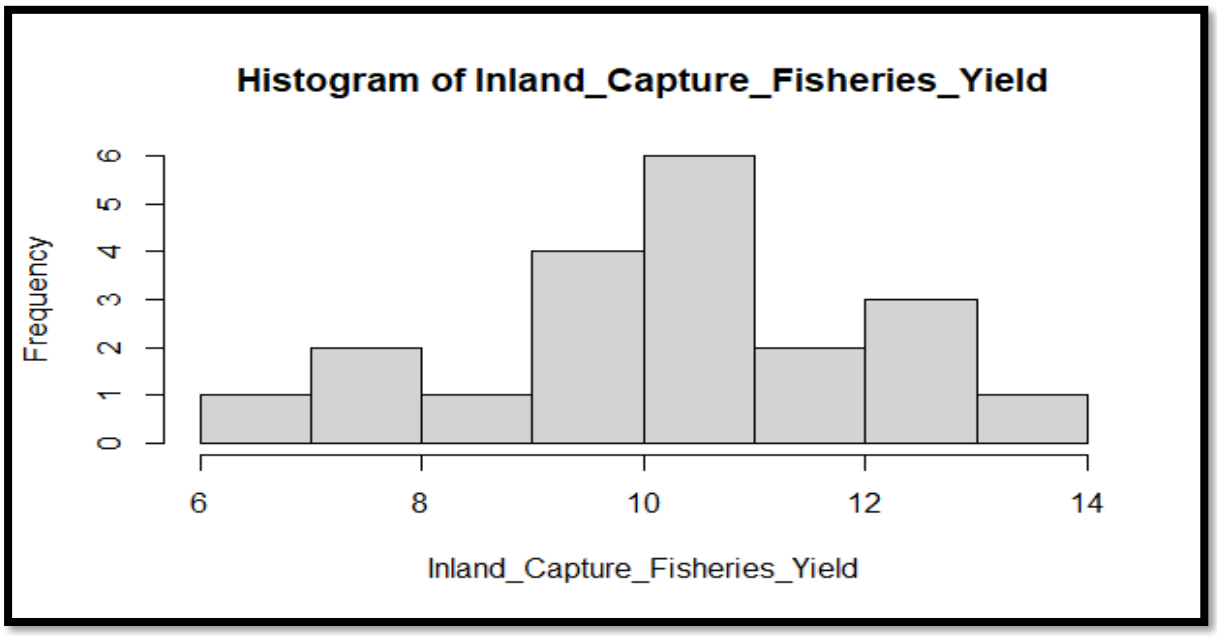

Figure 2. Histogram of the Inland Capture Fisheries Yield in Bangladesh from 2002 to 2021

The inland culture fisheries production violates the normality assumption due to the lack of bell shape among the different adjacent bars in the histogram plot in figure 3.

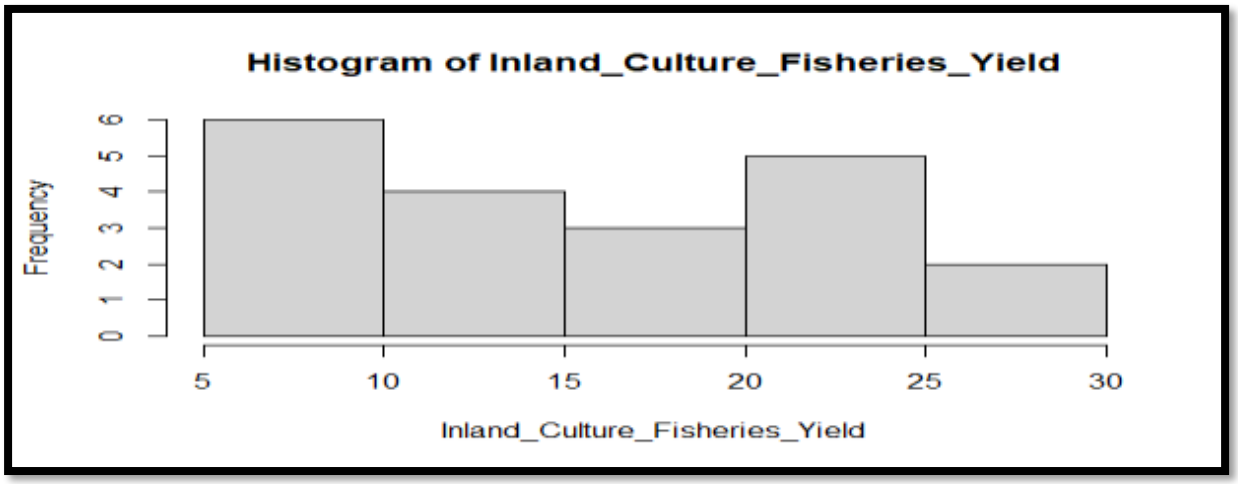

Figure 3. Histogram of the Inland Culture Fisheries Yield in Bangladesh from 2002 to 2021

Due to the violation of the normality assumption, the study relies on the MWWU test to evaluate the significant level of production gap between the inland capture and culture fisheries in Bangladesh. At a 5% level of significance, the hypothesis of the MWWU test is as follows-

$$\mathbf{H_0: M_1 = M_2}$$

vs.

$$\mathbf{H_1: M_1 \neq M_2}$$

Where, M_1 = Median of Inland Capture Fisheries Production

M_2 = Median of Marine Culture Fisheries Production

According to table 1, the null hypothesis might be rejected at a 5% level of significance as the P-value is 0.02272 < 0.05. The study concludes the production gap at the median point between the inland capture and culture fisheries in Bangladesh is statistically significant. The inland capture and culture fisheries production differs significantly in the fishery population in Bangladesh as in the sample data.

Table 1. The Output of the MWWU test

W value	95% CI		P-value
	LL	UL	
116	-10.79629	-0.50735	0.02272
Alternative hypothesis: true location shift is not equal to 0			
Sample estimates: difference in location, -6.01821			

According to table 2, the median of inland capture and culture fisheries production is 10.27 and 15.93 hundred thousand metric tons, respectively. On the other hand, the mean of inland capture and culture fisheries production is 10.19 and 16.21 hundred thousand metric tons, respectively. Both medina and mean, measurement of location, differ significantly in the sample data, and the study finds a similar result from the hypothesis test.

Table 2. Descriptive Statistics of Inland Fisheries Yield (Hundred Thousand Metric Tons)

Descriptive Statistics	Inland Capture	Inland Culture	Inland (total)
Sample Size	20	20	20
Lowest Observation	6.88	7.87	14.75
Highest Observation	13.01	26.39	39.40
Range	6.13	18.52	24.65
Sum	203.73	324.16	527.89
Median	10.27	15.93	25.99
Mean	10.19	16.21	26.39
SE. Mean	0.39	1.51	1.83
CI. Mean (0.95)	0.82	3.16	3.83
Variance	3.05	45.54	66.90
Standard Deviation	1.75	6.75	8.18

The above analysis of inland fisheries yield in Bangladesh is based on aggregate production, but what about the production unit-wise yield status, productivity, and growth rate? In table 3, the study considers the production unit-wise analysis. In 2021, the inland fisheries productivity was 0.84 MT/Ha, and the growth rate was 2.81%.

Table 3. Production Units, Area, Productivity, and Growth Rate of Inland Fisheries in 2021

Production Unit	Area ('000 Ha)	% Share in Area	Yields ('000 MT)	% Share in Yield	Productivity (MT/Ha)	Growth Rate %
Inland Fisheries (A+B)	**4,704.21**	**100.00**	**3,939.99**	**100.00**	**0.84**	**2.81**
A. Inland Capture (open water): 1+2+3+4+5	**3,860.47**	**82.06**	**1,301.24**	**33.03**	**0.34**	**4.23**
1. River and Estuary	853.86	18.15	337.05	8.55	0.39	1.58
2. Sundarbans	177.70	3.78	21.54	0.55	0.12	2.56
3. Beel	114.16	2.43	104.87	2.66	0.92	1.71
4. Kaptai Lake	68.80	1.46	12.35	0.31	0.18	-2.76
5. Floodplain	2,645.94	56.25	825.43	20.95	0.31	5.85
B. Inland Culture (close water): 6+7+8+9+10+11+12	**843.75**	**17.94**	**2,638.75**	**66.97**	**3.13**	**2.12**
6. Pond	407.63	8.67	2,090.79	53.07	5.13	2.18
7. Seasonal cultured water	150.49	3.20	226.61	5.75	1.51	0.29
8. Baor	5.67	0.12	11.32	0.29	2.00	3.19
9. Shrimp/Prawn Farm	263.03	5.59	278.42	7.07	1.06	3.07
10. Crab Production	9.60	0.20	12.34	0.31	1.28	-1.79
11. Pen Culture	7.31	0.16	14.28	0.36	1.95	6.38
12. Cage Culture	0.02	0.0004	5.00	0.13	279.05	8.82

**Area Means Water Area Used in Fishery Production in Thousand-Hectare (‘000 Ha), Yield in Thousand Metric Tons (‘000 MT), Share Means % of Area or Yield, Productivity in Metric Tons Per Hectare (MT/Ha), and Growth Rate % in 2021 over 2020

Inland capture fishery covers 82.06% of the inland production area but controls 33.03% of production. The productivity of this segment was 0.34 MT/Ha along with a 4.23% growth rate in 2021. Inland culture fishery controls 17.94% of inland water bodies and 66.97% of inland production. It showed a 2.12% growth rate with 3.13 MT/Ha productivity in 2021. The productivity of the inland culture fishery is 9.2 times higher than the inland capture.

1. River and Estuary- It is the large volume of natural water flowing through the different channels and finally converging in the sea. The country has 57 main rivers which form approximately 230 rivers in the country that enlarge its inland water bodies (Rounak and Md, 2013). Although the river and estuary control 18.15% of inland water bodies, it contributes only 8.55% to inland production. This sector showed a 1.58% growth rate and 0.39 MT/Ha productivity in 2021.

2. Sundarbans- The Sundarbans is one of the largest mangrove forests in the world. It has different biodiversity with many interconnected tidal rivers, creeks, and canals. The Sundarbans control 3.78% of inland water bodies and contribute 0.55% to inland production. It shows the lowest productivity, 0.12 MT/Ha, among all inland production units.

3. Beels- It is a special type of wetland with a relatively large surface of the static water body. It may or may not dry in the dry season. Beel represents 2.43% of inland water bodies and 2.66% of yield. It showed the highest productivity, 0.92 MT/Ha, among inland capture production units in 2021.

4. Kaptai Lake- It is a lake-shaped artificial creek located in the Rangamati District. It represents 0.31% of inland fisheries yield and 1.46% of production area. In 2021, this sector showed a negative growth rate, -2.76%, with the second lowest productivity, 0.18 MT/Ha, among all inland production units.

5. Floodplain- The floodplain is a relatively low-lying flat land area surrounded by rivers. It might be over-flooded by small rainfall. The floodplain fisheries include subsistence fisheries,

fry-released program fisheries, and haor-fisheries. It controlled the highest percentage of inland water area, 56.25%, and the second highest percentage of inland production, 20.95%, among all inland production units in 2021. In 2021, the floodplain sector showed the third highest growth rate, 5.85%, but its productivity was only 0.31 MT/Ha.

6. Pond- The pond is a manmade closed water body with a permanent boundary. It will be either perennial or seasonal based on water retention capacity. The pond unit controls 8.67% of the inland water area and 53.07% of inland production. In 2021, it showed the second-highest productivity, 5.13 MT/Ha, with a growth rate of 2.18%. Although the pond culture shows significant productivity, this productivity is not satisfactory compared to China, a giant of aquaculture and fisheries production. The productivity of pond culture in China was 8.42 MT/Ha in 2019 (Fangzhou, et al., 2021). Policymakers of Bangladesh should emphasize the technology, research, market development, and interest-free micro-credit to farmers and local traders to increase the productivity of the pond culture.

7. Seasonal Cultured Waterbody- It is the fisheries in seasonal waterbody during the flood period with temporary boundary. It has a 3.20% contribution to the inland waterbody and 5.75% to production. In 2021, the productivity of this unit was 1.51 MT/Ha, and the growth rate was 0.29%.

8. Baor- Baor is mainly a dead river making a free-standing water body for fisheries. It looks like a lake, but during monsoon, it may connect with the original river through channels. This unit covers 0.12% of the inland waterbody and 0.29% of production, but it shows the third highest productivity, 2.00 MT/Ha, among all inland production units.

9. Shrimp Culture and prawn farm- The shrimp culture is in the estuarine water, and the prawn culture is in the freshwater. The water bodies are closed with a boundary for shrimp and prawn culture. This farming unit occupies 5.59% of the inland production area and 7.07% of production. The productivity and growth rate of this unit was 1.06 MT/Ha and 3.07%, respectively, in 2021. Shrimp and prawn farming is more profitable and attractive than other freshwater fish farming. In the shrimp farming area, 78% of farmers claimed that shrimp farming is more profitable than rice farming, and 60% of farmers preferred shrimp farming over freshwater fish farming (Sunuram, et al., 2021). Bangladesh exported 36.17 thousand MT of shrimp products and earned $ 416.22 million in 2018 (Hosain et al., 2021). The department of fisheries of Bangladesh should emphasize shrimp and prawn production to achieve the vision of the country.

10. Carb production- The carb production unit is a new dimension in the fishery industry of Bangladesh because once people considered carbs as a non-consumable item, but now people consume and export it. In 2021, this segment showed moderate productivity, 1.28 MT/Ha, but its growth rate was negative, -1.79%.

11. Pen culture- It is an enclosure fish culture where fisheries are farming in enclosed water volume except the bottom side and permitting free water circulation from at least one side. The pen culture controls 0.16% of the inland water area and 0.36% of production. In 2021, it showed the second-highest production growth rate, 6.38%, among all inland production units with 1.95 MT/Ha productivity.

12. Cage culture- It is an intensive aquaculture system where fisheries are placed in a cage in the waterbody with sufficient water movement. It has a different measurement unit, cubic meter, due to the separate structure of the production area. In the original data file of the fisheries department, the volume of the cage was measured in 3 dimensions, but the study considers the area of the cage in 2 dimensions for matching with all production units.
In the data file, the volume of the cage was in a cubic meter

Volume = Length * Breadth * Height = X m^3

The study considers the area of the cage in a square meter,

Area = Length * Breadth = X m^2

Then, the study converted the X square meter to Y hectare. One hectare is equal to 10,000 square meters.

The cage culture showed the highest growth rate, 8.82%, and productivity, 279.05 MT/Ha in 2021, but it was a different production unit with a very insignificant production area, only 0.0004%, so it should not compare with other production units.

CONCLUSION

The inland fisheries contribute 85% of the total fisheries yield in Bangladesh. The yield of both inland capture and culture is growing, but the growth rate of culture is higher than the capture. The production gap between the inland capture and culture fisheries is statistically significant. The inland capture and culture fisheries controlled 82.06% and 17.94% of the inland water area and 33.03% and 66.97% of production, respectively, in 2021. The productivity of inland culture fisheries is 9.2 times that of inland capture fisheries.

Among 12 production units, the highest, second highest, and third highest production areas are controlled by the floodplain, river, and pond units, respectively, but the highest production share is controlled by the pond unit followed by the floodplain, and river. The government of Bangladesh should take separate policies to focus on these three production units to increase production and achieve the vision of the country. This study analysis the production area, productivity, production share, and growth rate of different production units based on the yield of 2020 and 2021 and shows only the static picture of 2021, but the study does not present the changing status of productivity, production share, and growth rate of units. Further studies are required based on the time series data to find the changing condition of production area, productivity, production share, and growth rate of the different production units of the inland fisheries in Bangladesh.

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