Capacity and Factors Affecting Capacity Utilization of Marine Fisheries: A Case of Gill-net Fleet in the Bay of Bengal

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Outline

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- Marine fisheries in Bangladesh
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Overview of Fisheries Sector

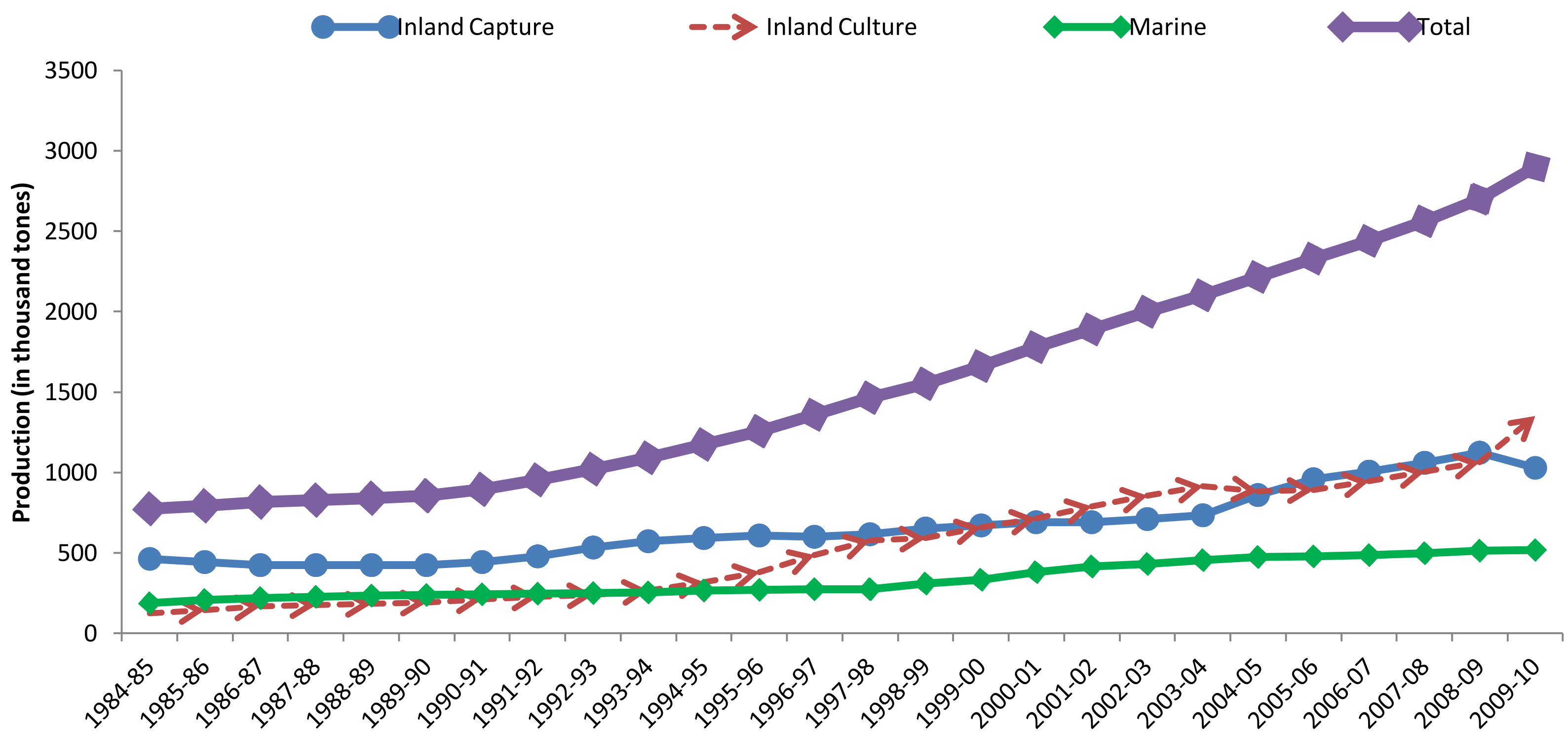
- Bangladesh produce 2% of global fish production.
- Bangladesh is the second largest inland capture fish producing country in the world after China and contributes 10.4% of world inland capture fish.

- About 13.3 million people involved in fisheries sector for livelihoods, Around 73% of the rural households are involved in freshwater aquaculture activities for their livelihood
- It contributes 4.64% to GDP, 23% to agricultural GDP, and 4% to foreign exchange earning. , 70% protein from fish,

- Both demand and supply of seafood has increased, we export
- Sub-sector: culture (53%), capture (29%) and marine (18%)

Overview of Fisheries Sector

Production trend



Marine Fisheries in Bangladesh

- Bangladesh situated at the apex of the Bay of Bengal with a coastal plain with 710 km of coastline and 166,000 km^2 of sea area.

- Growth rate of marine fish catch was 4.03% during last two decades.

- Around 93% of marine fish comes from artisanal fishery and only 7% comes from industrial fishery

Marine Fisheries in Bangladesh

- The industrial marine, only 129 fish trawlers and 33 shrimp trawlers operate in the Bay of Bengal.

- In contrast, 21,726 mechanized and 29,963 nonmechanized boats are being used for fishing in the artisanal fishery.

- Fishing gear: Gill-nets (131,326), set bag nets (52,824) and long-line nets (25,538)

- Gill nets alone contribute 62% of total artisanal fish landing and main target species is Hilsha shad (*Tenualosa ilisha).*

Motivation

- More than 70% of the world fisheries are either fully or overexploited (FAO 2010)
- Overcapacity is the main problem in marine capture fisheries (FAO)
- In Bangladesh, marine fisheries dominated by artisanal rather industrial
- Many more boats are operating than recognized by the DoF
- Official statistics on gear, boat, vessels, production do not reflects the reality
- Inshore are already overexploited (Hussain and Enamul 2010; Mazid 2003) and need to be controlled by regulating fishing boat, banning harmful fishing practices etc.
- Catches per vessel and trip have decreased over the last few years (Mome 2007), indicating existence of excess fishing capacity which could lead to overexploitation and vulnerability of the marine fishery.

Motivation

- Study on capacity utilization available in developed country but not in developing country (Tingley et al.2005, Vestergaard et al. 2005)
- Few research on marine fisheries in Bangladesh (Alam 2001, Hussain 2010, Mome 2007)
- To the best of our knowledge, there is no research on excess capacity and capacity utilization of marine in Bangladesh

Research objectives

I. determine whether the vessels are operating at over- or undercapacity, and if so, by how much;

II. determine whether they maximize production efficiency; and

III. some policy alternatives for sustainable marine fisheries management?

Study area and data…..

- Mainly three location :Chittagong Cox's Bazar and Patuakhali
- Gill-net fleet
- Cross-sectional data from 146 artisanal mechanized boat
- Chittagong (52) and Cox's Bazar (94) area in Bay of Bengal
- Both monsoon (146) and non-monsoon (125) data
- Through face-to-face interview with pretested questionnaire

Analytical technique

- An output-oriented version of DEA is used to estimate capacity output and CU.

- Fare *et al*. (1989; 1994) used DEA technique to estimate firm capacity and capacity output.

Analytical technique

$$CU(Observed) = \frac{u}{\theta_1 u} = \frac{1}{\theta_1}$$

Fare *et al*. (1994) argued that this ray measure may be biased downward, because the observed output that we use to calculate the CU measure may not be produced in a technically efficient manner.

In order to obtain the technically efficient measure, both fixed and variable inputs need to be constrained to their current levels.

analytical technique

Fare et al. (1989) proposed the following DEA problem:

$$Max_{\theta, z, \lambda} \theta_1$$

Subjected to

$$\theta_1 u_{jm} \leq \sum_{j=1}^{J} z_j u_{jm}, \; m = 1, \; 2, \ldots\ldots M,$$

$$\sum_{j=1}^{J} z_j x_{jn} \leq x_{jn}, \; n \in \alpha, \; \text{(fixed inputs constraint)}$$

$$\sum_{j=1}^{J} z_j x_{jn} = \lambda_{jn} x_{jn}, \; n \in \hat{\alpha}, \; \text{(variable input constraint)}$$

$$\sum_{j=1}^{J} z_j = 1$$

$$z_j \geq 0, \; j = 1, 2 \; \ldots\ldots J$$

$$\lambda_{jn} \geq 0, n \in \hat{\alpha}$$

Analytical technique

We can solve the following linear programming DEA problem to obtain technically efficient capacity output and CU measures:

$$Max_{\theta,z}\theta_2$$

Subjected to

$$\theta_2 u_{jm} \le \sum_{j=1}^{J} z_j u_{jm},\ m = 1,\ 2,\ldots\ldots M,$$

$$\sum_{j=1}^{J} z_j x_{jn} \le x_{jn},\ \text{n} = 1,2,\ldots\ldots\text{N}$$

$$\sum_{j=1}^{J} z_j = 1$$

$$z_j \ge 0,\ j = 1, 2\ \ldots\ldots J$$

Analytical technique

where θ_2 shows by how much production can be increased if the production procedure is technically efficient.

The technically efficient output can be estimated by multiplying θ_2 by the observed production.

The technically efficient or "unbiased" ray measure of CU is then the determined as:

$$CU(efficient) = \frac{CU}{TE} = \frac{1/\theta_1}{1/\theta_2} = \frac{\theta_2 u}{\theta_1 u} = \frac{\theta_2}{\theta_1}$$

Results: Summary Statistics

Variables	Monsoon		Nonmonsoon	
	Mean	Std. dev	Mean	Std. dev
Fishing experience (years)	23.68	7.01	21.69	7.93
Length of boat (feet)	47.80	6.42	47.94	6.48
Breadth of boat (feet)	12.61	2.83	12.75	2.92
Depth of boat (feet)	7.73	2.07	7.72	2.13
Boat capacity (Gross registered tonnage)	18.58	5.87	19.33	5.38
Engine horsepower (hp)	56.36	23.07	58.40	23.11
Length of net (feet)	285.79	65.38	271.35	60.22
Hilsha catch per trip (kg)	2069.04	1181.55	1207.20	805.56
Catch of other species per trip (kg)	590.47	468.86	834.94	705.43
Fishing duration per trip (days)	8.02	2.00	9.05	2.10
No. of trips per month	2.15	0.43	1.99	0.92
No. of hauls per trip	1.94	0.23	1.73	0.68
No. of crew on board per trip	18.29	3.42	18.51	3.19
Depth at points of operation (feet)	165.08	48.64	147.42	60.37
Ground distance (km)	224.45	86.20	222.94	121.71

Results
Capacity utilization and Technical efficiency

GRT group	Monsoon		Non-monsoon	
	CU	TE	CU	TE
≤ 10	0.69	0.71	0.47	0.47
11 ≤ 20	0.56	0.60	0.51	0.52
≥ 21	0.57	0.59	0.60	0.65
All groups	0.58	0.61	0.35	0.55

Boat operating at 58% of capacity with 61% TE in the monsoon season and at 35% capacity with 55% TE in the non-monsoon season.

In the monsoon season, both CU and TEs tend to show roughly a negative association with the GRT groups, which is opposite to the situation in the non-monsoon season.

It indicates that fishing with small boats works efficiently during monsoon seasons compared with large boats and vice versa during non-monsoon seasons.

Results

Observed output, capacity output, technical efficiency output

	GRT group ≤ 10		GRT group 11 ≤ 20		GRT group ≥ 21		All groups	
	Monsoon	Nonmonsoon	Monsoon	Nonmonsoon	Monsoon	Nonmonsoon	Monsoon	Nonmonsoon
Catch (observed)								
Hilsha	1206	454	2133	1158	2340	1505	2069	1207
Other	449	385	581	805	678	1014	590	835
All	1655	839	2714	1963	3018	2519	2659	2042
Capacity output								
Hilsha	1843	879	3855	2295	4263	2500	3706	2244
Other	656	969	1050	1579	1262	1907	1057	1630
All	2499	1848	4905	3874	5525	4406	4762	3874
TE output								
Hilsha	1756	877	3594	2211	4029	2368	3474	2152
Other	635	969	979	1518	1189	1771	992	1551
All	2391	1846	4573	3729	5218	4139	4466	3703

Results

Potential increase of capacity and technical efficiency

	GRT group ≤ 10		GRT group 11 ≤ 20		GRT group ≥ 21		All groups	
	Monsoon	Nonmonsoon	Monsoon	Nonmonsoon	Monsoon	Nonmonsoon	Monsoon	Nonmonsoon
Potential increase in capacity (%)								
Hilsha	52.82	93.61	80.73	98.19	82.18	66.11	79.12	85.92
Other	46.10	151.69	80.71	96.15	86.14	88.07	79.15	95.21
All	51.00	120.26	80.73	97.35	83.07	74.91	79.09	89.72
Potential increase in TE (%)								
Hilsha	45.85	93.17	68.50	90.93	72.18	57.34	67.91	78.29
Other	41.43	151.69	68.50	88.57	75.37	74.65	68.13	85.75
All	44.47	120.02	68.50	89.96	72.90	64.31	67.96	81.34
Potential increase in unbiased capacity (%)								
Hilsha	4.64	0.20	7.67	4.08	5.34	5.41	6.72	4.67
Other	3.09	0.00	8.19	3.90	5.11	7.40	6.72	5.05
All	4.22	0.14	7.78	4.00	5.29	6.53	6.72	4.83

Results

Determination of Decommissioned

- Policy makers are sometimes interested in removing some boats in order to eliminate excess capacity.

- As this data set is cross-sectional (only one year of data), we obtain point estimates of boat excess capacity.

- There are two ways to estimate the number of boats that could be removed to eliminate excess capacity:
  - one is by ordering boats from highest to lower capacity and removing the boats first with highest capacity (Squires et al. 2003). This approach involves minimum decommissioning implying fewer boats would be removed, leaving the largest fleet size for the target catch.

  - Another approach is by ordering the boats from lowest to higher capacity and remove the lowest capacity first. In this case, a larger number of boats would need to be removed, leaving the minimum number of boats for the catch. In this study, we use the former approach.

Results

Boat Capacity, Excess Capacity and Decommissioned

	GRT group ≤ 10		GRT group 11 ≤ 20		GRT group ≥ 21		All groups	
	Monsoon	*Non monsoon*	*Monsoon*	*Non monsoon*	*Monsoon*	*Non monsoon*	*Monsoon*	*Non monsoon*
Allowing technical inefficiency								
Vessel total catch (kg)	**31460**	**8388**	**236095**	**151146**	**120735**	**95735**	**388290**	**255269**
Vessel capacity output	47466	18486	426756	298321	221843	167446	696065	484253
Vessel excess capacity	16006	10098	190673	147172	100275	71945	306955	229214
% excess capacity	50.88	120.38	80.76	97.37	83.74	75.15	79.26	89.79
Total no. of vessels	19	10	87	77	40	38	146	125
No. of vessels removed	4	4	31	32	15	13	49	47
% of vessels removed	21	40	36	42	38	34	34	38

In the monsoon season about 34% of existing boats are required to be decommissioned to eliminate the excess capacity.

In contrast, in the nonmonsoon season, 38% vessels need to be decommissioned from the sea.

Results

Variable input utilization rates and optimal input size

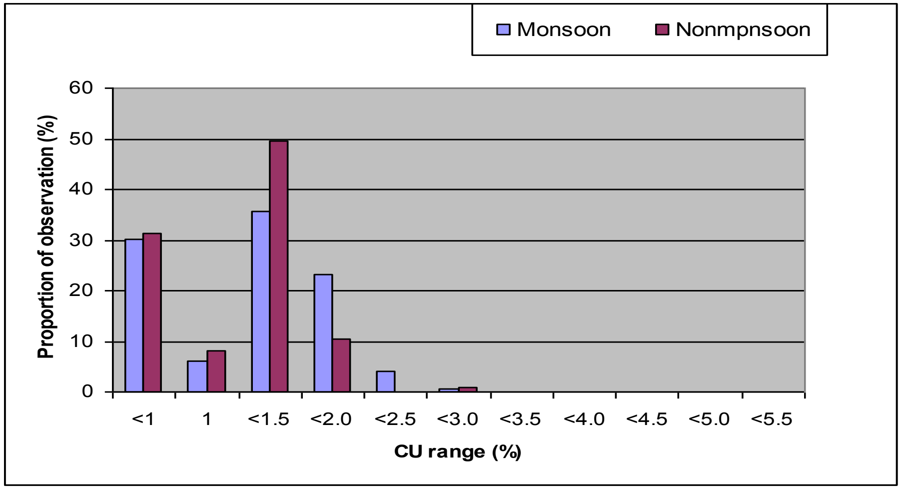
GRT group	Monsoon		Nonmonsoon	
	No. of crew	Fishing days	No. of crew	Fishing days
≤ 10	1.149 (16.39)	1.064 (7.89)	0.755 (9.33)	0.737 (4.09)
11 ≤ 20	1.305 (24.79)	1.450 (11.11)	1.109 (21.08)	1.000 (9.25)
≥ 21	1.169 (22.55)	1.383 (10.30)	1.264 (24.18)	1.267 (11.13)
All groups	**1.247 (23.09)** [18.29]	**1.381 (10.47)** [8.02]	**1.128 (21.08)** [18.51]	**1.061 (9.41)** [9.05]

Note: value in the (   ) indicates the optimal input size and value in the [ ] shows observed input

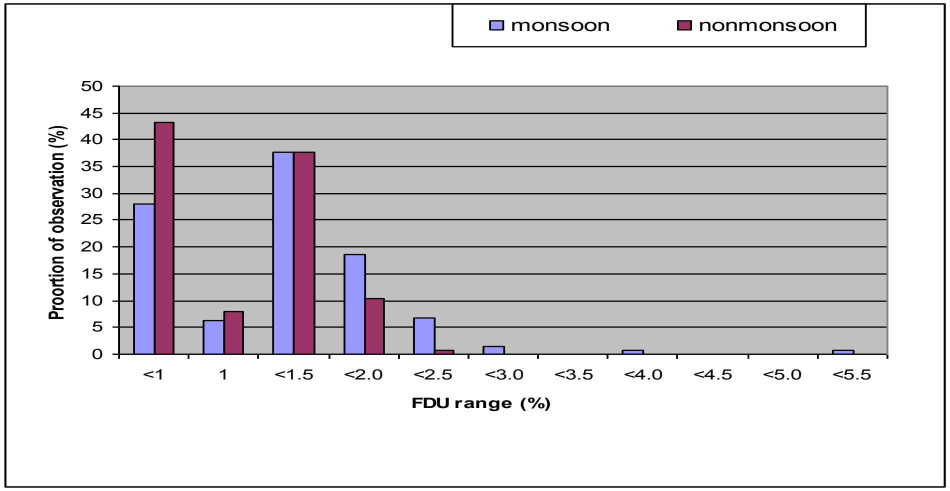
Average variable input utilization rates for both the number of crew and fishing days are higher in the monsoon season compared with the nonmonsoon season.

Results

Variable input utilization rates and optimal input size



Distribution of Crew Utilization (CU) Rates in the Two Seasons



Distribution of Fishing Day Utilization (FDU) Rates in the Two Seasons

More than 60% of the boats had Crew UR > 1.

About 66% of the boats had an average fishing day UR > 1 in the monsoon season and only 51% in the nonmonsoon season.

50% to 70% of the boats have variable input UR higher than 1 suggesting that there are considerable shortages of both crewmen and fishing days in gill-net fishing operations.

Results

Factors affecting capacity utilization

	Monsoon		Nonmonsoon	
	Coefficient	Std. error	Coefficient	Std. error
Constant	0.624***	0.092	0.860***	0.174
Port (dummy)	0.014	0.010	–0.009	0.026
Fishing experience (years)	0.001	0.001	0.001	0.001
Boat capacity (tonnes)	0.006***	0.002	–0.003***	0.003
Fish carrying capacity (tonnes)	–0.004*	0.002	0.006	0.006
Engine horsepower	–0.002***	0.000	–0.002	0.001
Net length (feet)	0.001**	0.000	0.001	0.000
Number of crew	–0.001	0.002	0.009	0.004
Trips per month (no.)	0.041***	0.011	0.001**	0.024
Trip duration (days)	0.017***	0.002	0.001	0.006
Hauls per day (no.)	0.056**	0.027	0.037	0.053
Water depth (meters)	0.001**	0.000	0.001	0.000
Log likelihood value	239.03		104.40	
χ^2 value	95.61		27.69	

Results summary

- Moderate and low degree of CU found in monsoon and non-monsoon season respectively.
- High degree of technical inefficiency in both seasons
- High degree of excess capacity exists in both season
- About one—third of boats need to be decommissioned.
- Variable input utilization rates are lower than its optimal.
- Boat capacity, number of trips per month and trip duration is the main factors affecting capacity utilization in the gill-net fleet.

Policy Recommendation

- License restrictions appear to be a preferred policy for reducing boat/vessel sizes. However, it is not the best solution.

- This policy would create an unemployment problem because most artisanal gill-net operators earn a subsistence living, and their livelihoods depend on their profession.

- To ensure their livelihood, one possible option may be to create alternative employment opportunities through agriculture-based industry development by the government as well as the private sector in coastal areas.

Policy Recommendation

- Banned or decommissioned boats/vessels could be used in alternate ways. Therefore, a comprehensive plan is required that outlines the best use of the banned boats. In this case, one potential policy may involve the transportation of people and goods or tourism in coastal areas.

- In this case, community-based marine fishery management might be successful where local people work under a management system and take all management responsibility.

- Still deep sea is underutilized due to lack of investment. Government should provide large amount of credit support trough a group of fisher so that they can fish in the deep sea.

- Large boat (less number) - more crew in a boat - more fishing days can solve the problem of excess capacity of the Bay of Bengal.

Thank You