

HARNESSING MACHINE LEARNING TO ESTIMATE AQUACULTURE'S CONTRIBUTIONS TO THE ECONOMY OF SOUTHWEST BANGLADESH

Ben Belton*, Mohammad Mahfujul Haque, Hazrat Ali, Amir Pouyan Nejadhashemi, Ricardo Hernandez, Khondker Murshed-e-Jahan, Hannah Ferriby

*Michigan State University, East Lansing, MI, USA, and WorldFish, Penang, Malaysia.

Email: b.belton@msu.edu

Aquaculture in Bangladesh has grown quickly over the past three decades, becoming a major contributor to the country's rural economy. National systems for collecting aquaculture statistics have not kept pace with these changes, so more accurate, up-to-date information is needed to inform policymakers. We used machine learning techniques to extract information from freely available satellite images and estimate the area of waterbodies used for aquaculture in seven districts in southern Bangladesh, one of country's most important aquaculture zones producing fish for domestic markets and crustaceans for export. We combined machine learning derived estimates of aquaculture farm area per district with data from statistically representative farm surveys to estimate farm size, productivity, and total output, economic value of production, on-farm employment generation by gender, and demand for formulated and non-formulated feeds. Machine learning estimates returned a total farm area similar to that reported in Department of Fisheries (DOF) statistics, but we estimate that production of crustaceans (shrimp + freshwater prawn production) is 31% lower than officially reported by DOF in 2020, while fish production and total aquaculture production (fish + crustaceans) are 41% and 27% higher, respectively. Aquaculture makes a massive contribution to food production, farmer incomes and employment in southern Bangladesh. We estimate that there were more than 500,000 farms in 2020, producing 787,000 t of aquatic food (89% fish and 11% crustaceans), with a mean yield of 3.1 t/ha. This production was worth a total \$1.45 billion (farmgate value) and generated farm profits of \$0.67 billion, after subtracting production costs (Table 1). These farms support 430,000 fulltime equivalent (FTE) jobs on-farm, of which 15% worked by women, and created demand for 759,000 t of feed, of which 30% comprised of formulated pelleted feeds. Our findings reveal great potential to combine remote sensing and machine learning techniques with representative surveys to estimate a range of statistics that are difficult to obtain otherwise, with potential to expand the approach to whole of Bangladesh and other countries.

Table 1. Estimates of selected aquaculture statistics in southern Bangladesh by district.

Estimate	Bagerhat	Barisal	Bhola	Gopalganj	Jashore	Khulna	Satkhira	All districts
Farm area ('000 ha)	73.6	6.2	11.1	5.8	37.8	72.2	72.1	278.8
No. of farms ('000)	66.8	17.2	29.7	19.1	183.3	130.0	101.8	546.9
Mean farm size (ha)	1.1	0.4	0.4	0.3	0.2	0.6	0.7	0.5
Mean yield (t/ha)	2.4	5.1	5.4	2.8	4.3	2.0	2.6	3.1
Aquatic food ('000 t)	177.4	31.6	60.4	15.9	163.9	147.6	190.1	787.1
Fish ('000 t)	148.9	31.6	60.4	15.6	160.0	120.6	163.6	700.7
Crustaceans ('000 t)	28.5	0	0	0.3	3.9	27	26.5	86.4
Farmgate value (Million USD)	394	39	106	20	220	335	341	1,454
Total farm profit (Million USD)	185	14	36	9	95	172	160	670
Total employment ('000 FTEs)	141.0	9.6	14.9	3.5	31.7	84.7	146	431.5
Female employment ('000 FTEs)	18.2	2.7	0.9	0.96	5.6	17.7	16.0	66.2