Causes of Fish Depletion – A Factor Analysis Approach

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Abstract

A study was conducted in 54 wetlands of 13 districts of Assam, India to evaluate the causes of fish depletion. Twenty-two variables were considered for the study. Seven factors were extracted through factor analysis (Principal Component Analysis) based on Eigen Value Criteria of more than one. These seven factors together accounted for 69.3% of the total variance. Based on the characteristics of the variables, all the factors were given descriptive names. These variables can be used to measure the extent of management deficiency of the causes of fish depletion in the wetlands. The factors are management deficiency, organic load interference, catchment condition, extrinsic influence, fishermen's ignorance, external environment and aquaculture program. Management deficiency accounted for a substantial portion of the total variance.

Introduction

Floodplain wetlands are a 'halfway house' between a flowing river and a pond. They are among the world's most productive ecosystems and have been providing tremendous economic benefits to mankind. Unfortunately, wetlands are presently among the world's most threatened habitats (Tiner 1984; William 1990). Wetlands have been deteriorating as they are being continuously encroached upon, altered by changes in land use patterns and their resources are being over exploited. These issues have been identified as the major problems faced in protecting the wetlands (Good et al. 1978; Kusler and Montanari 1978; Greenson et al. 1979; U.S. Environmental Protection Agency 1983; OTA 1984; Mitsch and Grosselink 1986).

This paper presents a study of the wetlands of Assam, India. Assam is gifted with a myriad of wetlands. The livelihood and economic condition of the fisher community depends mainly on the fish catch from these wetlands. The wetlands of Assam were highly productive in terms of fish diversity and production. Over the last few decades, fish production from these wetlands has been declining due to several extrinsic and intrinsic factors. An attempt has been made to evaluate the causes of this decline so that fish production can be enhanced and the socio-economic condition of the fishing communities improved.

Methodology

The present study was conducted in 54 wetlands of 13 districts of Assam. The wetlands were selected randomly. Twenty-two variables were considered to explain the causes of fish depletion. These variables were identified through extensive group discussions with the fishermen, physical verification of the wetlands and available literature on the subject (Sugunan 1995b; Vass 1997; Maltby 1991; Odum 1978; Agarwal 1996; Crow and MacDonald 1979; Deka et al. 1996; Dey 1981; Goswami 1985; Jha 1997; Jhingran 1989; Goswami et al. 1996; Kuster and Montanari 1978; Lahon 1979; Yadava 1987). During data collection, information was also collected from the fishermen who were engaged in fishing in the wetlands. The variables are as follows:

- siltation
- fishery rules
- inlet/outlet channels
- erosion
- anthropogenic activity
- autostocking
- fish disease
- fishermen illiteracy
- indiscriminate fishing
- breeding habitat
- weed infestation
- pollution
- impact of agriculture
- eutrophication
- aquaculture
- encroachment
- unplanned construction
- over fishing
- poaching
- mesh size of fishing net
- demarcation
- flood

The variables were measured for each wetland by using the Semantic Differential Scale. The assessment of all the variables (except the variable related to the internal environment) on the Semantic Differential Scale was made by physical observation of the wetlands and the surrounding (catchment zone) areas as well as discussions with the fishermen. In the case of variables related to the internal environment, the assessment was based on secondary data and information obtained from WFP report No. 2750.01 (Goswami et al. 1996). Factor analysis using Principal Component Analysis (PCA) was conducted to reduce the data and to develop and test the convergent validity of meaningful constructs. For the purpose of describing the underlying factor structure, the Eigen Value Criteria of more than one was used to determine the number of components to be extracted for further analysis.

One of the major problems encountered in the study was the determination of the fish depletion rate. The fish depletion rate was estimated from annual fish production (in terms of biomass) statistics for the last six years, from 1991 to 1996. The annual fish production figures were collected from the *mahalder*'s records during field visits and cross checked through discussions with the fishermen. From these figures, the annual decrease/increase in fish production was calculated for each of the five years and the average was taken. A negative average value was taken as the depletion rate and a positive average value was taken as the appreciation rate. Unfortunately, none of the wetlands showed positive average values.

To ascertain the causes of fish depletion, a multiple regression was carried out with the depletion rate as the dependent variable and the fish depletion factors identified by the PCA as the independent variables.

Results

Fish depletion rate

The depletion rate for each of the wetlands was calculated as the percentage decline in fish production over the period 1991–1996 (Table 1). They show that all the wetlands included in the study registered fish depletion of varying degrees. Most of the wetlands showed

Table 1. Estimated fish depletion rate in the Assam wetlands (%/yr).

Wetlands	Past fish production (kg) 1990	Present fish production (kg) 2000	Fish depletion rate
Bhoispuri	5 356	5 300	1.05
Hakama	2 112	2 000	5.30
Horinchora	3 585	3 500	2.40
Chandakhal	3 075	3 000	2.44
Nandini	2 600	2 500	3.85
Jogra	1 616	1 500	7.18
Barundanga	2 580	2 500	3.10
Salchapra	7 566	7 500	0.87
Baskandi	5 060	5 000	1.18
Bhitorpuni	1 633	1 500	8.10
Auti-Bauti	1 805	1 700	5.80
Tapang	8 570	8 500	0.80
Meda	1 150	1 000	13.04
Digarbakri	1 788	1 700	4.90
Ranimegna	1 817	1 700	6.44
Gapharsang	1 434	1 300	9.34
Sagar	4 071	4 000	1.74
Angang	2 686	2 600	3.20
Rata	7 107	7 000	1.50
Saitali	1 802	1 700	5.66
Sibnarayanpur	3 578	3 500	2.18
Satkarikandianua	9 262	9 200	0.67
Sone	14 568	14 500	0.47
Mori	8 264	8 200	0.77
Bormanaha	25 553	25 500	0.21
Jaluguti	5 262	5 200	1.17
Kasodhara	3 774	3 700	1.96
Kujibalipatty	10 154	9 995	1.02
Deora	12 572	8 064	2.55
Udori	78 750	40 750	2.30
Nandinikarmari	8 808	8 700	1.26
Thekera	3 571	3 500	1.98
Sialekhaiti	275	100	3.66
Dighaliputali	1 125	1 000	11.11
Satiyan	1 209	1 100	9.02
Borthal	1 633	1 500	8.14
Lakhanabondha	1 832	1 700	7.20
Brahmamyjan	857	700	6.65
Sagmara	5 873	5 800	1.24
Borbilla	6 075	6 000	1.23

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Wetlands	Past fish production (kg) 1990	Present fish production (kg) 2000	Fish depletion rate
Batuakamakha	6 085	6 000	1.40
Siligurijan	525	400	2.38
Deeporbeel	3 600	3 500	2.78
Pungani	3 577	3 500	2.15
Bihdia	2 430	2 300	5.34
Moridisoi	12 112	12 000	0.92
Ganakdubaiduba	12 112	4 000	5.35
Tinsukiborbeel	4 093	1 300	1.23
Goroimari	13 061	9 000	1.65
Merkolaberia	9 061	8 200	1.02
Teliadanga	8 273	8 000	2.00
Botalikhosa	3 405	3 300	5.52
Moridikhow	2 775	1 000	8.46
Dhaka	1 225	300	75.51

Table 2. Fish depletion rate by district (%/yr).

Name of district	Minimum	Maximum	Average
Dhubri	1.05	7.10	12.60
Silchar	0.80	13.04	5.78
Karimganja	0.47	9.34	4.44
Hailakandi	0.00	4.90	4.90
Nowgaon	0.21	1.98	1.12
Morigaon	1.26	63.36	1.41
Borpeta	0.00	1.24	6.82
Nalbari	1.23	1.24	1.24
Kamrup	1.40	2.78	2.84
Golaghat	0.91	6.54	2.88
Jorhat	0.00	3.32	5.52
Sibsagar	2.00	8.46	5.23

a gradual and consistent decline in fish production. A few wetlands exhibited an irregular pattern, with increase and decrease in fish production in alternate years. The annual rate of fish depletion varied between 0.21% (Bormanaha wetland) to 75.51% (Dhaka wetland), with a mean of 4.94% and a standard deviation (SD) of 10.24. The high SD indicates that the fish depletion rate was not uniform across the studied wetlands. The variation in the fish depletion rate by district is shown in Table 2. The average decline in fish production was the highest in Dhubri district and lowest in Nowgaon district.

Causes of fish depletion

The factor analysis extracted seven factors based on Eigen Value Criteria more than one. Table 3 presents the factor loading, communality, Eigen value and percentage of variance. These seven factors together accounted for 69.3% of the total variance. Based on the factor loading of the individual variable, each factor has been given a descriptive name, as indicated below.

Factor 1 - management deficiency - consists of eight variables, namely, siltation, encroachment, over fishing, anthropogenic activity, mesh size of fishing net, flood effect, indiscriminate fishing and fishery rules. This factor explained 23.8% of the total variance. To measure the extent of management deficiency, these eight variables were used. The score of each wetland on this factor was determined by taking the average score of the eight variables.

Factor 2 - organic load interference - consists of three variables, eutrophication stress, fish disease and weed infestation. All these variables had a factor loading of more than 0.72, indicating that all the variables within factor 2 have almost equal importance on the Organic Load Interference scale. Factor 2 contributed 12.1% of the total variance.

Factor 3 - catchment condition - includes four variables that together account for 9.8% of the total variance. The four variables in factor 3 are destruction of breeding habitat, destruction of inlet/outlet channels, unplanned construction (including *bundh*, embankment, canal, railway, sluice gate for flood control, irrigation and transportation) and autostocking capacity of the floodplain wetlands. All the variables had a factor loading > 0.55. Unplanned construction had a higher factor loading of 0.83.

Factor 4 - extrinsic influence - consists of three variables, namely, erosion, poaching and pollution. All the variables had a factor loading of > 0.46.

Factor 5 - fishermen's ignorance – consists of two variables, namely, impact of agriculture and fishermen's illiteracy. Both variables had a factor loading of > 0.45 and together can explain > 5.6% of the total variance.

Table 3. Results of the factor analysis of the causes of fish depletion.							
Variables	**Factor 1 Management deficiency**	**Factor 2 Organic load interference**	**Factor 3 Catchment condition**	**Factor 4 Extrinsic influence**	**Factor 5 Fishermen's ignorance**	**Factor 6 Physical environment**	**Factor 7 Aquaculture program**
Siltation	0.57						
Encroachment	0.69						
Breeding ground			0.68				
Inlet/outlet channel			0.55				
Over fishing	0.74						
Demarcation						0.72	
Anthropogenic activity	0.73						
Mesh size	0.67						
Eutrophication		0.80					
Fish disease		0.72					
Flood affect	0.54						
Indiscriminate fishing	0.80						
Fishery rules	0.81						
Unplanned construction			0.83				
Autostocking			0.77				
Weed infestation		0.75					
Erosion				0.65			
Poaching				0.46			
Agricultural impact					0.74		
Aquaculture							0.91
Pollution				0.68			
Fishermen illiteracy					0.44		
Eigen value	5.24	2.66	2.16	1.71	1.23	1.20	1.07
Percentage of variance explained	23.8	12.1	9.8	7.8	5.6	5.4	4.8

Factor 6 - physical environment - comprises only one variable, demarcation of the wetlands, and explains 5.4% of the total variance. The variable showed a high factor loading of 0.72.

Factor 7- aquaculture program - also consists of one variable, namely, lack of aquaculture in the wetlands. This factor explained 4.8% of the total variance. This variable had a very high factor loading of 0.91.

Analysis of fish depletion factors and fish depletion rate

The correlation between the fish depletion rate (dependent variable) and fish depletion factors was high, i.e., 0.62. All factors together explained 69.3% of the fish depletion in the wetlands. The remaining 30.7% of the fish depletion rate was explained by some other intrinsic factors. The overall regression equation was also found to be significant ($F = 0.93$, $p < 0.05$) indicating that these factors together significantly influenced the fish depletion rate.

Of the seven factors accounting for fish depletion in the wetlands, factor 6 and factor 1 were highly significant (Table 4). Factor 6 had the highest impact on the decline in fish production and was followed by factor 1. Looking at the components of factor 6 and factor 1, it is clear that the internal environment and effects of siltation, anthropogenic activities, indiscriminate killing of brooder fishes and use of uncontrolled mesh size of fishing gears were largely responsible for the fish depletion in the wetlands of Assam.

Discussion

Fish production in the wetlands of Assam has been gradually decreasing over the last few years. The rate of fish depletion in some of the wetlands studied (Table 1) is remarkably high and few wetlands have had a low depletion rate. The decline in fish production in the wetlands can be explained by the combined effect of

Table 4. The coefficients of the multiple regressions and their significance.			
Parameters	**Coefficient**	**T**	**P**
Factor 1	0.29	1.88	0.07
Factor 2	0.17	1.11	0.30
Factor 3	0.13	1.05	0.24
Factor 4	0.12	1.00	0.20
Factor 5	0.08	0.65	0.52
Factor 6	0.51	3.77	0.005
Factor 7	0.08	0.58	0.57

seven main factors. Of these, two factors (physical environment and management deficiency) are primarily responsible for the decline in fish production in the wetlands of Assam.

Management deficiency consists of seven variables; a very significant effect is from siltation. For example, the decline in fish production in Mead and Gapharsang (Karimganj district), Tapang, Bhitorpuni and Saitali (Silchar district), Merkolaberia (Golghat district) and Borbilla (Nalbari district) wetlands is due to the effect of allochthonous and autochthonous siltation. Siltation raises the waterbed and consequently reduces the water depth in the wetlands, which results in loss of perenniality and subsequently of fish stocks and fish seed. Siltation has severely affected some of the wetlands. For example, in the Tapang and Meda wetlands, siltation has raised the waterbed above the bed level of the inlet/outlet channels. As a result, the wetlands cannot retain water for more than two to three months of the year. Further, siltation has facilitated encroachment on several of the wetlands that were included in this study.

Encroachment is one component of the management deficiency factor. Many wetlands, including Sagmara, Borbilla, Batuakamakhya, Nandini-Karmari, Dighali-Putali, Lakhanabandha, Brahmamyjan, Barthol, Ganakdubaiduba, Goroimari-Bihdia-Japara, Ranimegna, Salchapra, Meda, Gapharsung, Tapang and Saitali wetlands, are facing encroachment from paddy cultivation, which has reduced the productive water surface for the fishermen. The combined effect of the encroachment and cultivation has been a reduction of fish production and increased siltation in these wetlands.

The study also showed that many wetlands (34%) now have no inlet/outlet channels or their channels are in poor condition. The destruction of inlet/outlet channels has reduced the autostocking capacity of the wetlands. The inlet/outlet channels of Jogra (Dubri district) and Sibnarayanpur (Silchar district) wetlands have been completely destroyed by the construction of railways and roads. Following the construction of the roads, fish production in these two wetlands dropped sharply. In some of the other wetlands, the fishermen and farmers have been responsible for the destruction of the inlet/outlet channels with the construction of *bundhs* for various purposes, e.g., retting of jute. These obstructions are adversely affecting autostocking in these wetlands during the flood season.

The study also suggests that the destruction of breeding habitats, indiscriminate killing of gravid fishes and over fishing are also responsible for fish depletion. Eight wetlands have totally lost the breeding habitats due to anthropogenic activities, mainly paddy cultivation. The bylaws regulating the fisheries are not being enforced in these wetlands. In most of the wetlands included in this study, the fishermen use nets of small mesh size, 1-3 mm, to catch the small fishes. It was also noted that in some wetlands the fishermen make *bheta* (a special fishing technique) in the inlet/outlet channels. All these practices affect autostocking and subsequently fish production.

Weed infestation has also been affecting fish production and fish recovery in many wetlands of Assam. The water surface of the Satiyan, Lakhanabandha, Dighali-putali and Moridikhow wetlands is completely covered by swamp (mat) formation. The study noted that in these wetlands: (i) the fish recovery was very low or nil due to the difficulty in netting inside the swamp covers; (ii) only catfishes and featherback fishes were dominant in these wetlands; and (iii) it facilitates autochthonous silt load to the wetlands. This means that other fish species, like IMC and minor group fish species (*Puntius* spp., *Gadusia chapra*, *Chanda* spp., etc.) cannot survive beneath the swamp cover and the fish diversity is limited. The decomposition of macrophytic weed and its silt load reduces the water depth in these wetlands.

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