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Research Article

Threat Detection Technique in Context to Mangrove Ecosystem of Indian Sundarbans

Abstract

The mangrove ecosystem in the lower Gangetic delta is one of the most biologically productive and taxonmically diverse ecosystems of the tropics, which is threatened by a variety of stressors. The main threats operating in this fragile ecosystem are erosion, natural disasters (like cyclone, wave actions, tidal surges etc), over exploitation of natural resources, pollution, siltation, sea level rise etc. In this research, we have attempted to develop a mechanism to evaluate and rank the magnitude of threats based through collection of expert opinion from different groups of respondents. The respondents were categorised into five major classes namely policy maker, researcher, fisherman, agriculturist and local inhabitant. About 305 respondents belonging to this 5 categories were asked about the types of threats and their respective magnitude by ranking the threats between 1 to 6. Three different Composite Threat Scales were constructed for three sectors (western, central and eastern) of Indian Sundarbans as these three sectors have contrasting variations with respect to geographical features, salinity, biodiversity, and vulnerability of threats. The present approach of threat analysis can be a road map to identify the types of threats along with their magnitude in the mangrove ecosystem of the world. This scale can also be regulated because of regional settings, which would subsequently lead towards the path of conservation priority of natural resources.

Introduction

The mangrove ecosystem of Indian Sundarbans (located between 21°32′- 22°40′ north and between 88°85′- 89°00′ east) offers a wide spectrum of ecosystem services like erosion control, protection against natural disasters, supply of natural resources linked with the livelihood of the local population (like timber, fishes, honey, wax etc), bioremediation, protection against sea level rise (through accretion of silt particles), carbon sequestration etc [1-6]. Because of this wide range of services to mankind these unique halophytes are over exploited in many parts of the world including India. About 50% of the mangroves in Indian Sundarbans have been destroyed since the last few decades. The major reasons of this destruction may be categorized into anthropogenic and natural causes. The anthropogenic threats include factors like pollution, over exploitation of natural resources, cutting of mangroves for shrimp farming, development of unplanned tourism units, pollution etc. and the natural factors encompass storms, tidal surges, siltation, sea level rise etc. These threats are, however, regions specific, *e.g.*, the western sector of Indian Sundarban is prone to pollution, where as in the central sector, siltation is the major problem due to which salinity is increasing in this sector [3,7-10]. Again, in the eastern sector, over exploitation of natural resources is more frequent because of the presence of reserve forest in this sector, which is saturated with natural resources - fishes, crabs, timber, fuel wood, fodder, honey, wax etc. The type of threat is, therefore, significantly different in three sectors of Indian Sundarbans. On this background, the present paper aims to construct three different Composite Threat Scales (CTS) considering the nature and magnitude of threat in the three sectors of Indian Sundarbans (western, central and eastern sectors) so that the conservation plan may be sector- specific instead of a generalized one.

Materials and Methods

The entire network of the present study consist of three stages i) identification of respondents (policy maker, researcher, fisherman, agriculturist and local inhabitants) ii) identification of major threats (6 in number) and iii) evaluation of the respondent's response to construct the threats scale through ranking and voting. Although threats can be of various types, our list captures the major threats operating on the mangrove ecosystem of Indian Sundarbans. Threats were ranked in terms of their importance by building a Threat Assessment Matrix (TAM). However, as there is high probability of variation of

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this ranking with the category of respondents, therefore the views of the respondents were also considered (by inclusion of the % of voting along with their respective ranking factor) and finally Composite Threat Scale (CTS) for each of the three sectors of Indian Sundarbans was constructed on the basis of Threat Scale (TS) computed as per the expression: It is to be noted in this context that the sample size of respondents are variable e.g., for policy maker it is 15, but for other five groups of respondents n = 58 for each group.

CTS = TS1 + TS2 + TS3 + TS4 + TS5

Where, TS = Threat Rank (TR) × % of Vote

Results

The results generated after the present excersise revealed few interesting findings as listed here.

i) For western Indian Sundarbans, the order of CTS is pollution (986.4) > erosion (583.2) > natural disaster (499.1) > siltation (237.3) > sea level rise (100.4) > over exploitation of natural resources (37.9) (Table 1).

ii) The picture of central Indian Sundarbans is different from the western sector as siltation in this sector is assigned with the highest score (1172.4), followed by natural disaster (464.9), erosion (457.4), pollution (164.5), over exploitation of natural resources (81.8), and sea level rise (78.2) (Table 2).

iii) The respondent analysis conducted on the threats operating on eastern sector of Indian Sundarbans (Table 3) assigned highest value to erosion (1019.5), followed by natural disaster (571.5), sea level rise (291.0), over exploitation of natural resources (230.2), pollution (32.1) and siltation (20.6).

Thus, it is observed that the CTS as perceived from the angle of respondents exhibits significant spatial variation.

Discussion

Threat ranking techniques in context to ecosystem have been developed by several workers to aid conservation priority setting [11-13]. In this study, we used the expert opinions as the foundation stone of threat ranking by dividing the respondents into 5 major categories. Also we constructed different Composite Threats Scales for three different sectors of Indian Sundarbans as they have contrasting variations with respect to geographical features, anthropogenic pressure, salinity, threat types and biodiversity. The anthropogenic threats like pollution gradually decrease as one proceeds from western to eastern sectors of Indian Sundarbans mainly because of the presence of industrial belt along the Hoogly River in the western sector and reserve forest in the eastern sector [3,5]. We therefore attempted to segregate the CTS for three different sectors of Indian Sundarbans and observed contrasting spatial variation.

The issue of pollution secured the highest CTS value in the western Indian Sundarbans mainly because of the presence of large number of industries along the western bank of the River Hooghly [3,14-17]. The central Indian Sundarbans exhibited highest value in siltation that completely synchronizes with the ground reality as a major portion of the Matla estuary has been silted due to complete blockage of the Bidyadhari, since the late 15th century [1]. The eastern sector of Indian Sundarbans is the main reservoir for natural resources due to presence of Reserve Forest (RF) and as such over exploitation of natural resources

Table 1: Threat type with scaling in Western Indian Sundarbans.

Respondent Type 1	Policy Maker		
	TR	% of Vote	TS1
Erosion	5	20.1	100.5
Natural Disaster	5	17.8	89
Over-exploitation of Natural Resources	1	1.9	1.9
Pollution	6	30.2	181.2
Siltation	4	17.3	69.2
Sea Level Rise	3	12.7	38.1
Respondent Type 2	Researcher		
	TR	% of Vote	TS2
Erosion	5	19.8	99
Natural Disaster	5	16.2	81
Over-exploitation of Natural Resources	6	1.4	8.4
Pollution	6	38.7	232.2
Siltation	4	16.8	67.2
Sea Level Rise	4	7.1	28.4
Respondent Type 3	Fisherman		
	TR	% of Vote	TS3
Erosion	6	15.1	90.6
Natural Disaster	5	22.8	114
Over-exploitation of Natural Resources	1	1.1	1.1
Pollution	6	50.2	301.2
Siltation	5	7.3	36.5
Sea Level Rise	3	3.5	10.5
Respondent Type 4	Agriculturist		
	TR	% of Vote	TS4
Erosion	6	28.1	168.6
Natural Disaster	4	23.4	93.6
Over-exploitation of Natural Resources	2	4.7	9.4
Pollution	5	27.4	137
Siltation	4	6.8	27.2
Sea Level Rise	2	9.6	19.2
Respondent Type 5	Local inhabitant		
	TR	% of Vote	TS5
Erosion	5	24.9	124.5
Natural Disaster	5	24.3	121.5
Over-exploitation of Natural Resources	3	5.7	17.1
Pollution	4	33.7	134.8
Siltation	4	9.3	37.2
Sea Level Rise	2	2.1	4.2

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has taken considerable weightage. It is, however, interesting to note that in all the three sectors over exploitation of natural resources was assigned with low weightage (in terms of TR) by policy makers, fisherman and local inhabitants, but with maximum weightage by researchers. This contradictory picture may be an attempt to mask and/or expose the ground zero observation by varoius groups of respondents. However, a comparative study of the CTS (sector-wise) leads us to conclude that the types of threats are strikingly different in magnitude to the ecological stability in the three selected sectors of this World Heritage Site in the lower Gangetic delta.

Table 2: Threat type with scaling in Central Indian Sundarbans.

Respondent Type 1	Policy Maker		
	TR	% of Vote	TS1
Erosion	5	19.3	96.5
Natural Disaster	5	18.4	92
Over-exploitation of Natural Resources	1	1.1	1.1
Pollution	2	11.5	23
Siltation	6	40.1	240.6
Sea Level Rise	2	9.6	19.2
Respondent Type 2	Researcher		
	TR	% of Vote	TS2
Erosion	4	20.6	82.4
Natural Disaster	5	22.3	111.5
Over-exploitation of Natural Resources	6	10.9	65.4
Pollution	5	12	60
Siltation	6	26.8	160.8
Sea Level Rise	4	7.4	29.6
Respondent Type 3	Fisherman		
	TR	% of Vote	TS3
Erosion	5	18.3	91.5
Natural Disaster	4	19.1	76.4
Over-exploitation of Natural Resources	1	2.5	2.5
Pollution	4	6.8	27.2
Siltation	6	49	294
Sea Level Rise	2	4.3	8.6
Respondent Type 4	Agriculturist		
	TR	% of Vote	TS4
Erosion	5	17.5	87.5
Natural Disaster	5	20.2	101
Over-exploitation of Natural Resources	2	2.9	5.8
Pollution	3	7.3	21.9
Siltation	6	41.5	249
Sea Level Rise	1	10.6	10.6
Respondent Type 5	Local inhabitant		
	TR	% of Vote	TS5
Erosion	5	19.9	99.5
Natural Disaster	5	16.8	84
Over-exploitation of Natural Resources	1	7	7
Pollution	4	8.1	32.4
Siltation	6	38	228
Sea Level Rise	1	10.2	10.2

Table 3: Threat type with scaling in Eastern Indian Sundarbans.

Respondent Type 1	Policy Maker		
	TR	% of Vote	TS1
Erosion	6	30.1	180.6
Natural Disaster	5	20.2	101.0
Over-exploitation of Natural Resources	2	17.7	35.4
Pollution	1	12.3	12.3
Siltation	1	2.0	2.0
Sea Level Rise	4	17.7	70.8
Respondent Type 2	Researcher		
	TR	% of Vote	TS2
Erosion	5	38.9	194.5
Natural Disaster	5	19.6	98.0
Over-exploitation of Natural Resources	4	16.6	66.4
Pollution	1	7.3	7.3
Siltation	1	1.6	1.6
Sea Level Rise	3	16.0	48.0
Respondent Type 3	Fisherman		
	TR	% of Vote	TS3
Erosion	6	50.0	300.0
Natural Disaster	5	22.5	112.5
Over-exploitation of Natural Resources	2	7.4	14.8
Pollution	1	3.7	3.7
Siltation	1	1.3	1.3
Sea Level Rise	4	15.1	60.4
Respondent Type 4	Agriculturist		
	TR	% of Vote	TS4
Erosion	5	28.2	141.0
Natural Disaster	5	27.3	136.5
Over-exploitation of Natural Resources	4	23.8	95.2
Pollution	1	6.4	6.4
Siltation	1	4.5	4.5
Sea Level Rise	4	9.8	39.2
Respondent Type 5	Local inhabitant		
	TR	% of Vote	TS5
Erosion	6	33.9	203.4
Natural Disaster	5	24.7	123.5
Over-exploitation of Natural Resources	2	9.2	18.4
Pollution	1	2.4	2.4
Siltation	2	5.6	11.2
Sea Level Rise	3	24.2	72.6

Table 4 highlights the ANOVA results between the different respondents and the sectors. It is observed that there is considerable variations between erosion, pollution, siltation and sea level rise between the sectors, but natural disaster like cyclone, tidal surges and massive wave actions hit almost uniformly throughout the entire Sundarban belt.

Table 4: ANOVA results between the different respondents and the sectors.

Erosion		
	F_{cal}	F_{crit}
Between sectors	9.039	4.459
Between respondents	0.340	3.8387
Natural disaster		
Between sectors	2.053	4.459
Between respondents	0.571	3.8387
Over –exploitation of natural resources		
Between sectors	3.847	4.459
Between respondents	1.733	3.8387
Pollution		
Between sectors	32.460	4.459
Between respondents	1.166	3.8387
Siltation		
Between sectors	67.956	4.459
Between respondents	0.456	3.8387
Sea level rise		
Between sectors	18.932	4.459
Between respondents	1.263	3.8387

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