RESPONDENT ANALYSIS IN CONTEXT TO IMPACT OF CLIMATE CHANGE ON THE REGULATING SERVICES OF MANGROVE VEGETATION

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Abstract

The mangrove ecosystem in the lower Gangetic delta is noted for providing several regulatory services. The major regulatory services include erosion, natural disaster, Phytoremediation, carbon sequestration, siltation, and sea-level rise. Here, we have attempted to develop a mechanism of assessing and ranking the magnitude of regulatory services offered by Sundarban mangroves based on stakeholder’s views on the subject. The respondents were categorized into five major classes namely policy level worker, researcher, fisherman, agriculturist, and local inhabitant. About 295 respondents belonging to these 5 categories were asked about the types of regulatory services and their respective magnitude by ranking the services between 1 and 6. Finally, based on data generated, three separate Combined Mangrove Regulating Service Scale (CMRSS) were assessed for three sectors (western, central, and eastern) of Indian Sundarbans. The basic root for such assessment is contrasting variations between these three sectors based on geographical features, salinity, and biodiversity. The present approach of analysis can be a road map to identify and empirically score the regulatory services of mangroves.

Keywords: Mangrove ecosystem, Lower Gangetic delta, Respondents, Regulatory services of mangroves, Mangrove Regulating Service Scale (MRSS)
I. Introduction

Indian Sundarbans, with rich halophytic vegetation, located between 21°32’-22°40’ north and between 88°85’- 89°00’ east, offers a wide spectrum of regulating the type of ecosystem services. This includes control of embankment and shoreline erosion, alternation of the degree of natural disasters, water quality up-gradation, protection against sea-level rise (through accretion of silt particles), carbon sequestration, etc. [III], [VI], [X], [XI], [XII], [XV]. Because of this wide range of regulating services to mankind these unique halophytes need to be conserved. However, it is a tragedy that a considerable percentage of the mangroves in Indian Sundarbans have been destroyed over the last few decades. Such destruction, which is a type of serious anthropogenic threat depends on the need of local inhabitants and is extremely region/sector-specific in nature [I], [VI], [VIII], [IX], [XIII]. The type of threat is, therefore, significantly different in three sectors of Indian Sundarbans. However, mangroves have the potential to overcome these threats by offering several regulatory services like erosion control, attenuation of waves caused by natural disasters, phytoremediation, carbon sequestration, accretion of silt to combat sea level rise, etc. On this background, the present paper aims to construct the different Mangrove Regulating Service Scale (MRSS) of Sundarban halophytes on the feedback of respondents from each sector, so that the conservation plan may be sector-specific instead of a generalized one.

II. Materials and Methods

To initiate the present research work, the first stage was the identification of respondents like policy level workers, researchers, fishermen, agriculturists, and local inhabitants followed by assessment of six major types of very common threats. Finally, a Mangrove Regulating Service Scale was constructed by ranking the major six threats and voting. Although regulatory services can be of various types, our list captures the major services offered by mangroves that are intricately related to climate change. However, as there is a high probability of variation of this ranking with the category of respondents, therefore the views of the respondents were also considered (by the inclusion of the % of voting along with their respective ranking factor) and finally Combined Mangrove Regulating Service Scale (CMRSS) for each of the three sectors of Indian Sundarbans was constructed based on individual Mangrove Regulating Service Scale (MRSS) computed as per the expression

\[
\text{CMRSS} = \text{MRSS1} + \text{MRSS2} + \text{MRSS3} + \text{MRSS4} + \text{MRSS5}
\]

Where, MRSS = Mangrove Service Rank (MSR) × % of Vote

III. Results and Discussions

The results obtained from such stakeholder analysis varied significantly between three sectors of Indian Sundarbans.

i) For western Indian Sundarbans, the order of CMRSS varies as per the sequence carbon sequestration (986.4) > erosion (583.2) > natural disaster (499.1) > siltation (237.3) > sea level rise (100.4) > phytoremediation (37.9) (Table 1).

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### Table 1: Types of mangrove regulating service with ranking and subsequent scaling in western Indian Sundarbans

| Category 1 Respondent | Policy Level Worker        | MSR | % of Vote | MRSS1 |
|-----------------------|---------------------------|-----|-----------|-------|
| Erosion               |                           | 5   | 20.1      | 100.5 |
| Natural Disaster      |                           | 5   | 17.8      | 89    |
| Phytoremediation      |                           | 1   | 1.9       | 1.9   |
| Carbon sequestration  |                           | 6   | 30.2      | 181.2 |
| Siltation             |                           | 4   | 17.3      | 69.2  |
| Sea Level Rise        |                           | 3   | 12.7      | 38.1  |

| Category 2 Respondent | Researcher                | MSR | % of Vote | MRSS2 |
|-----------------------|---------------------------|-----|-----------|-------|
| Erosion               |                           | 5   | 19.8      | 99    |
| Natural Disaster      |                           | 5   | 16.2      | 81    |
| Phytoremediation      |                           | 6   | 1.4       | 8.4   |
| Carbon sequestration  |                           | 6   | 38.7      | 232.2 |
| Siltation             |                           | 4   | 16.8      | 67.2  |
| Sea Level Rise        |                           | 4   | 7.1       | 28.4  |

| Category 3 Respondent | Fisherman                 | MSR | % of Vote | MRSS3 |
|-----------------------|---------------------------|-----|-----------|-------|
| Erosion               |                           | 6   | 15.1      | 90.6  |
| Natural Disaster      |                           | 5   | 22.8      | 114   |
| Phytoremediation      |                           | 1   | 1.1       | 1.1   |
| Carbon sequestration  |                           | 6   | 50.2      | 301.2 |
| Siltation             |                           | 5   | 7.3       | 36.5  |
| Sea Level Rise        |                           | 3   | 3.5       | 10.5  |

| Category 4 Respondent | Agriculturist              | MSR | % of Vote | MRSS4 |
|-----------------------|---------------------------|-----|-----------|-------|
| Erosion               |                           | 6   | 28.1      | 168.6 |
| Natural Disaster      |                           | 4   | 23.4      | 93.6  |
| Phytoremediation      |                           | 2   | 4.7       | 9.4   |
| Carbon sequestration  |                           | 5   | 27.4      | 137   |
| Siltation             |                           | 4   | 6.8       | 27.2  |
| Sea Level Rise        |                           | 2   | 9.6       | 19.2  |

| Category 5 Respondent | Local inhabitant           | MSR | % of Vote | MRSS5 |
|-----------------------|---------------------------|-----|-----------|-------|
| Erosion               |                           | 5   | 24.9      | 124.5 |
| Natural Disaster      |                           | 5   | 24.3      | 121.5 |
| Phytoremediation      |                           | 3   | 5.7       | 17.1  |
| Carbon sequestration  |                           | 4   | 33.7      | 134.8 |
| Siltation             |                           | 4   | 9.3       | 37.2  |
| Sea Level Rise        |                           | 2   | 2.1       | 4.2   |

ii) In central Indian Sundarbans the highest score was generated for massive siltation (1172.4), followed by natural disaster (464.9), erosion (457.4), carbon sequestration...

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(164.5), phytoremediation (81.8), and sea-level rise (78.2) (Table 2). This result is by the ground reality as the central Indian Sundarbans witnesses siltation since the 15th century that has been referred to as Bidyadhari siltation [V], [VI], [VIII], [X], [XI].

Table 2: Types of mangrove regulating service with ranking and subsequent scaling in central Indian Sundarbans

| Category 1 Respondent | Policy Level Worker | Category 2 Respondent | Policy Level Worker | Category 3 Respondent | Policy Level Worker | Category 4 Respondent | Policy Level Worker | Category 5 Respondent | Policy Level Worker |
|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|
| Erosion               | MSR 5, % of Vote 19.3, MRSS1 96.5 | Erosion               | MSR 4, % of Vote 20.6, MRSS2 82.4 | Erosion               | MSR 5, % of Vote 18.3, MRSS3 91.5 | Erosion               | MSR 5, % of Vote 17.5, MRSS4 87.5 | Erosion               | MSR 5, % of Vote 19.9, MRSS5 99.5 |
| Natural Disaster      | MSR 5, % of Vote 18.4, MRSS1 92 | Natural Disaster      | MSR 5, % of Vote 22.3, MRSS2 111.5 | Natural Disaster      | MSR 4, % of Vote 19.1, MRSS3 76.4 | Natural Disaster      | MSR 5, % of Vote 20.2, MRSS4 101 | Natural Disaster      | MSR 5, % of Vote 16.8, MRSS5 84 |
| Phytoremediation      | MSR 1, % of Vote 1.1, MRSS1 1.1 | Phytoremediation      | MSR 6, % of Vote 10.9, MRSS2 65.4 | Phytoremediation      | MSR 1, % of Vote 2.5, MRSS3 2.5 | Phytoremediation      | MSR 2, % of Vote 2.9, MRSS4 5.8 | Phytoremediation      | MSR 4, % of Vote 8.1, MRSS5 32.4 |
| Carbon sequestration  | MSR 2, % of Vote 11.5, MRSS1 23 | Carbon sequestration  | MSR 5, % of Vote 12, MRSS2 60 | Carbon sequestration  | MSR 4, % of Vote 6.8, MRSS3 27.2 | Carbon sequestration  | MSR 6, % of Vote 49, MRSS4 294 | Carbon sequestration  | MSR 6, % of Vote 41.5, MRSS5 249 |
| Siltation             | MSR 6, % of Vote 40.1, MRSS1 240.6 | Siltation             | MSR 6, % of Vote 26.8, MRSS2 160.8 | Siltation             | MSR 2, % of Vote 7.4, MRSS3 29.6 | Siltation             | MSR 4, % of Vote 4.3, MRSS4 8.6 | Siltation             | MSR 1, % of Vote 10.6, MRSS5 10.6 |
| Sea Level Rise        | MSR 2, % of Vote 9.6, MRSS1 19.2 | Sea Level Rise        | MSR 4, % of Vote 7.4, MRSS2 29.6 | Sea Level Rise        | MSR 6, % of Vote 49, MRSS3 294 | Sea Level Rise        | MSR 2, % of Vote 4.3, MRSS4 8.6 | Sea Level Rise        | MSR 4, % of Vote 4.3, MRSS5 8.6 |

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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), phytoremediation (230.2), carbon sequestration (32.1) and siltation (20.6).

Table 3: Types of mangrove regulating service with ranking and subsequent scaling in eastern Indian Sundarbans

| Category 1 Respondent | Policy Level Worker | MRSS1 |
|-----------------------|---------------------|-------|
| Erosion               | 6                   | 30.1  |
| Natural Disaster      | 5                   | 20.2  |
| Phytoremediation      | 2                   | 17.7  |
| Carbon sequestration  | 1                   | 12.3  |
| Siltation             | 1                   | 2.0   |
| Sea Level Rise        | 4                   | 17.7  |

| Category 2 Respondent | Researcher | MRSS2 |
|-----------------------|------------|-------|
| Erosion               | 5          | 38.9  |
| Natural Disaster      | 5          | 19.6  |
| Phytoremediation      | 4          | 16.6  |
| Carbon sequestration  | 1          | 7.3   |
| Siltation             | 1          | 1.6   |
| Sea Level Rise        | 3          | 16.0  |

| Category 3 Respondent | Fisherman | MRSS3 |
|-----------------------|-----------|-------|
| Erosion               | 6         | 50.0  |
| Natural Disaster      | 5         | 22.5  |
| Phytoremediation      | 2         | 7.4   |
| Carbon sequestration  | 1         | 3.7   |
| Siltation             | 1         | 1.3   |
| Sea Level Rise        | 4         | 15.1  |

| Category 4 Respondent | Agriculturist | MRSS4 |
|-----------------------|---------------|-------|
| Erosion               | 5             | 28.2  |
| Natural Disaster      | 5             | 27.3  |
| Phytoremediation      | 4             | 23.8  |
| Carbon sequestration  | 1             | 6.4   |
| Siltation             | 1             | 4.5   |
| Sea Level Rise        | 4             | 9.8   |

| Category 5 Respondent | Local inhabitant | MRSS5 |
|-----------------------|------------------|-------|
| Erosion               | 6                | 33.9  |
| Natural Disaster      | 5                | 24.7  |
| Phytoremediation      | 2                | 9.2   |
| Carbon sequestration  | 1                | 2.4   |
| Siltation             | 2                | 5.6   |
| Sea Level Rise        | 3                | 24.2  |

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

IV. Discussion

To impart proper weightage to conservation strategy, one has to know the threats to the ecosystem, to minimize and manage them [II], [IV], [XIV]. However, regulating the service ranking of natural resources has been rarely addressed [VII]. In this study, we used expert opinions as to the foundation stone of Mangrove Regulating Service Ranking (MRSS) after receiving the feedback of five categories of respondents. Also, we constructed different Combined Mangrove Regulatory Service Scale (CMRSS) for three different sectors of Indian Sundarbans as they possess variable natural resource volume, environmental setup, and are exposed to different categories of threats. The regulating services like carbon sequestration, siltation, and erosion control received the highest scores at western, central, and eastern Indian Sundarbans respectively, which is by the previous workers [VI], [X]. The central Indian Sundarbans is noted for massive siltation as observed by early researchers due to inhibition of head-on discharge [III]. The eastern sector of Indian Sundarbans is the storehouse of natural resources as it encompasses the Reserve Forest (RF) zone. Hence, to meet up the daily need of the local inhabitants, those who are mostly Below the Poverty Line (BPL), the over-exploitation of natural resources has gained considerable weightage. This may have triggered the erosion in this sector as mangroves are noted to bind the soil particles with their intricate root system.

V. Conclusion

In this respondent analysis, we have attempted to develop a scale by scoring the importance of regulating the service of mangroves in three different sectors of Indian Sundarbans. The respondents were categorized into five major classes namely policy level worker, researcher, fisherman, agriculturist, and local inhabitant. About 295 respondents belonging to these 5 categories were asked about the types of regulatory services offered by mangroves in context to climate change and their respective outlooks were scored between 1 and 6. Three different Combined Mangrove Regulating Service Scale (CMRSS) were constructed for three sectors (western, central, and eastern) of Indian Sundarbans as these sectors have a significant variation of hydrological parameters (preferably salinity) that primarily govern the survival, growth, and regulating services of mangroves. The regulating services like carbon sequestration, siltation, and erosion control received the highest scores at western, central, and eastern Indian Sundarbans respectively, which speaks in favour of a separate management action plan in context to mitigation of climate change by these unique halophytes.

Conflicts of Interest:

The authors declare that no conflict of interest to report the present study.

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