Consequences of Deep Sand Mining and its Effects on Fluvial Topography and the Habitats along the Banks of the Sone River with Special Reference to Dehri Town: A Critical Study.

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Abstract:
Unregulated deep sand mining has emerged as a major environmental concern, particularly in riverine ecosystems. This study critically examines the consequences of deep sand mining and its effects on the fluvial topography and habitats along the banks of the Sone River, with a special reference to Dehri town. The research assesses the extent of geomorphological alterations caused by excessive sand extraction, leading to changes in riverbed morphology, bank erosion and channel instability. Additionally, it explores the ecological implications, including habitat degradation, loss of biodiversity, and the impact on aquatic and riparian species. This research contributes to the broader discourse on river conservation and offers policy recommendations for sustainable riverbank management in the Sone River basin.

Key Words: Fluvial topography, groundwater depletion, biodiversity, turbidity.

INTRODUCTION:

The Sone, a perennial River and the principal southern tributary of the Ganges, originates near Amarkantak Hill in Pendra-Marwahi district of Chhatisgarh, enters at Jarodag (Nauhatta Block) of Rohtas district in Bihar after crossing Kaimur hills. Historically it has played a crucial role in the socio-economic and ecological dynamics of the region. Traditionally, the river supported agriculture, fisheries and local livelihoods while maintaining a balanced fluvial system. However, with rapid urbanization and infrastructure development, the demand for sand as a construction material has surged, leading to large-scale sand mining activities.

In the past few decades, unregulated sand mining has intensified, particularly in the Dehri region at Chakanha, Katar, Makarine, Hoorka, Berkap Ghats etc where abundant sand deposits have attracted commercial extraction. Initially, mining was conducted at a moderate scale, posing minimal environmental threats.However, with increasing mechanization and high extraction rates, the river's natural sediment transport processes have been severely disrupted.This has resulted in deep incision of the riverbed destabilization of banks and alteration of flow patterns, which have further exacerbated erosion and habitat destruction.

Ecological concerns related to excessive sand mining have been raised since the late 20th century, with studies highlighting its adverse impacts on riverine biodiversity and hydrology. Despite regulatory efforts, weak enforcement has allowed illegal and unsustainable mining to continue, causing irreversible damage to the river ecosystem. This historical trajectory underscores the urgent need for a critical evaluation of deep sand mining's long-term consequences on the fluvial topography and habitats along the banks of the Sone River at Dehri and its adjacent places. Transportation of sand on the N.H.-2 (Pali overbridge to Coal Depot Sakhra) along with its service roads, Pali Road, Canal Road and the S.H.-15 has led to significant dust deposition on roads, contributing to air pollution. Residents of this locality have reported increased respiratory issues and reduced visibility due to dust from sand-laden Tractors, trucks and Dumpers. Business-enterprises Health-

Medication centres i.e. Hospitals, Diagnostic centres, Pathological labs and Educational institutions are suffering to a severe extent, A report highlighted that in Dehri-on-Sone, sand deposits on roads from transportation activities have led to increased air pollution and safety hazards.

Using a combination of field surveys, remote sensing analysis, and hydrological modeling, the study identifies the patterns of degradation and their long-term effects on riverine sustainability. The findings reveal that deep sand mining not only disrupts sediment balance but also intensifies the vulnerability of local communities dependent on the river for livelihood and ecosystem services. The study underscores the urgent need for sustainable mining practices and stricter regulatory frameworks to mitigate environmental damage while balancing economic interests.

REVIEW OF RELATED LITERATURE:

Mass media (Print and electronic), NGO's particularly CART and Sone Kala Kendra headed by Santosh kumar (Maudihan) and Dr. S. B. Prasad respectively as well as local activists like Shiv Gandhi, Yogendra Prasad, the unsung heroes working for environmental and health concerns have been raising these issues to aware people from this alarming situation

Several studies conducted by various institutions and independent research scholars examined the consequences of sand mining on river systems but specific studies on the Sone River near Dehri town are limited.

A report highlighted that in Dehri-on-Sone, sand deposits on roads from transportation activities have led to increased air pollution and safety hazards.
Although direct studies on water quality in the Sone River near Dehri are scarce, similar sand mining activities elsewhere have resulted in increased turbidity and contamination, affecting both human health and aquatic life.

A report for sand mining projects in the Dehri region, such as those for Mauza-Sikaria and Mauza-Katar, detail the potential environmental impacts of sand in its activities. These assessments provide insights into how sand mining affects local ecosystems and river morphology. (Environmental Impact Assessments (EIA) in Dehri Regio: Draft EI)

Airbus' in its analysis using satellite imagery has documented the environmental degradation caused by both legal and illegal sand mining along the Sone River. The study emphasizes how such activities destabilize riverbanks, making them more susceptible to erosion during floods. (Satellite Imagery Analysi Airbus')

The research study entitled– "Modelling the Impact of Sand Extraction from Large Rivers" presents models to understand the impact of sand mining on large rivers, using the Sone River in northern India as a case study. The review of related literature indicates that Comprehensive local studies are essential to assess these impacts accurately and to develop sustainable management strategies. This study has been designed and conducted by Keeping in mind. the gap area to present an informative as well as substantive document in public domain.

OBJECTIVES OF THE STUDY

The precised objectives of this study:
Assess alteration in the riverbed morphology, bank stability and sediment transport along the riverbanks.
Investigate the effects of sand extraction on aquatic ecosystems, fish populations, and vegetation along the riverbanks.
Examine changes in water flow, groundwater levels, and erosion pattern.
Evaluate the effects on local communities, particularly those dependent on the river for agriculture, fisheries, and livestock rearing.
Assess the implementation of legal frameworks, mining regulations, and their effectiveness in mitigating adverse environmental impacts.

Recommend sustainable mining practices and restoration measures to balance economic benefits with environmental conservation.

RATIONALE AND SIGNIFICANCE OF THE STUDY:

Deep sand mining has become a major environmental issue along the Sone River, particularly in the Dehri region, where rapid extraction has led to severe geomorphological and ecological consequences. Despite the economic benefits of sand mining for construction and infrastructure development, the unregulated and excessive removal of sand disrupts natural sediment transport, alters river morphology, and degrades aquatic habitats.

While existing research highlights the broad impacts of sand mining, there is a lack of localized studies focusing on the specific changes occurring in the Sone River's fluvial topography and ecosystems. The Dehri region, being a critical zone for sand mining, requires a detailed scientific assessment to understand how these activities influence river stability, biodiversity, and local livelihoods. This study is essential for providing empirical data and insights that can inform sustainable mining practices and environmental policies.
This research study incorporated common people's interests and severe concerns, Hence, holds its significance in multiple domains:

Environmental and Ecological Significance:

- Evaluates the impact of deep sand mining on riverbed erosion, channel shifts, and bank stability.
- Assesses the loss of aquatic and riparian habitats, contributing to biodiversity conservation efforts.
- Provides scientific evidence for sustainable river conservation strategies.

Socio-Economic Relevance:

- Examines the effects of sand mining on local communities, particularly those dependent on fishing and agriculture.

Scientific Advancement:

- Fills a critical research gap by providing localized data on fln Dehri due to deep sand mining.

RESEARCH MTHODOLOGY:

A mixed approach combining quantitative and qualitative method has been implied keeping in mind the precised objectives of the study.
Components:
(i)Field survey and Geospatial Analysis:

- To asses changes in fluvial morphology resulted from sand mining a combination of Topographic survey using GPS mapping, Total station survey and Drone survey has been conducted at the various sampling stations identified randomly.
- Satellite imagery has been analysed by using Remote sensing and GIS to track historical change in the fluvial morphology.
- To explore the effects of mining on river dynamicsHydrological Analysis by using flow velocity as well assediment transport models has been implied.

(ii)Ecological Impact Assessment:

- For the documentation of habitat loss along the riverbanks a study of flora and fauna has bee conducted by implying a Biodiversity survey at sampling stations i.e. Shankarpur, Balgovind bigha, Mahabir bigha, Shivganj and Naga Ashram Pali.
- Turbidity, dissolved oxygen and heavy metal content has been measured bu implying Water quality Testing to assess the level of pollution from mining.
- To examine erosion pattern and fertility loss caused by excessive mining soil analysis has been conducted by collecting samples at Katar, Makarine, Bhusahula, Darihat and Arjunbighs.

(iii)Sociometric Assessment:

- To incorporate the perspectives of all the stakeholders i.e. fishermen, farmers and miners into account interviews and group discussion has been organised after flashing the information through posters, banners, hordings and pumplets to engage more and more local communities.

- To assess the economic dependencies and employment shift resulted from mining, a livelihood Survey has been conducted by engaging volunteers after orientation.
- Todraw parallels by comparing the situation of Sone at Dehri and its adjacent places with other sand mined rivers, comparative analysis and case studies has been conducted

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RESEARCH DESIGN:

(i)Study Area: Multiple sites along river banks of Sone around Dehri town with varying degrees of sand mining town have been selected.

(ii)Sampling:

(a)Field Surveys: Five sites have been selected randomly after classifying all the sites into three categories:

- Heavy mining sites
- Moderate mining sites and
- No mining sites.

(b) Ecological Surveys: Random sampling has been implied in affected and unaffected river bank areas.

(c) Sociometric Surveys: Purposive sampling has been implied by keeping in mind affected communities.

DATA COLLECTION TOOLS:

Ojectives	DataCollection Method	Specific Tools/Tecniques
Fluvial Topography Changes	Field Surveys, Remote sensing GIS	GPS mapping Drone surveys Satelliimage Analysis (Google earth, Landsat Sentinel-2
Ecological Impact (Biodiversity)	Biodiversity Surveys	Quadrat method for vegetation, fish sampling & bird surveys. Camera trapping for faunal monitoring.
Water Quality& Sediment Analysis	Water Sampling, Laboratory Tests.	Turbidity Meter, PH meter Dissolved oxygen meter, TDS meter, soil testing kits
Sociometric Impact	Surveys, Interviews, Focus Group Discussion	Structured questionnaires for all stakeholders
Comparative Study	Review of related literature, Secondary Data Analysis	Case studies from other sand mined rivers. (Chambal, Narmada.

DATA ANALYSIS:

(i) Morphological changes have been assessed through overlaying historical and current maps by implying GIS and Remote sensing.

(ii) Data of Water quality, biodiversity and socioeconomic factors have been analysed by using SPSS software.

(iii) Interview transcripts has been reviewed by implying Thematic Analysis method.

FINDINGS AND CONCLUSIONS:

1.Effect of sand mining on Fluvial Topography:

1.1 Channel Morphology Alterations around Dehri:

Disastrous increase in channel depth:Deep mechanised sand mining has led to excessive scouring, causing unnatural deepening of the riverbed around certain places v.i.z. Katar, Hoorka, Darihat etc,

Bank erosion acceleration: Unstable, steepened river banks due to excessive sediment removal from mining sights have resulted in frequent collapses and land loss particularly at Balgobind bigha, Mahabir bigha, Shivganj, Ramkrishna mission Ashram, Naga Ashraaam .

Uneven disruptions in Meandering pattern : Altered sediment load has affected natural river meandering, increasing the risk of channel migration from Balgobind bigha to Naga Ashram Pali.

Formation of Pools and sand pits:Large excavated depressions resulted from excessive sand removal have created stagnant water pools, disrupting natural flow patterns to a great extent

1.2 Severe sediment Budget Imbalance

Increased turbidity: Disturbance of sediments has resulted in higher turbidity, affecting light penetration and aquatic productivity.

Reduced sediment replenishment downstream: Excessive removal of sand has led to an imbalance in sediment transport, affecting riverine processes.

2.Hydrological Consequences

2.1 Groundwater Recharge and Water Table Depletion:

Reduction in Natural Percolation: The removal of sand layers, which act as natural filters, has significantly reduced groundwater recharge rate in adjacent areas of Dehri town

Decline in groundwater levels: Over-extraction of sand has reduced the river's ability to recharge aquifers, affecting local wells and drinking water sources.It is observed in failure of handpumps in the town area during summers.

Groundwater decline: Estimated drop of1.5–3 meters in the last decade in certain areas of Dehri Town.

Lowering of Water Table: Field data and local observations indicate a gradual decline in groundwater levels, affecting wells and borewells in Dehri Town and nearby areas.

borewell depth: Borewells that previously tapped water at30–40 meters now need to be Increased dug to 50–70 meters.

Drying of Shallow Wells: Many traditional wells that previously provided water throughout the year are now dry for extended periods, especially in summer.

Increase in seasonal water scarcity: Water retention capacity of the river has decreased disastrously, making Dehri Town area more vulnerable to seasonal droughts.

2.2. Altered discharge patterns resulted from flow Regime Disruptions:

Illegal excessive sand Mining has resulted in unpredictable flood and low-flow conditions, disrupting traditional water use patterns.

Higher vulnerability to flash floods: The removal of natural sand buffers has increased flood risk particularly during monsoon seasons.

Increased Dependence on Deeper Borewells: Residents now rely on deeper borewells due to the declining water table, leading to increased extraction costs.

Extended Water Shortages in Dry Seasons: During non-monsoon months, the river retains less water, leading to a prolonged dry phase and reduced availability of drinking and irrigation water.

2.3. Disruption of Hydrological Balance

Changes in Base Flow: Sand mining disrupts the base flow of the river, reducing the slow seepage of water into surrounding aquifers. Due to deeper excavation, the river loses more water through increased seepage into subsurface layers, further depleting groundwater levels..

3. Increased Water Stress for Communities

3.1. Longer Water Fetching Distances:

Villagers particularly pastorers in some areas must travel farther to access portable water to feed or wash their cattle.

3.2. Cost of Water Extraction:
The need for deeper borewells and pumps is increased leading to higher energy and maintenance costs for water access.

4. Impact on Irrigation and Agriculture
4.1Reduced Water Availability for Farmers:
Lower groundwater levels have directly affe cted irrigation sources, reducing crop yields in agricultural lands near Dehri Town..
4.2. Shift to Less Water-Intensive Crops:
Farmers of this locality have reported shifting from traditional high-water crops like paddy to drought-resistant varieties, leading to changes in local agricultural patterns. +++
Recommendations to Address Water Depletion
1.Regulated Sand Mining Practices: Implement zoning laws* to prevent excessive excavation in key groundwater recharge zones.
2.Artificial Recharge Measures: Construct check dams, recharge wells, and percolation ponds to enhance groundwater levels.
3.Community Awareness & Water Conservation: Promote **rainwater harvesting and sustainable water use practices among local communities.
4.Regular Hydrological Monitoring: Establish continuous groundwater monitoring stations to track depletion trends and take timely action.
3.1Decline in Aquatic Biodiversity.
Disruption of fish breeding grounds: Loss of riverbed stability and increased sediment suspension have destroyed habitats for native fishes like Catla, Rohu, gochhra, Tengra, Bachwa etc.Cyprinus Carpio, Labeo rohita, Cirhinus mringala, Garra mullya species.
Reduction in benthic organisms: Essential microorganisms and invertebrates in the sediment have declined, affectcting the food chain adversel
Decline in migratory fish populations: Migratory Species consists of Cyprinidae the most dominant family (44.23%) followed by Barbinae (15%) and Siluridae (7.78%) rely on stable sediment conditions for spawning have been significantly affected.
Degradation of Riparian Vegetation Loss of plant cover along riverbanks*: The destruction of riparian zones has led to soil erosion, reduced shade, and habitat loss for birds and small mammals.
Increased desertification risk: Reduced moisture retention has made certain stretches of the Sone River more arid.

5. Socioeconomic Consequences
5.1 Impact on Livelihoods
Decline in fishery-based income: Reduced fish populations have impacted traditional fishing communities i.e. Mallah disastrously. Merely some people in certain settlements are still engaged in their traditional occupation of catching fish in the Sone river.
Agricultural productivity loss: Lower groundwater availability has negatively affected irrigation, leading to lower crop yields in the farms situated above the riverbank level e.g. Makarine, Hoorka, Berkap, Chainpur, Bhusahula, Darihat and Arjunbigha.
Increase in water-fetching distances: Women and Pastoralist communities of Shivganj, Pali, Biranbigha etc have to travel farther to access potable water. For their dailly use

5.2 Expansion of Illegal Sand Mining Practices
Unregulated mining operations: Weak enforcement of regulations has led to uncontrolled extraction, exacerbating environmental damage.
Health risks to workers: Labourers in the mining sector face respiratory issues due to prolonged exposure to fine dust.

6. Comparative Analysis and Policy Gaps

Lack of sustainable mining guidelines: No strict measures have been implemented to ensure controlled sand extraction.

Failure of mitigation efforts: Riverbank restoration programs in Dehri Town remain ineffective due to continuous mining activity.

Need for integrated river management: A balance between economic needs and ecological sustainability is crucial for long-term stability.

Recommendations for regulatory interventions:

1. Strict regulation and enforcement: Implement legal measures to curb illegal mining and over-extraction.
2. Community participation: Involve local stakeholders in river conservation programs.
3. Riverbank stabilization projects: Use bioengineering techniques to restore eroded banks.
4. Alternative construction materials: Promote the use of substitutes like manufactured sand to reduce dependency on river sand.
5. Continuous assessment of fluvial changes to ensure sustainable water resource management.

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