

Sand Mining in India and its Evaluation using SWOT Analysis- A Review

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Abstract

The importance of mining to long-term economic development in developing nations has been a hot topic in recent years. Mining offers enormous potential for local and national output, employment, revenue distribution, and economic growth. Among all minerals, Sand became the most widely used building resource on the earth that is creating the physical foundation of the built environment but the mining industry was unconcerned with the environmental consequences of resource exploitation. A Strength, Weakness, Opportunity, and Threat (SWOT) analysis is done in this review article to give proper highlights on the issues and impacts of sand mining that need to be readdressed by mining authorities and by sand mining owners. Sand mining has some economic and social benefits, including the creation of jobs and revenue, as well as the enhancement of the local economy. But after water, Sand is now the second most exploited and exported resource by volume. Its exploitation is wreaking havoc on the environment and provoking political-economic tensions. This article concludes with some suggestions for potential direction of change/ improvement in sand mining in India.



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Introduction

Sand is a naturally occurring aggregate produced over many years by rock erosion. Sand became the most widely used building resource on the earth that is creating the physical foundation of the built environment, but after water, Sand is now the second most exploited and exported resource by volume. Its exploitation is wreaking havoc on the environment


and provoking political- economic tensions.^{1,2}

The rate of sand and gravel extraction has tripled over the past two decades due to increased economic activity, reaching 40 billion tons annually.³ Sand is a naturally occurring granular, loose, broken substance made up of particles of matter such as rock, coral, shells, and other elements. In most circumstances, it is finer than gravel but coarser than

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silt. It has a different composition based on where it comes from and the circumstances that exist there.

The most common ingredient of sand in inland continental regions is silica (silicon dioxide), usually in the form of quartz. Aragonite, a kind of calcium carbonate, is commonly found in the sand that has been formed over centuries by coral and shellfish.⁴ Sand, being a hard material, can withstand shear pressures at rest, but it can also go through massive dynamic loading without losing its characteristics, acting similarly to a fluid. Sand cannot be split into bits as a result of erosion since it is already a broken ('clastic') substance.⁵

Sand Mining

The importance of mining to long-term economic growth in underdeveloped countries has been a hot topic in recent years. This problem comes up at a time when investment in both new and established "mining nations" is quickly increasing, influenced by the ease of investing and the significant demand for minerals in China and India's developing economies.⁶ Several countries' economic success is dependent on the production and use of minerals, notably fuel minerals, which leads to increased mining activity.⁷ Previously, the mining industry was unconcerned with the environmental consequences of resource exploitation. The situation has altered dramatically in recent years, as stakeholders have begun to

place a greater emphasis on the environmental consequences of resource extraction operations. One such mining type is Sand mining. The recent fast industrialization, urbanization, and related changes have increased the need for sand.⁸ Therefore, river-sand mining has been chosen as one of the most effective techniques of sand extraction to supply the need for sand.

There are two types of sand deposits: terrestrial and marine (offshore). Residual soil deposits, river channel deposits, and floodplain alluvial deposits are examples of terrestrial sources, whereas coastal and offshore deposits are the most prevalent marine sources.⁹ Sand is carried via the bed, partially in bed and partially in suspension, and completely in suspension in river channels under various energy circumstances. Sand particles have a vital function in limiting the velocity of natural agents like wind and water, which helps to protect biodiversity and richness.¹⁰ But experts and riverbed managers have long misunderstood impact of mining on numerous components of river ecosystem since it is not always evident and observable right away.¹¹ Many researchers had researched sand mining's effects on the environment, especially on riverine all over the world. So, here is a list of some of the researchers who have researched sand mining impacts on the environment and Indian riverine (Table 1).

Table 1: Sand mining in Indian rivers and its impacts

S.No.	River Name	Place	Impact of sand mining	References
1.	Umtyngngar	Meghalaya	Increase in bank erosion and channel shifting	Shymbin <i>et al.</i> , 2022 ¹²
2.	Sone river	Koelwar, Bihar, Bihta	Hike in silica particles and turbidity was found. Also, the concentration of DO was found higher at mining sites.	Kumar <i>et al.</i> , 2021 ¹³
3.	Kangsabati River	South Bengal	Deterioration in water quality. It also changes species diversity & richness in aquatic community Or Instream biota.	Bhattacharya <i>et al.</i> , 2019 ¹⁴
4.	Ganga River	Around Patna, Bihar, India	Impacts on zooplankton were identified. Increased turbidity leads to decrease in water transparency.	Prabhakar <i>et al.</i> , 2019 ¹⁵
5.	Kangsabati River	West Bengal	Impacts on Instream organisms in rivers. Mastacembelidae and Anguillide species families' were found vulnerable. Both habitat loss and toxic contamination are	Bhattacharya, 2018 ¹⁶

6.	Ramganga River Dam	Kalagarh, Uttarakhand	a challenge to benthic zoos. In comparison to chemical Features such as water-soluble sulfate and acid-soluble chloride, physical properties of sediments, such as particle size distribution, show more fluctuation.	Daityari <i>et al.</i> , 2017 ¹⁷
7.	Different Rivers	All over India	The colour of river water ranges from brown to reddish-orange. Various impacts of water degradation include low pH, high electrical conductivity, and high concentrations of harmful heavy metals, low DO, and high BOD.	Saviour, 2012 ¹⁸
8.	Muvattupuzha River basin	Kerala	Widespread flood plain sand mining has negative consequences in the area's geo-hydrological context. Saltwater intrusion concerns in the area are exacerbated by mining, which causes fresh water excavated wells to become saline.	Maya <i>et al.</i> 2011 ¹⁹
9.	Ithikkar River	South west coast of India	Destabilizes the delicate equilibrium that exists in the natural ecosystem of the river. Fishery wealth was found to be declining. Suspended particulates and turbidity limit planktonic and benthic organisms' photo-synthetic activity, production, and growth.	Sheeba 2009 ²⁰
10.	Kulsi River	Assam	One of the possible risks to the dolphin population is sand mining.	Mohan, 2000 ²¹

(Source- Made by Author)

Sand demand can be fulfilled by desert sand also as deserts encompass over 20% of the land surface of the earth, with sand covering 20–30% of the world's deserts.²² But desert sand, which is made up of tiny and fine grains, does not match industrial standards in several ways. The utilization of a particular type of sand in various sectors is determined by some variables (size, density, composition, etc.).²

Table 2: Sand uses in different Industries

Type of Industry	Uses of Sand
Glass Making	<p>Silica-sand is the primary component.</p> <p>Used to create flat glasses for food containers, automobiles, and construction.</p> <p>Used to make fiberglass insulation & reinforcing glass fibers by ground silica.</p> <p>Used to create specialist glass products, such as test tubes and other scientific instruments.</p>
Metal Casting	<p>A crucial component of both non-ferrous and ferrous foundries.</p> <p>Sand is used in the casting process for metal goods such as engine parts and sink faucets.</p> <p>Thermally or mechanically recycled core sand can be used to make fresh cores or mold.</p>

Metal Production	A number of non-ferrous and ferrous metals are produced with the help of sand as a crucial ingredient. Sand is used in the metal and casting industries for grain refinement and de-oxidation.
Chemical Production	Sand is a key ingredient of several chemicals, including silicon gels, silicon tetrachloride, and sodium silicate.
Construction	The main structural element in building is sand. Provide flexural strength without compromising the binding system's chemical characteristics.
Paint and Coating	Used to enhance the endurance and look of architectural and industrial paint and coatings. Brightness & reflectance, color constancy, and oil absorption are all influenced by high purity silica.
Filtration and Water Production	Used for purifying water. In removal of contaminants in potable water and wastewater. Silica gravel is used as a packaging in deep-water wells to increase aquifer production.
Oil and Gas Recovery	Used as prop pant. Deep wells are propped open and their flow rates are increased by pumping sand down the holes.
Recreational Products	Sand is used to clean up oil spills and can resist chemical attacks. Sand is also used in sports and recreational activities. Silica sand is utilized in the creation of natural and synthetic sporting fields, as well as golf-course bunkers and greens. The qualities necessary for drainage, healthy plant development, and stability are provided by the steady, evenly dispersed particle size distribution of silica.

(Source- Wisconsin industrial- sand association (WISA))²³

As we have discussed before (Table 2), many items depend on sand for their manufacturing and it is specially used in construction work. However, because the operation disrupts channel hydraulic systems and the productivity of neighboring habitats, in-channel or near channel sand mining may unavoidably change ecosystem balance. Furthermore, the process has significant negative consequences for river bank stability, structural systems built to safeguard rivers, and the capacity to satisfy social needs.^{24,25}

Sources of Sand

Various sources of sand can be broadly classified as natural sources and artificial sources.

Natural Sources

Sand from a natural source is further grouped into river sources that are sand extracted from in-channel sources (active river channel) and off-channel

sources (flood plains or terraces areas). These river sources cannot be renewable in terms of human life. Flood plain area is prime agricultural land or dense settlement land, so to safeguard this land sand extraction from these plains has to be restricted.

The non-river source includes 'On-land sand and shore & offshore' sand deposits. On land sand includes sand from lake, lagoon & backwater-sand, paleo-beach and dune sand, reservoir sand and Shore & off-shore sand includes sand deposits on the beach and marine sand. These non- river sources are protecting the river environment from exploitation but as the demand for sand is increasing day by day these non-river sources should also be protected by regulations.

Artificial Sources

An artificial source of sand includes Primary aggregates and Secondary aggregates. Primary

aggregates are produced by drilling, blasting, washing, and sieving hard rock into artificial sand²⁶ also known as manufactured sand (M-sand). M-sand is the most frequent substitute for river sand, and it has already established itself in various southern states.

Grinding rocks and quarry stones to a size of 150 microns are used to make it (Sand mining framework, 2018). Secondary sand is obtained by crushing and grading construction and demolition waste. This C & D waste contains some of the materials that have the potential to recycle as secondary aggregates.²⁶ Many nations have embraced the technique of producing sand through a sequence of crushers, including

primary jaw crushers, secondary cone crushers, and tertiary vertical shaft impact (VSI) crushers, to lessen the harm that mining for river sand has to the ecosystem. V7 dry sand production technique was created in Japan. The gradation of manufacturing sand (M-Sand) is equivalent to that of river sand.³

Methods of Sand Extraction

Alluvial sand is extracted using a number of processes. Kondolf developed many strategies for extracting sand from riverine ecosystems' active channels and floodplains/terraces²⁷ and the description of the method was given by Padmalal, D.²⁸

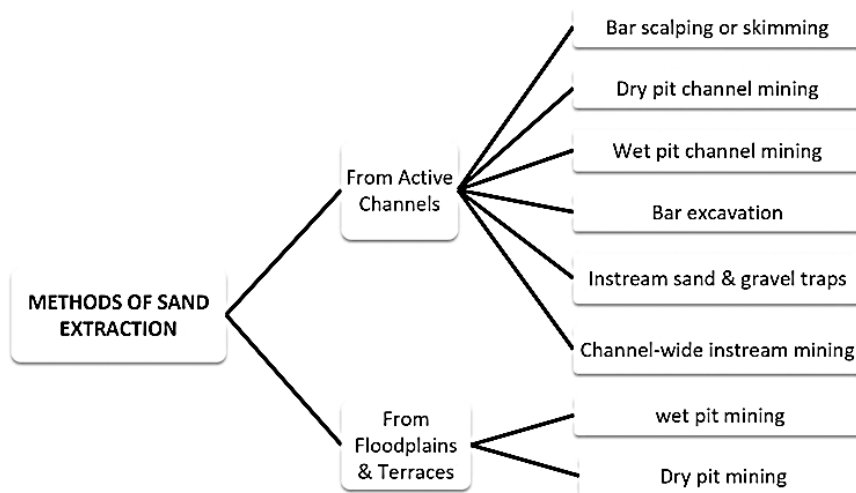


Fig. 1: Methods of sand extraction from River
(Source- Made by Author)

Sand excavation from Active channels

The methods used for instream gravel and sand mining is described by Padmalal, D.²⁸

Bar Scalping or Skimming

The removal of gravel and sand from tops of the bars is known as bar scalping/skimming. It is based on the pace at which silt builds up on bars each year. In order to maintain the hydraulic control the riffle head's hydraulic control imposes upstream, the best bar skimming technique entails leaving the upper portion of the bar intact. Only two-thirds length of bar may be mined at its downstream end.

Dry Pit Channel Mining

Sand is excavated inside the current channel of a dried-up stream bed using either manual or mechanical methods. This type of mining also leaves some sudden & unexpected margins upstream, which cause damage during high flow seasons.

c)Wet pit channel mining-

Wet-pit mining is excavating a pit in an active-channel beneath the surface water in a perennial-stream or below the alluvial ground-water table, which calls for the employment of a dragline or

hydraulic excavator to recover the sand and gravel from below the water's surface.

Bar Excavation

Bar excavation is done at the bar's downstream end. Sand/gravel are kept in a pit that is made as a supply of aggregate. The pit could be joined to the canal at its downstream end after work is finished to create a side channel habitat.

In-Stream Gravel Traps

Sand-and- gravel traps or bed load traps have been used to limit sand flow in downstream streams for habitat improvement. If the quantity gathered is feasible from a business sense, these traps might be potential sources of commercial aggregate. The trap has the benefit of concentrating mining impacts to a single location, where heavy equipment may take sand and gravel without causing significant damage to riparian vegetation or other natural channel characteristics. Sand and gravel extraction may be done on an annual basis after the gravel traps are put up.

Channel-Wise Instream Mining

During the dry season, gravel and sand are regularly removed over whole active channel in rivers with a highly varied flow regime. The riverbed is leveled and lowered uniformly (or nearly so).

Sand Excavation from a Flood Plain

Flood-plains and river-terraces are two important places to find alluvial sand. These source criteria utilize mining techniques. Wet pit mining and dry pit mining are the two types of mining.

Wet-Pit Mining

In wet pit mining, the excavation pit's depth reaches the groundwater table,

Dry-Pit Mining

Sand extraction in dry pit mining is limited to the top of the dry bed.

The SWOT Analysis

A SWOT (strengths, weaknesses, opportunities, and threats) analysis is a tool that can be used to support an organization or activity in determining its strategic plans.²⁹ A SWOT analysis evaluates both external and internal factors, as well as present and potential future outcomes. SWOT analysis

is a technique to find the strengths and weaknesses of any activity or organization by giving realistic facts and data about the activity or organization.³⁰ SWOT analysis is a strategic planning method that gives you tools to examine situations. By highlighting the most important strengths, weaknesses, opportunities, and threats, fact-based analysis, new perspectives, and fresh ideas are produced. Internal aspects define a system's strengths and weaknesses, while external influences determine opportunities and dangers.

A SWOT analysis is presented in this part to emphasize sand mining constraints, potential, and challenges. By analyzing many reports, news articles, and literature by different authors it was discovered that river-mining is a serious threat to the environment and it can be effectively visualized by SWOT analysis. Some of the unusual characteristics of sand mining are highlighted by this SWOT analysis.²⁹

Strengths

Strength recognize economic growth and abilities of sand mining, this may lead to development of mining activity future. It demonstrates that there are several opportunities to enhance mining operations by taking some of the strong legal action taken by the government, minimizing illegal mining activities, and by giving proper restricted rules to mining owners.

The strength of sand mining also lies in the type, ways, and amount of sand mining is performed with proper planning and regulation. The strength of sand mining activity is well defined when mining is being performed with adequate rules and restrictions allotted by regulatory authorities.

River Environment

River channels are used to harvest sand and gravel for a variety of environmental benefits. Sand is extracted from river channels for improving the navigation of river water and also for boats. By excavating sand and gravel in proper and controlled ways, these new route navigations aid water as well as boats in learning about the area of river. How much gravel and sand can be removed from the riverbed depends on the river's width and pace of replenishing.³¹ Extraction of sand from the river in an adequate manner helps in developing agricultural drainage systems and in the regulation

of floods.³² According to MoEF & CC in guidelines for sand mining, 2020 several considerations are kept in mind such as the depth of mining shall not exceed

more than 3m and the distance from the riverbank should be 1/4th of river width.

Table 3: SWOT analysis of sand mining-

Strength	Type of Environment	Details
Strength	River Environment	To facilitate navigating For creating a drainage system for agriculture To control flooding
	Socio-economic Environment	Sand demand is fulfilled Sand for production of aggregate material Sand for exporting Employment is increased Growth in country's economy
Weakness	River Environment	Excavation more than legally allowed. Effects on river ecosystems due to illegal mining.
	Water & air Environment	The natural filter of river has been effected. Water & air parameters rise to standard limits.
	Biological Environment	Impact on terrestrial and aquatic biodiversity. Impact on wildlife including avifauna.
Opportunities	Socio-economic Environment	Proper guidelines and safety measures are not taken. Health issue due to over exploitation of mining operations.
	River Environment	Replenishment of River Development more drainage facilities Creating more area for river water Increase in employment.
Threats	Socio-economic Environment	More foreign connection by exporting sand. Economic development of county's GDP. Increase in public awareness. More legal laws were amendment in the EIA of mining.
	River Environment	Change in grain size. The river is unable to replenish again due to high excavation. River bed lowering.
	Water & Air Environment	Water & air get polluted due to mining operations. High levels of PM and suspended solids in both the water and the air. Deterioration in the drinking water's quality.
	Biological Environment	Extinction of rare species of flora & fauna. Adverse effects on benthic fauna.
	Socio-economic Environment	Threat to health of humans & animals due to dust. Living being face breathing problems near mining sites.

(Source- Made by Author)

Socio-Economic Environment

The mining sector is a critical source of construction and a key facilitator of a country's development.³³ Sand mining is one of the mining sectors which contributes to both the infrastructure and economic growth of the country. Sand mining is one of the major sources of income³⁴ and employs the residents of riparian areas. Government authorities also allow exporting some specified quantities of river sand, this increases trade relationships and growth in the country's economy (New Delhi news, 2019).

Sand also plays a vital role in the manufacturing of many materials (Glass making, paint, mortar, metal casting & production, chemical production, oil & gas recovery, etc.). The sand sector is thought to be valued over \$4 billion and is rapidly expanding at a pace of roughly 6% per year.³⁵

Weakness

The present scenario of sand mining is not up to the mark in the whole world, it has several weaknesses such as sand mining causing irreversible damage to the river ecosystem and nearby environment. The river is known for its replenishment but excessive extraction of sand from the river gives several weaknesses and reduces the replenishment rate of the river.

River Environment

River-sand utilization in the Indian construction industry grew from 630 to 1400 million tonnes between 2010 and 2020.³⁶ So, the effects on rivers of sand mining will take a generation or more to manifest themselves at detectable levels. Excessive sand mining can disrupt the riverbed, causing it to shift direction, erode the banks, and cause flooding.³⁷ In addition to influencing groundwater recharge, it damages the habitat of aquatic creatures and microorganisms. Due to the mining enabling the flow to spread throughout the whole river channel rather than being limited to one single channel during the dry summer months, Kondolf (1993) discovered channel widening and a fall in river level linked with bar scalping.³⁸ Riparian forests along the Lower Eygues River in France have been impacted by access roads and storage facilities constructed to support aggregate mining.³⁹

The incision was connected to mining techniques such as bar scalping and skimming. The coarser

armored layer is removed from river bars, exposing the underlying finer sediment layers to the river's flow. Because finer particles are mobilized by smaller flows than coarser sediments, erosion might become more severe, causing the bars to be removed. Such collapses affect the river's hydrodynamic regime, which can have far-reaching consequences for the riverine and riparian habitats.³⁸

Water & Air Environment

Increased turbidity, changes in water temperature, changes in the distribution and availability of habitats, and increased pollutants and saltwater intrusion are all associated with sand and gravel mining.⁴⁰ Turbidity variation also affects macro invertebrate communities by affecting drift,⁴¹ as drifting invertebrates act as important food sources for organisms. Widening of the channel increases water temperature, this increase in temperature results in lower dissolved oxygen concentration, reduction in the availability of shelter, and an increase in toxicity of pollutants.^{38,42} Air quality also had deteriorated due to sand mining processing. Mechanical mining and vehicle mobility have moderately unfavorable effects on ground stability and air/noise pollution. Impacting behaviors such as hand mining would have little direct influence on air quality. However, mining-related activities such as vehicle traffic along unplanned/non-paved roads have a significant negative impact on ambient air quality while also increasing noise levels.⁴³

Biological Environment

Rivers' normal flow patterns and ecological processes are disrupted by human activity, which harms their biological riches.⁴⁴ The chemical, physical, and biological ecosystems of river-systems are negatively impacted by sand-mining in a number of direct and indirect ways. Excessive sand extraction from rivers has an impact on the eco-biology of many terrestrial insects that start their lives in water. Sand mining can also have a deleterious impact on the survival and spread of Polychaeta, Crustacea, and Mollusca benthic creatures.⁴³ Benthic invertebrate loss has a severe detrimental impact on fisheries and will eventually result in a decrease in the amount of resources available for inland fishing. The first and most important justification for employing fish to monitor riverine biodiversity is that these fishes are extremely varied, with various species reflecting different environmental circumstances.⁴⁵ Aquatic

vegetation is critical for sustaining and increasing the health of river ecosystems but Sand mining harms the riparian flora that grows along river banks. By supplying organic matter through litter fall and shading stream water, the riparian canopy regulates stream sediment and nutrients dynamics. In addition to supporting the riverbank, their root systems also filter lateral silt and fertilizer inputs.⁴⁶

Socio-Economic Environment

River sand mining causes the quality of water used for drinking, bathing, and other household requirements to decline. Riparian landowners and people are negatively affected by mining activity along with water scarcity during the dry period became a major issue in many river stretches.⁴³

Negative societal effects include disagreements over the use of agricultural lands, particularly in countries where agricultural lands are few, and the ability to restore them after extraction. In Ghana, investigations by Musah and Barkarson have shown that sand and gravel extraction results in the loss of the local people's major source of subsistence (farmland).⁴⁷ It also has an impact on local populations' culture. Furthermore, the trenches created by sand extraction have been left to their own devices, resulting in the accumulation of a wide range of pollutants, including malaria mosquitoes. As a result, the health of local populations is in grave danger.⁴⁷ The business and selling of sand have also caused major damage to the roads and tension between local inhabitants, according to their research.⁴⁸

Opportunity

River Environment

Sand mining hasn't done much to help the river's ecosystem, but if enough sand is removed, the river's pace of replenishing may be increased. For a variety of reasons and causes, including (i) improving navigation, (ii) developing agricultural drainage systems, (iii) controlling flooding, (iv) producing aggregate materials, etc., sand and gravel are removed from river channels. The mining industry that is most lucrative in terms of both volume and financial gain is that of extracting these minerals for aggregates.²⁷ Flood control measures, river straightening to allow for the development of floodplains, dredging to facilitate navigation, and the diversion of river water for irrigation

are all examples of channel alteration. River channel modification can have many of the same consequences as aggregate mining.

Greater flow speeds arise from straightening and narrowing rivers, worsening incision. Levees built to defend against flooding may shut rivers off from their floodplains while also straightening and shrinking them.⁴⁰

Socio-Economic Environment

Mining offers enormous potential for local and national output, employment, revenue distribution, and socioeconomic development. Sand is a precious mineral that is also the primary supplier of construction materials all around the world.⁴⁹ These mines have the potential to generate both direct and indirect job opportunities. Local small employment, for example, is generated, particularly for drivers and others who support them with products and services, resulting in shifts in salary levels in particular and income disparities in an area as a whole.⁵⁰ On the other side, this may be beneficial to the income of local mining employees.⁵¹

Threats

River Environment

Sand mining threatens the availability of the following resources: (i) pure water, which is used for drinking, washing, cleaning, irrigation, and other uses; (ii) land and access to land; (iii) a decrease in the supply of food; and (iv) a degradation of trees and other vegetation. The livelihoods of those who live in river basins might be adversely affected by the loss of important crops regions in physiographic provinces like highlands, midlands, and lowlands as well as animal loss.²⁸ The connection between afforestation and sand & gravel mining has been discovered to be complex. Riparian woods can extend onto abandoned braided river channels and isolated floodplains as river channels narrow owing to incision.³⁹

Examples of documented impacts include modifications to the water quality, adjustments to sediment composition and movement, modifications to larger-scale River features, changes to the flow regime, and adjustments to channel morphology.⁴⁰ Although river sand mining affects local and downstream water quality, it has little effect on the chemical qualities of the sand. Sand mining

in wet mining pits stirs up the water and causes the formation of clouds of tiny organic and inorganic particles.⁵²

Water & Air Environment

The decrease in river levels caused by sand mining may also result in a decline in the local water table. Efficiency of wells can be harmed as a result of this decline^{38,53} posing a danger to the water supply for both local people and agriculture, resulting in economic losses.⁵³ Mining may pollute groundwater and endanger the health of individuals who drink it by agitating rivers and introducing contaminants. Incision not only Threat River's bank but also Lower the groundwater level and affect groundwater availability and recharge.⁵⁴ Fish population issues have also been linked to the impact of aggregate quarrying on groundwater table.

Not only the water environment but the air environment also had major threats due to sand mining as Mechanical mining in lowland regions can have detrimental effects on air quality and noise levels, although only at low levels.²⁸

Biological Environment

According to Sunil Kumar's research, clandestine sand mining has a significant impact on many aquatic creatures, particularly the benthos.⁵⁵ Lowering riverbeds will be detrimental to psammophilic fishes that require a sandy substrate for breeding.⁵⁶ During their embryonic stages, and fish are directly endangered by suction dredging. Even though juvenile and mature fish have a higher chance of avoiding or surviving transit through a suction dredge, species-to-species variation in fatality rates is significant.⁵⁷ In recent years, the number of dragonflies in sand mining- affected areas has decreased dramatically. Sand mining also causes a threat to important bird areas, disrupting the natural habitat that migratory and other birds rely on.

Socio-Economic Environment

Drawbacks of river-mining usually exceed the immediate advantages. The frequency of unintentional deaths has increased over time as a result of the holes, which are dangerous especially due to their partially covered condition with silt and clay deposits. Manual sand mining has a severe impact on the health of individuals in the lowlands.⁵⁸

The process of a riverbed deepening and expanding makes the riverbed unstable on both the vertical and lateral axes. Buildings, roads, and underground pipes might be undermined and collapse due to increasing erosion as well as the deterioration of riparian and aquatic vegetation. Residents and owners of riparian land are also affected. In a case study they conducted, it was shown through risk analysis that slope stability of levees is substantially endangered and that the chance of instability risk has virtually quadrupled as a result of sand mining. Aside from bank collapse and slope instability, agricultural land losses may grow as a result of the decreased groundwater level since irrigation systems won't be able to access the water as easily.⁵⁹

Sand mining came with both beneficial & adverse effects on the socio-economic environment. Sand mining has a major threat to health as the dust particles while transportation and during sand excavation through machinery creates dust and these dust particles create major health issues for humans as well as animals in breathing.

The Potential Direction of Change/Improvement in Sand Mining in India

The government has to reevaluate its commitments to controlled sand mining by updating policy directives, streamlining administrative procedures, and putting policies in place to strengthen the role of sand mining governing organizations. The initiative would necessitate improved monitoring and the availability of environmental experts who are well- versed in sand mining and its effects on varied habitats. After gaining a better understanding of the system's flaws and challenges, some recommendations for improving Indian sand mining practice have been made to allow for more rigor in the analysis, appraisal, monitoring, and enforcement of sand mining activities to achieve the larger goal of environmental protection.

Increase the Mining Specialists' Accountability

Certification of consultants is thought to be required in order for only licensed agencies to conduct sand mining. In EIA reports, the authors should be acknowledged so that the project developers or consultants feel accountable and so that each data point can be tracked back to its original source.⁶⁰ EIA specialists should analyze all information

on mining sites so that if any serious impacts are found, sand mining at that place will be prohibited, and other sites will be identified.

Manage Baseline Data Properly

The absence of trustworthy and precise data is one of the uncertainties in the sand mining forecast. As a result, it is proposed that a shared database be established where all relevant authorities may pool their data and make it available to project proponents upon request. Many illegal sand mining operations were carried out along practically every river, with no data on these operations gathered and examined to date. Mining regulatory agencies should move quickly to stop these illicit sand mining operations.

Improve Monitoring and Implementation

In order to remove, compensate for, or reduce consequences throughout the mining and transportation stages of operations, mining authorities should clearly advise prevention, supervision, and organizational techniques. The efficacy of mitigation strategies and the requirement for any necessary corrective action must be guaranteed during EIA implementation. To guarantee successful implementation, mining processes must be monitored and evaluated on a regular basis. Environmental monitoring measures that are effective produce baseline data for sand mining and increase understanding of the relevance and impact of mining activities on environmental changes, hence enhancing the knowledge base for future mining processes.

Focus on Alternatives to River Sand Mining

Government should focus on alternate options for river sand and regulate over-exploitation of river sand mining. Manufactured sand (M-sand) and sand from the overburden of coal can be used as alternates for river sand. M-sand, which may be created by crushed rocks and quarrying stones down to 150 microns, is a popular substitute for river sand. It is economically feasible, cheaper, and is better than river sand. Mining authorities should take a step forward to convince the sand mining project consultant/owners to adopt M-sand manufacturing in place of the river mining process. There should be the implementation of strict rules regarding the adoption of M sand. Many experiments explained different alternatives of sand such as Coal bottom ash, Recycled glass, Waste glass cullet and palm

oil clinker. These alternatives of sand can be used. The inclusion of steel slag, granite dust, and marble dust results in a considerable improvement in observed UPV values when compared to the corresponding control concrete. It suggests that the concrete's quality has improved.^{61,62}

Integrate Environmental Concerns with River Sand-Mining

There is need for proper guidelines given to the public and mining operators regarding rivermining's impact on the environment & nearby surroundings. Mining clearance should be given to consultants only when the public nearby the river-mining is fully convinced of mining project and the public will get compensation and opportunity in the mining process. Sand mining creates an intensive impact on the environment so to minimize these adverse effects more amendments should be made to sand mining guidelines by the ministry of mines.

Conclusion

With the help of SWOT analysis, it can be seen, Sand mining has many economic and social benefits, including the creation of jobs and revenue, as well as the enhancement of the local economy. Sand mining is beneficial as sand is the basic need in construction and the manufacturing of many materials as explained. But, extensive sand extraction causes various threats to the environment and these effects on the environment reduce the beneficial or positive effects of sand mining. SWOT analysis segregates the strength, weaknesses, opportunities, and threats of sand mining in India. Sand mining strengthens the economic environment but it creates a major threat to the river environment. After SWOT analysis some of the conclusions have been derived.

Implementation of Proper Guidelines for Sand Mining

The Ministry of Mines of India should implement guidelines regarding mines in every region and take regulatory action if some illegal sand mining is being performed in any river. Every mine should have an Environment clearance report and all the data regarding mines should be submitted to the EIA authority.

Public Participation

Public awareness and participation should be one of the major concerns for mining authorities.

Due to sand mining activity people nearby these mines are majorly affected. Therefore the time to time monitoring of mining activities is important with public consultation.

Adaptation of M-Sand Or Alternatives

As it is seen, sand plays a vital role in construction as well as in the economic growth of the country. So, to fulfill the demand for sand substitutes for river-sand should be adopted such as manufactured-sand. M-sand is cheaper, better, and more feasible than river sand. Sea sand can also be used as it enhances the mechanical qualities of concrete, the sustainability of natural resources may be improved by using seashore sand and sea-water in concrete.

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Conflict of Interest

The Author(s) declare no conflict of interest.

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