Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The Tragedy of Sand Commons and Environmental Justice in India's Riverine Ecosystems

Vikas Kumar

vikas1978in@gmail.com

University of Delhi

Sharma K. Saurav

University of Delhi

Article

Keywords: riverbed sand mining, minor mineral, tragedy of sand commons, environmental justice, riverine ecosystems

Posted Date: November 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10709286/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

The Tragedy of Sand Commons and Environmental Justice in India's Riverine Ecosystems

Abstract

Riverbed sand, a vital ecological component and an indispensable resource for India's infrastructure boom, has become the site of a profound constitutional and environmental crisis. The unregulated and extensive extraction of sand epitomizes the 'Tragedy of Sand Commons', where developmental imperatives override ecological and community interests

creating a crisis of law and sustainability. The foundational legal flaw is the classification of sand as a "minor mineral" under the Mines and Minerals (Development and Regulation) Act, 1957. This framework prioritises revenue over ecology, creating a systemic failure of governance and a profound implementation gap in the State's constitutional mandate to protect the environment under the Directive Principles of State Policy (DPSP), particularly Article 48A.

The Supreme Court's landmark judgment in *Deepak Kumar v. State of Haryana* (2012) and subsequent interventions by the National Green Tribunal (NGT) recognised the massive ecological damage caused by unregulated extraction and closed the exemption under which minor mineral leases below five hectares had escaped environmental appraisal altogether. This judicial activism is rooted in the Public Trust Doctrine, which reframes the State's role from a mere licensor to a trustee, constitutionally bound to protect rivers as a public resource.

This paper situates riverbed sand mining within the broader discourse of constitutional environmentalism, exploring how India's environmental jurisprudence has evolved to recognise nature's intrinsic rights and the state's duty as trustee of natural resources. It also critically examines the "SDG Paradox": the aggressive pursuit of SDG 9 (Industry, Innovation, and Infrastructure) is proceeding at the cost of progressive degradation of riverine ecosystems, directly undermining SDG 14 (Life Below Water) and SDG 15 (Life on Land). Through doctrinal and policy analysis, the paper argues that achieving true environmental justice requires a doctrinal shift: legally re-classifying riverbed sand from "minor mineral" to a "vital ecosystem component" under a unified national legislation, and embedding ecological restoration and community participation within the legal framework.

Keywords: riverbed sand mining, minor mineral, tragedy of sand commons, environmental justice, riverine ecosystems.

The Tragedy of Sand Commons: Constitutional Gaps, Judicial Interventions, and the Quest for Environmental Justice in India's Riverine Ecosystems

The growth of the infrastructure has made riverbed sand as an indispensable resource for the development of India and an essential part of the river ecology. This resource, often

referred as the bone of the modern civilisation, is the most used natural resource in the world, after water (United Nations Environment Programme [UNEP], 2019). Driven by rapid urbanisation and infrastructure development, global annual extraction exceeds 50 billion tonnes (UNEP, 2019). This unremitting rate of acceleration is far in excess of the natural rate of renewal, and puts a heavy and unsustainable burden on riverine ecologies worldwide (S. Kumar et al., 2023).

This tension between economic development and ecological preservation presents a significant governance challenge. On one hand, sand is essential for infrastructure and economic growth; on the other, unchecked mining threatens to destabilise natural systems that are foundational to climate adaptation and sustainable development. Sand mining disrupts river hydraulics by altering natural flow and sediment dynamics, impacting both riverbed and suspended sediment transport (Padmalal & Maya, 2014). Such disruptions often lead to changes in channel shape, bed and bank shear stress, and consequently the overall channel planform. When sediment is excessively removed, the resulting deficit can trigger "hungry water" conditions where sediment-starved water increases erosion due to aggressive flow, deepens channels, creates turbulence, and accelerates meandering (Kondolf, 1997).

Moreover, the ecological implications are very obvious. Sand-based habitats support a wide range of biodiversity, from microorganisms involved in nutrient cycling and water filtration by the natural filtration system by sand to plant and animal species dependent on stable wet and dry sediment (UNEP, 2019). Channel degradation from sand and gravel mining affects habitat quality for aquatic life (Bhattacharyya, 2011). Bank erosion, sediment loss, and bed coarsening disrupt the spawning and feeding grounds of benthic organisms like turtle and fish. Further the lowering of groundwater levels due to pit-induced infiltration exacerbates water quality issues affecting ground water quality and quantity (Nguyen et al., 2025).

The result of such extensive exploitation is the “Tragedy of Sand Commons”. The ‘Tragedy of the Commons’ is a foundational concept in environmental economics and resource governance. This concept, proposed by Hardin in 1968 (Hardin, 1968), explains the inescapable exhaustion and deterioration of a common, finite Common-Pool Resource (CPR) where rational individuals act solely in their own self-interest (Torres et al., 2017). Riverbed sand is an ideal CPR due to the fact that its extraction is hardly regulated and as a result it is being extracted extensively without considering its long-term impacts (Torres et al., 2017). When the self-centric interest for short-term profits guide over extraction, the inevitable outcome is riverbed degradation, destruction of aquatic ecosystems and the depletion of the resource for all. This situation is worsened by weak regulations, poor enforcement, and systemic corruption that allow unsustainable practices to flourish, especially in regions with low education levels, unemployment, and eroding traditional livelihoods (Zabyelina & Van Uhm, 2020). The “Tragedy of the Sand Commons”, therefore, offers a powerful analytical framework to understand the sand crisis and underscores the need for the proper measures and comprehensive strategies for sustainable use of sand commons.

This systematic failure has its roots in a foundational legal flaw, namely, the legal categorisation of riverbed sand as a “minor mineral” by the Mines and Minerals (Development and Regulation) Act (hereinafter MMDR Act), (1957). This categorisation of riverbed sand systematically prioritises revenue collection over ecological conservation. Achieving environmental justice requires a doctrinal shift: the reclassification of riverbed sand not as a commodity defined by its end use, but as a vital ecosystem component – a material whose legal treatment follows from its ecological function and from its rate of natural replenishmen – anchored in judicial principles such as the Public Trust Doctrine. The analysis proceeds by doctrinal and policy method, examining the regulatory framework governing riverbed sand, the gaps within it, and the judicial responses those gaps have

provoked; the sources and their selection are set out in the section that follows.. It further examines the SDG paradox, in which the aggressive pursuit of infrastructure (SDG 9) compromises essential environmental promises (SDGs 14 and 15), and offers a comprehensive legal restructuring to create systemic sustainability.

This article proceeds by doctrinal and policy analysis. Doctrinal analysis identifies the authoritative sources governing a question – constitutional provisions, statutes, subordinate instruments and judicial decisions – reconstructs the rules they establish, and evaluates their internal coherence and their adequacy to the purposes they are said to serve. Policy analysis extends this to non-binding executive instruments and to the administrative practice through which legal norms are, or are not, implemented. The method is interpretive and normative rather than empirical: its object of study is a body of law, and its findings are claims about what that body of law provides and where it fails.

The primary legal sources examined comprise the constitutional provisions bearing on environmental protection, principally Articles 21, 48A and 51A(g); the Mines and Minerals (Development and Regulation) Act, 1957, with particular attention to Sections 3(e), 4, 15 and 23-C; the Environment (Protection) Act, 1986, and the Environmental Impact Assessment Notifications issued under it in 2006 and as amended in 2016; the National Green Tribunal Act, 2010; and the Sustainable Sand Mining Management Guidelines, 2016 and the Enforcement and Monitoring Guidelines for Sand Mining, 2020.

Judicial decisions were selected on two criteria: subject matter, being decisions of the Supreme Court of India and of the National Green Tribunal dealing directly with riverbed sand or minor mineral extraction; and doctrinal function, being decisions establishing the constitutional and principle-based framework on which the analysis depend. The decisions examined span the period from 1991 to 2025 and were consulted through the Supreme Court

Cases series and SCC Online; statutes and notifications through the India Code portal and the publications of the issuing ministries.

Scientific literature establishes the ecological and hydro-geomorphological context against which the adequacy of the legal framework is assessed; it is reported, not independently verified. Peer-reviewed studies were identified through Scopus and the publishers' databases, and legal commentary through HeinOnline and SCC Online, using combinations of the terms 'sand mining', 'riverbed mining', 'minor mineral' and 'environmental clearance', supplemented by citation-chaining from the works so identified; the final search was conducted in September 2026.

This is not a systematic review and no claim of exhaustive coverage is made. The selection is purposive, and every source relied upon is publicly available and fully cited.

The Foundational Constitutional Gap and Regulatory Failure

The crisis due to riverbed mining represents a critical implementation gap in the constitutional mandate of state, placing the extensive extraction of resources in direct conflict with fundamental constitutional environmental mandates. India's environmental jurisprudence, evolving through judicial activism, has placed the management of natural resources in the context of the wider constitutional environmentalism, recognising the inherent value of nature and the State is put in charge as trustee of these resources.

This model considers the natural ecological worth of nature and perceives the role of the State in the light of the Public Trust Doctrine (PTD). The PTD asserts that natural resources like air, water, woods are extremely significant to the people and that they belong to the nation as a whole (N. Kumar, 2023). The State is thus ethically obligated to perform as a custodian of these resources to conserve them on behalf of all the citizens including the future generation (M.C. Mehta v. Kamal Nath, 2000). The judicial intervention in matters of

riverbed sand mining is rooted in the PTD, which requires the State to cease being just a licensor to the active maintenance of riverine ecosystems.

The evolution of the Indian environmental jurisprudence highlights that development should be undertaken with a balanced approach which prioritises environmental conservation, moving away from anthropocentric perspective towards ecocentrism (Yanquiling et al., 2024). Extensive unregulated sand mining, which creates profound environmental concern in riverine ecology, fundamentally clashes with this ethos (Tastet, Emily, 2019).

Conflict with Constitutional Mandates and Implementation Gaps

Article 21 guarantees the right to life which the Supreme Court has expansively interpreted to include right to a clean, healthy, and pollution-free environment (Poddar, 2020). Such a metamorphosis of an environmental right into a fundamental right gives citizens the authority to resort to court action against environmental degradation (Aishwarya, G., 2025). In *Subhash Kumar v. State of Bihar* (1991), the Supreme Court held that Article 21 recognises the right to unpolluted water and air, which provided a foundation of addressing the environmental problems in terms of fundamental rights litigation.

In context of riverbed sand mining, the ecological interests protected by this expansive interpretation of Article 21 were documented by the Supreme Court in *Deepak Kumar v. State of Haryana* (2012). The Court observed that sand mining on both banks of a river, upstream and in-stream, is among the causes of environmental degradation and a threat to biodiversity, and that India's rivers and riparian ecology have been badly affected by unrestricted extraction, which damages river ecosystems, weakens riverbeds, destroys the habitats of organisms living on them, and disrupts fish breeding and migration. These observations describe precisely the harm that the constitutional right addresses, although the Court's

directions were framed in terms of the environmental clearance regime rather than as a declaration of constitutional violation.

~~Further, in *Deepak Kumar v. State of Haryana* (2012), the Supreme Court explicitly reinforced Article 21, and said that right to life should be guaranteed for a clean and healthy environment. The court pointed out that the impact of unchecked sand mining degrades the riverine ecosystem, riverbeds, causes habitat loss, and contribute to environment degradation, thus violating the Article 21.~~

Moreover, Article 48A requires that the State shall endeavour to protect and improve the environment and to safeguard the forests and wild life of the country. This Directive Principles of State Policy (DPSP) is a constitutional mandate on the State to guarantee quality of the environment. In *Vellore Citizens Welfare forum v. Union of India* (1996), relying on the constitutional mandate of Article 48A and 51A(g) the Supreme Court concluded that the concept of sustainable development is a part of the domestic law. This case established the framework for balancing developmental needs (use of riverbed sand) with environmental protection required by 48A.

Article 51A(g) provides a primary responsibility on all citizens to conserve and enhance the natural environment, such as forests, lakes, rivers, and wildlife, etc. This provision indirectly governs the citizen responsibility on sustainability of the environment. . These three provisions were drawn together by the Supreme Court in Deepak Kumar v. State of Haryana (2012). Directing that the recommendations made by the Ministry of Environment and Forests in March 2010 and the Model Rules framed by the Ministry of Mines be given effect, the Court stated that this was to be done inculcating the spirit of Article 48A and Article 51A(g) read with Article 21 of the Constitution. By reading the two directive provisions together with the fundamental right, and by attaching that composite standard to executive

instruments governing minor mineral extraction, the Court treated compliance with the ecological safeguards applicable to sand mining as a constitutional expectation rather than a matter of administrative discretion. The implementation gap identified in this article is accordingly a gap in the discharge of that expectation.

The judiciary has proactively checked the pervasive threat of illegal and unsustainable sand mining by giving certain directives based on these constitutional principles, which have perceived the vast ecological significance of rivers.

Principles of Environmental Justice

The Indian Supreme Court has deployed several international environmental principles, including the concept of Environmental Justice, to protect environment, especially concerning resource conflicts like riverbed sand mining (Poddar, 2020).

Sustainable Development

The official definition of sustainable development in World Commission on Environment and Development Report (1987) is as development that attends the needs of the current generation without spoiling the capacity of future generations to address their needs. In 1996, this idea was integrated by the Supreme Court into the law of the land in the case of *Vellore Citizens Welfare forum* (1996) 5 SCC 647. This principle entails a compromise between the economic development (based on riverbed sand) and the ecological conservation (*State of U.P. v. Gaurav Kumar*, 2025 SCC OnLine SC 1069).

Precautionary Principle

This is a principle that requires the government to act in anticipation, prevention, and attack of all the causes of environmental degradation. The incomplete scientific certainty cannot be an excuse to delay preventive action where there is the threat of some serious and irreversible harm (Vellore Citizens' Welfare Forum v. Union of India, 1996) (such as the

degradation of rivers due to extensive mining). In riverbed sand governance this principle finds its operational expression in the DSR, introduced by the amendment of 15 January 2016 to the Environmental Impact Assessment Notification, (2006), which requires that areas of deposition and erosion be identified and the annual rate of replenishment calculated before extraction is permitted. The Supreme Court has since held that a valid and subsisting Report is a mandatory precondition to environmental clearance, and that a Report prepared without a replenishment study cannot support a clearance at all (State of Uttar Pradesh v. Gaurav Kumar, 2025)..

Polluter Pays Principle (PPP)

According to this principle, the polluter is required to pay the cost incurred in the form of pollution into the environment to the victims of its pollution, and he is also required to shoulder the financial cost of returning the damaged environment (Vellore Citizens' Welfare Forum v. Union of India, (1996) 5 SCC 647). The Supreme Court expressly applied the principle in Indian Council for Enviro-Legal Action v. Union of India (1996), where industrial units at Bichhri had discharged untreated toxic effluent that contaminated soil and groundwater, and were directed to bear the cost of the remedial measures required to restore the affected area. The principle was declared part of the domestic law later the same year in Vellore Citizens' Welfare Forum.. Section 20 of National Green Tribunal Act, (2010) expressly mandates this principle. Under this provision the NGT has imposed heavy penalties on government entities and mining lease holders for illegal sand mining based on PPP.

All these judicial actions enforcing the constitutional mandate aim at establishing and meting environmental justice by making sure that the weak populations (who tend to reside along the river banks affected by floods and erosion of resources) are safeguarded against the harmful effects of uncontrolled extraction. The focus on community involvement, safeguarding the

local water and food resources, and accountability in making regulatory decisions further enhances the pursuit of environmental justice.

The Legal Flaw: Sand as a "Minor Mineral"

The Constitution assigned the legislative control to both Union and State governments through Entry 54 of List I and Entry 23 of List II (Constitution of India, 1950), allowing for concurrent legislative competence. The central legislation governing the mining sector is the MMDR Act, (1957). The MMDR Act categorises sand as a “minor mineral” under Section 3(e). This classification result in legal flaw as terming river sand as minor mineral results in commodification of a vital ecological component.

Under Section 15 of the MMDR Act state governments are empowered to make rules for regulating mining leases and concessions relating to minor minerals, including sand. This decentralised governance model entrusts states with the authority to grant leases, impose royalties, and monitor mining operations (N. Kumar, 2023). However, the absence of a standardised national framework has led to varied regulatory approaches across states, resulting in disparities in enforcement, environmental compliance, and transparency (N. Kumar, 2023).

Further, Section 4 of the MMDR Act explicitly prohibits the mining of any mineral, including sand, without the necessary licenses and environmental clearances. Mining operations carried out without such authorisation are considered illegal. Furthermore, Section 23-C of the Act allows states to enact rules specifically to prevent illegal mining, transportation, and storage of minerals. Acting under this provision, over 20 states including Andhra Pradesh, Gujarat, Punjab, Tamil Nadu, and Uttar Pradesh have notified their respective rules to control illegal sand mining(N. Kumar, 2023). Despite these efforts, illegal sand extraction continues to thrive due to weak monitoring infrastructure and the influence of entrenched interest groups.

While the MMDR Act focuses primarily on the regulation and development of mineral resources, it offers limited consideration of environmental concerns(Varadharajan, 2020). Therefore, mining activities must also comply with broader environmental laws, such as the Water (Prevention and Control of Pollution) Act, (1974), Air (Prevention and Control of Pollution) Act, (1981), Forest (Conservation) Act, (1980), The Wildlife (Protection) Act, (1972), and the Environment (Protection) Act, (1986) (Hereinafter EPA, 1986). The EPA, (1986), serves as an umbrella Act for the protection of the environment. Section 3 of EPA confers rule making power to the central government to control pollution and preserve environmental quality. One of its key instruments for environment protection is the issuance of Environmental Impact Assessment (EIA) Notifications while exercising power under section 3(2)(v). The EIA notification (2006) requires prior environmental clearance for mining lease areas more than 5 hectares, this requirement was bypassed by several states and resulted in regulatory failure. After decades of ecological abuse in riverbed, this failure was checked in *Deepak Kumar v. State of Haryana* (2012).

Judicial Interventions and the Quest for Environmental Justice

The Turning Point: *Deepak Kumar v. State of Haryana,* 2012

The threatening increase of the unregulated extraction attracted the focus of the constitutional courts and tribunals on the riverbed sand governance. Recognising the severe ecological degradation and the evident governance gaps in the regulation of sand resources, the Supreme Court of India, various High Courts, and the National Green Tribunal (hereinafter NGT) have taken proactive steps to address the legal, administrative, and environmental complexities involved.

The historic intervention of the Supreme Court in *Deepak Kumar v. State of Haryana* (2012) emphasised the need for a scientific approach to regulate the extraction of sand, especially in

light of increasing environmental degradation and unregulated and illegal mining practices. The operative direction was that leases of minor minerals, including their renewal, for areas of less than five hectares be granted by States and Union Territories only after obtaining environmental clearance from the Ministry of Environment and Forests. Since leases of five hectares and above already required clearance under the Environmental Impact Assessment Notification, 2006, the effect was to close the exemption through which smaller operations, and homogeneous areas fragmented into blocks below the threshold, had escaped environmental appraisal altogether. The Central Government subsequently described the order as having made prior environmental clearance mandatory for minor minerals irrespective of the area of the mining lease. The Court also directed all States, Union Territories, the Ministry of Environment and Forests and the Ministry of Mines to give effect, within six months, to the recommendations of the Ministry's March (2010) report and to the model guidelines framed by the Ministry of Mines. The hon'ble court order immediately transferred sand control out of the revenue department to an environmental necessity.

From Direction to Instrument: The 2016 Amendment and the District Survey Report

The translation of this judicial direction into a regulatory instrument took a further four years. It was the amendment to the EIA Notification, 2006, issued on 15 January 2016, that gave the clearance requirement an operative scientific content. The preamble to that amendment records that it was made in pursuance of the order of 27 February 2012, and that prior environmental clearance had thereby become mandatory for mining of minor minerals irrespective of the area of the mining lease. The amendment established District Level Environment Impact Assessment Authorities, created a distinct Category B2 for sand mining, and, through the insertion of paragraph 7(iii), required for the first time the preparation of a District Survey Report (DSR) for sand and riverbed mining. Appendix X to the notification prescribes the procedure for that Report, whose stated objectives include identifying areas of

deposition where mining may be permitted, identifying areas of erosion where it must be prohibited, and calculating the annual rate of replenishment. The Report forms the basis of any application for environmental clearance and is to be updated every five years.

The District Survey Report is therefore the instrument through which the precautionary principle acquires operational form in riverbed sand governance, and it is a creature of the 2016 notification rather than of the 2012 order. That distinction matters for the argument advanced here. The interval between a direction of the Supreme Court and the regulatory architecture capable of giving it effect was four years, during which extraction continued under a clearance regime that had no scientific basis for determining how much sand a given river stretch could sustainably yield. The lag is not incidental to the governance failure described in this article; it is an instance of it.

Recent decisions have hardened the requirement. In State of U.P. v. Gaurav Kumar (2025) the Supreme Court held that a valid and subsisting DSR is mandatory for the grant of environmental clearance for sand mining, and annulled clearances granted on the basis of a draft Report as untenable in law. In Union Territory of J&K v. Raja Muzaffar Bhat (2025) the Court went further, holding that a Report unsupported by a proper replenishment study is equally untenable, since without an estimate of the rate at which a river stretch renews its sediment there is no foundation for determining a sustainable extraction limit. Reviewing a clearance that had been granted despite the appraisal committee's own recorded finding that the Report lacked replenishment data, the Court observed that this is how regulatory failure occurs.

Strengthening Mechanisms: NGT and Executive Guidelines

The NGT is India's specialised environmental tribunal. . The Tribunal has upheld the direction of the Supreme Court by treating environmental clearance as a requirement for the

issue of any mining lease. It applies the major environmental principles including the polluter pays principle, imposing substantial penalities on those who fails to comply. The NGT has fined violators big amounts to enforce compliance and provide the environmental restoration. In *Anjani Kumar v. State of U.P*, (2017) the NGT held that environmental clearance must be a precondition for granting any mining lease, regardless of the size of the lease area. Further, it mandated that the lease agreements must incorporate specific conditions related to resource replenishment and ecological protection and states must ensure that all regulatory clauses are strictly enforced to operationalise the principle of sustainable mining.

Executive Policies and Guidelines

The Ministry of Environment, Forest and Climate Change (MoEFCC) had issued the Sustainable Sand Mining Management Guidelines (2016) and the Enforcement and Monitoring Guidelines of Sand Mining (2020) after the judicial push. These principles require the preparation of DSR, encourage monitoring technologies, and are intended to achieve the environmentally and socially responsible mining. The legal status of this executive framework is no longer in doubt: the Supreme Court has held that the 2016 and 2020 Guidelines constitute binding directives for regulatory authorities, whose observance is indispensable to safeguarding ecology and the public interest. The difficulty is one of compliance rather than of legal form. Clearances have continued to be granted on Reports that the appraising authorities themselves recorded as non-compliant, and the persistence of illegal extraction reflects gaps in monitoring capacity and institutional enforcement rather than any deficiency in the binding character of the norms.. This is a weakness, and the inability to be enforced with institutional capacity gaps and inconsistency in the enforcement implies that the high levels of illegal sand mining still plague the will of the judicial system and environmental protection.

The SDG Paradox: Development against Ecological Integrity

India's stated ambition is to reach a gross domestic product of approximately thirty trillion United States dollars by 2047, a target that presupposes sustained expansion of the construction and infrastructure sectors (NITI Aayog, 2024). . That expansion depends on aggregate, and principally on riverbed sand, placing unprecedented pressure on riverine ecology. The result is an SDG paradox: the developmental commitments the State has undertaken and the ecological commitments it has undertaken pull in opposite directions, and are pursued through instruments that do not acknowledge the conflict. **The Main Disagreement: Infrastructure Development on Weak Ecosystems**

Sand mining sits at the sharpest point of this paradox of environmental constitutionalism: the pursuit of SDG 9 (Industry, Innovation, and Infrastructure) proceeds on the progressive degradation of the riverine ecosystems on which other commitments depend. River sand is being mined in amounts significantly greater than they can be replaced through natural processes in response to the explosive urbanisation and population explosion (Nguyen et al., 2025). The uncontrolled extraction is the epitome of the so-called Tragedy of Sand Commons(Torres et al., 2017), where the development objectives are the main factor that contradicts the system organisation of natural systems (Ioannidou et al., 2020). Therefore, the quest to grow, although a necessity to the developing countries, introduces unsustainable externalities that risk the whole Sustainable Development Goals (SDGs) agenda (Yasmin et al., 2024). Although the Riverbed Sand Mining affects all the SDGs directly or indirectly, its direct impact on SDG 14 and SDG 15 is precisely defined below.

The environmental impact of sand mining is direct and far-reaching. The main effect on the SDG 14 (Life Below Water) is the physical destruction of aquatic habitats and biodiversity(Torres & Simons, 2017). Streams become degraded and deep pits ruin important feeding and spawning areas of benthic animals and fish(Nguyen et al., 2025). These effects

propagate through the aquatic food web, since the benthic organisms displaced by dredging occupy its base. Species whose life cycles depend on the exposed sand substrate rather than on the water column are considered below in relation to SDG 15.. Moreover, the mining process significantly raises the turbidity and the total suspended solids in water (Zou et al., 2019), which reduces the quality of water through the impairment in the penetration of light to support photosynthesis and influences fauna abundance (Koehnken et al., 2020).

In the case of SDG 15 (Life on Land) Riverbed Sand Mining has a significant impact on the terrestrial ecosystems along the river. Over extraction brings about incision of channels and bank instability culminating into acute erosion of rivers banks and fertile land (Podimata & Yannopoulos, 2016). Mining activities destroy the riparian habitats (Qin et al., 2020) and hasten desertification which directly stifles the objectives of restoring degraded land (SDG Target 15.3). Mechanised extraction removes the exposed sand of dry riverbeds, which is the nesting and basking substrate for a range of riverine reptiles (Torres & Simons, 2017). The critically endangered gharial (Gavialis gangeticus) illustrates the dependency with unusual clarity. Surveys in the National Chambal Sanctuary record that sand banks, bars and islands are used preferentially for basking and nesting, and find a positive association between gharial numbers and the availability of sand habitat features, with markedly lower numbers in a reach where a substantial sand bank had been converted to agriculture (Katdare et al., 2011). The dependency has since been demonstrated experimentally: where reduced flow allowed vegetation to colonise open sand banks in a regulated river-reservoir habitat, nesting sites and nest numbers declined by more than forty per cent, and the removal of vegetation together with the addition of sand reversed that decline (Vashistha et al., 2021).

The significance of this for sand governance lies in what is presently at stake. The gharial population of the Chambal, which accounts for approximately four-fifths of the global total, has been recovering, with nesting effort rising from 402 nests in 2017 to 486 in 2019, and

habitat-use analysis confirming a strong preference for sandy substrate (Sharma et al., 2025). That recovery is the product of five decades of conservation effort and it is contingent on the continued availability of the very material that the law classifies as a minor mineral available for commercial extraction. The population-level effect of riverbed sand mining on the species has not been quantified, and no such claim is made here. What can be stated is narrower and more troubling: a recovery that depends on nesting substrate is proceeding under a legal regime that treats that substrate as a construction input.. More importantly, bed deepening caused by riverbed sand mining lowers the water table in alluvial reaches (Kresojević et al., 2023), preventing the establishment and survival of the riparian vegetation that forms the natural barrier to bank erosion (Koehnken et al., 2020).

Apart from this direct and visible impact on SGD, several other SDGs are being impacted. Achievement of SDG 6 (Clean Water and Sanitation) is undermined because uncontrolled riverbed sand mining can be a great danger to water security. This reduction of the ground water table caused by the excessive infiltration by the pits increases the problem of water quality and the reduction of reserves required by humans, as well as irrigation (Kresojević et al., 2023). Channel incision in coastal regions enhances intrusion of saline water in the freshwater sources and estuaries (Gibson et al., 2013).

Moreover, SDG 13 (Climate Action) goals are correlated based on destabilisation of the whole riverine ecosystem. The decline in the quality of riverine systems adversely affects their capacity to be protective in the face of disasters brought about by climate changes. Riverbed sand mining destroys riparian wetlands and vegetation that act as important carbon sinks thus lowering the ability of ecosystem to absorb carbon dioxide (Qin et al., 2020). Erosion and degradation of the river deltas that result increase the risk of floods and storm surge to the communities which surround it (Koehnken et al., 2020). Moreover,

mechanisation of sand mining and its transportation with the use of heavy machinery burns fossil fuels, which also lead to greenhouse gases (GHG).

The existing approach is also inconsistent with SDG 12 (Responsible Consumption and Production), since it permits the consumption of a finite resource at rate exceeding that of its natural replacement rate. The process of extraction is usually haphazard, without proper scientific planning, conforming to carrying capacity of the river, or restoration of the site of the resource as part of sustainable resource management. This presents a severe market failure, in which ecological costs are not internalised and calculated as part of the price of the commodity sand (Tastet, Emily, 2019). It is a culture of poor governance in which systemic institutional failure thrives, which has a direct negative impact on SDG 16 (Peace, Justice, and Strong Institutions). Corruption and poor enforcement of the law make illegal mining of sands a lucrative enterprise. Illegal sand extraction has in several jurisdictions acquired the characteristics of organised crime, with documented associations between extraction networks, the corruption of enforcement agencies, and violence directed at officials, journalists and residents who obstruct it (Zabyelina & Van Uhm, 2020). Where enforcement authorities are themselves compromised, the erosion of institutional accountability is not a side effect of unregulated extraction but a condition of its continuation.

Charting the Path to Ecological Justice: Policy Recommendations and the Doctrinal Shift for Reform

Proposing the Change in Doctrines: Reclassification

Environmental justice requires an essential change of doctrine. The main defect in the institutional structure is the statutory classification of sand as a minor mineral under the MMDR Act, 1957. This defective categorisation is basically giving precedence to revenue at the expense of ecosystem conservation. The crisis means that it is necessary to go beyond

regulation and reinvent the resource itself. The most important change is that riverbed sand should be given a legal designation as an “vital ecosystem component”. The content of that designation requires specification. A vital ecosystem component is here proposed as a legal category comprising a naturally occurring material whose significance lies in the function it performs within a functioning ecosystem rather than in its utility as an extractive commodity, and whose removal at a rate exceeding its natural replenishment impairs that function. Two features of the definition warrant emphasis. The first is that classification turns on ecological function rather than on end use. The existing scheme classifies minerals by the purposes to which they are put, with the consequence that a material of considerable ecological significance is grouped with building stone and ordinary earth because both are used in construction. The second is that the criterion of replenishment is not novel. Indian law already applies it, though only at the point of authorisation: the DSR requires the annual rate of replenishment of a river stretch to be calculated before extraction is permitted, and the Supreme Court has held that a Report prepared without such a study cannot support an environmental clearance at all (Union Territory of J&K v. Raja Muzaffar Bhat, 2025).

The reform proposed here is therefore narrower than it may appear. It does not introduce an unfamiliar standard into Indian environmental law; it carries a standard the legal system already applies operationally into the classificatory scheme that governs the resource. At present the two are misaligned. Sand is classified by the use to which it is put, and then regulated, at the point of clearance, by reference to the rate at which the river renews it. A resource that must be licensed against its replenishment rate is not adequately described by a category that turns on what it is used for.

It follows that riverbed sand should not be relocated within the existing dichotomy of major and minor minerals, since both categories rest on the same end-use logic. The designation proposed here places riverbed sand outside that scheme altogether, within the

dedicated riverine ecosystem legislation discussed below, under which extraction would be permissible only within scientifically determined replenishment limits and subject to the restoration and participation requirements considered in the sections that follow. This re-conceptualisation recognises sand not merely as a construction input but as a constituent of riverine ecological functions , to be safeguarded under the constitutional provisions considered above and under the Public Trust Doctrine.

Legislative and Governance Reforms

The need to incorporate regulatory fragmentation requires a bold step towards coherence. India should enact a single framework statute for the protection of riverine ecosystems, within which the reclassification proposed above would be given effect.. Such framework would coordinate various state regulations and make certain that there is one, uniform national standard. The Sustainable Sand Mining Management Guidelines of 2016 and the Enforcement and Monitoring Guidelines of 2020 should be placed on a statutory footing. Their binding character on regulatory authorities is no longer in question, but it presently derives from judicial enforcement rather than from a legislative source, and the Guidelines carry no penalty regime of their own. Incorporating their substantive requirements into the proposed framework legislation would give them an independent statutory basis, attach consequences to their breach, and remove the need for their authority to be re-established through litigation in each instance. . The institutional accountability needs to improve. This involves constituting special state-level regulatory bodies that have audit mandate that is backed by local grievance redressal mechanisms to ensure a strict interpretation of the law. The Central Government should also exercise its legislative powers to set minimum standards on the national interest.

Technological Surveillance and Green Alternatives

Sustainable extraction should be anchored on scientific data and stringent monitoring. The most important measure is the introduction of a National Sand Budget and Monitoring System that would measure the replenishment rates and ecological limits, basing on the strict scientific evaluation. This will have to use technologies such as GPS, remote sensing, as well as hydrological models to monitor in real-time and give transparency to the population electronically. At the same time, the market must be shifted away from destructive river extraction. The policymakers should be keen to ensure that they encourage the use of other materials, including Manufactured Sand (M-sand), recycled aggregates, and industrial by-products including fly ash using powerful legal and financial incentives. This advances the principles of the circular economy (SDG 12) while reducing the unsustainable strain on natural riverine resources.

Community and inclusive Governance

In the context of sustainable governance, inclusion and participatory strategies have to be introduced into the regulatory framework. The ecological restoration and community involvement has to be formally incorporated in the legal framework, acknowledging the local knowledge and customary rights. Local communities have an inherent self-interest in the sustainability of the resource that would make them important monitors of illegal mining. In order to improve transparency and accountability (SDG 16), it is necessary to empower local entities, namely Panchayati Raj Institutions, and make them a part of the monitoring and decision-making procedures, which involves the creation of the institutional capacity at the local level.

Limitations

Several limitations follow from the design of this study and bound the claims made in it.

The analysis is doctrinal and normative. It examines what the law provides and where it fails, and it does not generate primary empirical evidence. Its ecological, hydrological and geomorphological propositions are drawn from the published scientific literature and are reported rather than independently verified; where causal attribution to sand extraction is contested or unquantified, the argument is correspondingly qualified.

The account of judicial intervention is built from reported decisions of the Supreme Court and orders of the National Green Tribunal selected for their bearing on riverbed sand and on the constitutional principles engaged. High Court jurisprudence and state-level litigation, which is voluminous and is often the forum in which enforcement is actually contested, has not been systematically examined. What is offered here is therefore an account of the direction of authority rather than an exhaustive survey of it. The decisions of 2025 discussed above are recent, and their effect on regulatory practice cannot yet be assessed.

No state-level implementation or enforcement data have been analysed. The conclusion that the regulatory framework fails in practice rests on the findings of courts and tribunals, on the Ministry's own guidance documents, and on published commentary, rather than on independent measurement of compliance. The extent of variation among states –which is considerable, and which bears directly on any assessment of regulatory failure –remains outside the scope of this article.

The reform proposed here is untested. Reclassifying riverbed sand as a vital ecosystem component, and removing it from the major and minor mineral scheme of the Mines and Minerals (Development and Regulation) Act, 1957, would carry consequences for state

revenue, for administrative capacity, and for the distribution of legislative competence between the Union and the States in respect of mines and mineral development, none of which is modelled here. The replenishment criterion on which the proposed category depends is moreover only as reliable as the survey data that operationalise it, and the adequacy of DSR in practice – a matter on which the Supreme Court has recently expressed considerable doubt – is an empirical question this article identifies but does not resolve.

Finally, the analysis is confined to India. Comparative material is used illustratively, and no systematic comparison has been attempted with jurisdictions that classify and regulate aggregate extraction on a different basis.

These are limits of scope and of evidence, and each marks a direction for further work. None of them qualifies the central claim advanced here, which is a claim about legal coherence rather than about ecological magnitude: a resource that must be licensed against its rate of natural replenishment is not adequately classified by reference to the use to which it is put.

Conclusion

The Tragedy of Sand Commons is based on an underlying legal and governance failure: the classification of sand as a minor mineral. This legislative shortcoming gives more preference to revenue, at the cost of environmental stabilisation. Judicial intervention became necessary, and a decisive change followed when environmental appraisal was made a precondition of extraction and, subsequently, when that appraisal was required to rest on a scientific estimate of replenishment. The Public Trust Doctrine supplies the constitutional rationale for that shift, reconceiving the State as trustee rather than licensor, but it has not yet been carried into the statutory classification of the resource itself. Still, there is inconsistency in implementation and regulation fragmentation. Environmental justice will require a systemic change. The key element of sustainability is a change of doctrine: riverbed sand

should be classified not as a commodity defined by its end use, but as a vital ecosystem component defined by its function and by the rate at which the river renews it. Reclassification would not by itself resolve the governance failures described here. It is, however, the condition on which coherent policy depends: for so long as riverbed sand is defined in law by the use to which it is put, the framework governing it will continue to treat as a question of revenue what is in substance a question of ecological limits.

Data availability:

No datasets were generated or analysed during this study, and none underpin its findings. The article is a doctrinal and policy analysis whose object of study is a body of law. Its sources consist of the Constitution of India, primary legislation, subordinate instruments and notifications, guidelines issued by the Ministry of Environment, Forest and Climate Change, judgments of the Supreme Court of India and orders of the National Green Tribunal, reports of intergovernmental organisations, and published peer-reviewed literature. Every source relied upon is cited in full in the reference list.

All of these materials are publicly available. Indian legislation and subordinate instruments may be accessed through the India Code portal maintained by the Ministry of Law and Justice (https://www.indiacode.nic.in) and through the websites of the issuing ministries. The judgments and tribunal orders cited are reported in the Supreme Court Cases series and are accessible through SCC Online; the same decisions are freely accessible without subscription through Indian Kanoon (https://indiankanoon.org), and recent judgments of the Supreme Court are published on the Court's own website. The report of the United Nations Environment Programme cited in this article is available at https://wedocs.unep.org/20.500.11822/28163, and the report of the World Commission on Environment and Development at

https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf. All peer-reviewed sources are identified by digital object identifier or by a stable repository link in the reference list.

No proprietary, confidential, restricted or personal material was used in the preparation of this article, and no material relied upon has been withheld. No custom code, software, script or statistical procedure was generated or applied, and there is accordingly no code to deposit.

Ethics declarations:

This article is a doctrinal and policy analysis of constitutional provisions, legislation, subordinate instruments, executive guidelines and judicial decisions. The research involved no human participants and no data relating to human participants. It employed no surveys, questionnaires, interviews, focus groups, observational or ethnographic methods; it collected no demographic or personal data; it involved no audio or video recording of participants; and it analysed no social media or other digital trace data relating to individuals. No animals were involved. Approval by an institutional or licensing ethics committee was therefore not required for this research, and none was sought. Informed consent was not applicable.

Consent for publication: Not applicable. This article contains no data, images or other material relating to any identifiable individual.

Additional information

Author contributions: Vikas Kumar conceived the study and developed the doctrinal argument. Sharma K. Saurav conducted the analysis of the statutory and judicial materials and drafted the manuscript. Both authors reviewed and approved the final version.

Competing interests: The author declares no competing interests, financial or non-financial.

Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.References

I.IndianStatutes

Air (Prevention and Control of Pollution) Act, No. 14 of 1981 (India).

Enforcement & Monitoring Guidelines for Sand Mining (29-1-2020) (India). Ministry of Environment, Forest and Climate Change.

Environment (Protection) Act, No. 29 of 1986 (India).

Environmental Impact Assessment Notification, S.O. 141(E) (2016) (India). Ministry of Environment, Forest and Climate Change.

Environmental Impact Assessment Notification, S.O. 1533(E) (2006) (India). Ministry of Environment, Forest and Climate Change.

Forest (Conservation) Act, No. 69 of 1980 (India).

Mines and Minerals (Development and Regulation) Act, No. 67 of 1957 (India).

National Green Tribunal Act, No. 19 of 2010 (India).

Sustainable Sand Mining Management Guidelines (2016) (India). Ministry of Environment, Forest and Climate Change.

The Constitution of India, 1950 (India).

Water (Prevention and Control of Pollution) Act, No. 6 of 1974 (India).

Wildlife (Protection) Act, No. 53 of 1972 (India).

II. Indian Case Laws

Anjani Kumar v. State of U.P., 2017 SCC OnLine NGT 979 (India).

Deepak Kumar v. State of Haryana, (2012) 4 SCC 629 (India).

Indian Council for Enviro-Legal Action v. Union of India, (1996) 3 SCC 212 (India).

M.C. Mehta v. Kamal Nath, (2000) 6 SCC 213 (India).

Union Territory of Jammu and Kashmir v Raja Muzaffar Bhat. 2025 INSC 1025

State of Uttar Pradesh & Anr. v. Gaurav Kumar & Ors. 2025 SCC OnLine SC 1069

Vellore Citizens' Welfare Forum v. Union of India & Ors. (1996) 5 SCC 647

III. Books, Reports, and Articles

Aishwarya, G. (2025). Illegal Sand Mining in India. *LawFoyer International Journal of Doctrinal Legal Research*, *3*(1), 178-189. https://heinonline.org/HOL/Page?handle=hein.journals/lwfyrinl3&id=186

Bhattacharya, R. K., & Das Chatterjee, N. (2021). River sand mining modelling and sustainable practice: The Kangsabati River, India. Springer. https://doi.org/10.1007/978-3-030-72296-8

Gibson, J. J., Fennell, J., Birks, S. J., Yi, Y., Moncur, M. C., Hansen, B., & Jasechko, S. (2013). Evidence of discharging saline formation water to the Athabasca River in the oil sands mining region, Northern Alberta. *Canadian Journal of Earth Sciences*, *50*(12), 1244–1257. Scopus. https://doi.org/10.1139/cjes-2013-0027

Hardin, G. (1968). The Tragedy of the Commons. *Science*, *162*(3859), 1243–1248. https://doi.org/10.1126/science.162.3859.1243

Ioannidou, D., Sonnemann, G., & Suh, S. (2020). Do we have enough natural sand for low-carbon infrastructure? *Journal of Industrial Ecology*, *24*(5), 1004–1015. https://doi.org/10.1111/jiec.13004

Katdare, S., Srivathsa, A., Joshi, A., Panke, P., Pande, R., Khandal, D., & Everard, M. (2011). Gharial (Gavialis gangeticus) populations and human influences on habitat on the River Chambal, India. Aquatic Conservation: Marine and Freshwater Ecosystems, 21(4), 364–371. https://doi.org/10.1002/aqc.1195

Koehnken, L., Rintoul, M. S., Goichot, M., Tickner, D., Loftus, A., & Acreman, M. C. (2020). Impacts of riverine sand mining on freshwater ecosystems: A review of the scientific evidence and guidance for future research. *River Research and Applications*, *36*(3), 362–370. https://doi.org/10.1002/rra.3586

Kondolf, G. M. (1997). Hungry Water: Effects of Dams and Gravel Mining on River Channels. *Environmental Management*, 21(4):533-551.

Kresojević, M., Ristić Vakanjac, V., Trifković, D., Nikolić, J., Vakanjac, B., Polomčić, D., & Bajić, D. (2023). The Effect of Gravel and Sand Mining on Groundwater and Surface Water Regimes—A Case Study of the Velika Morava River, Serbia. *Water (Switzerland)*, *15*(14). Scopus. https://doi.org/10.3390/w15142654

Kumar, N. (2023). Sand Mining in India – Grain of Despair: Failure of Regulatory Machinery | SCC Times. *SCC Times*. Retrieved September 18, 2026, fromhttps://www.scconline.com/blog/post/2023/02/08/sand-mining-in-india-grain-of-despair-failure-of-regulatory-machinery/.

Kumar, S., Park, E., Tran, D. D., Wang, J., Loc Ho, H., Feng, L., Kantoush, S. A., Van Binh, D., Li, D., & Switzer, A. D. (2023). A deep learning framework to map riverbed sand mining budgets in large tropical deltas. *GIScience and Remote Sensing*, *61*(1). Scopus. https://doi.org/10.1080/15481603.2023.2285178

Ministry of Environment and Forests. (2010, March). Environmental aspects of quarrying of minor minerals: Report of the Group. Government of India. https://ibm.gov.in/writereaddata/files/07152014151559Report_minor.pdf?

Nguyen, B. Q., Kantoush, S. A., & Sumi, T. (2025). Assessing the multidimensional impacts of riverbed sand mining on geomorphological change and water transfer rate: A comprehensive investigation of Central Vietnam's Vu Gia Thu Bon River system. *Journal of Hydrology*, *654*. Scopus. https://doi.org/10.1016/j.jhydrol.2025.132853

NITI Aayog. (2024). Vision for Viksit Bharat @ 2047: An Approach Paper. Government of India. https://www.niti.gov.in/

Padmalal, D., & Maya, K. (2014). *Sand Mining: Environmental Impacts and Selected Case Studies*. Springer.

Poddar, A. K. (2020). Indian Supreme Court and sustainable development: A tool for delivering environmental justice. Environmental Law & Practice Review, 7, 57–86..

Podimata, M. V., & Yannopoulos, P. C. (2016). A conceptual approach to model sand–gravel extraction from rivers based on a game theory perspective. *Journal of Environmental Planning and Management*, *59*(1), 120–141. https://doi.org/10.1080/09640568.2014.991381

Qin, Y., Chen, Z., Ding, B., & Li, Z. (2020). Impact of sand mining on the carbon sequestration and nitrogen removal ability of soil in the riparian area of Lijiang River, China. *Environmental Pollution*, *261*, 114220. https://doi.org/10.1016/j.envpol.2020.114220

Sharma, S. P., Katdare, S., Badola, R., & Hussain, S. A. (2025). Unraveling population trend of a critically endangered freshwater crocodylian, gharial (Gavialis gangeticus) in the National Chambal Sanctuary, India. Ecology and Evolution. https://doi.org/10.1002/ece3.72643

Tastet, Emily. (2019). Stealing beaches: Law and economics policy analysis of sand mining. *LSU Journal of Energy Law and Resources*, *7*(2), 525–552. https://heinonline.org/HOL/Page?handle=hein.journals/lsujoenre7&id=533

Torres, A., Brandt, J., Lear, K., & Liu, J. (2017). A looming tragedy of the sand commons. *Science*, *357*(6355), 970–971. Scopus. https://doi.org/10.1126/science.aao0503

Torres, A., & Simons, S. (2017). Impacts of sand mining on ecosystem structure, process, and biodiversity in rivers. *Environmental Management*, *59*, 134–145. https://doi.org/10.1007/s00267-016-0766-5

United Nations Environment Programme. (2019). *Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources*. Retrieved September 18, 2026, from https://wedocs.unep.org/20.500.11822/28163

Varadharajan, S. (2020). The Facade of Federalist Incongruity: A Political Pretense to a Popular Menace. *SCC TIMES*, *2.1 GLS LJ (2020) 21*.

Vashistha, G., Lang, J. W., Dhakate, P. M., & Kothamasi, D. (2021). Sand addition promotes gharial nesting in a regulated river-reservoir habitat. Ecological Solutions and Evidence, 2(2), e12068. https://doi.org/10.1002/2688-8319.12068

World Commission on Environment and Development. (1987). *Our Common Future: Report of the World Commission on Environment and Development*. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Yanquiling, R. S., Cuadrado-Quesada, G., & Schmeier, S. (2024). Exploring the rights of nature in freshwater and marine ecosystems. *Earth System Governance*, *22*, 100224. https://doi.org/10.1016/j.esg.2024.100224

Yasmin, T., Clark, J., Sambrook Smith, G., Daham, A., Nicholas, A., & Gasparotto, A. (2024). Towards sustainable governance of freshwater sand – A resource regime

approach. *Earth System Governance*, *22*, 100228. https://doi.org/10.1016/j.esg.2024.100228

Zabyelina, Y., & Van Uhm, D. (Eds.). (2020). *Illegal Mining: Organized Crime, Corruption, and Ecocide in a Resource-Scarce World*. Springer International Publishing. https://doi.org/10.1007/978-3-030-46327-4

Zou, W., Tolonen, K. T., Zhu, G., Qin, B., Zhang, Y., Cao, Z., Peng, K., Cai, Y., & Gong, Z. (2019). Catastrophic effects of sand mining on macroinvertebrates in a large shallow lake with implications for management. *Science of The Total Environment*, *695*, 133706. https://doi.org/10.1016/j.scitotenv.2019.133706