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Unsustainable Sediment Harvesting: A Review of AIoT-Enabled Monitoring Approaches, Detection Strategies, and Environmental Implication

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ABSTRACT

Unsustainable sediment harvesting in coastal environments has emerged as a critical environmental concern, contributing to shoreline erosion, habitat degradation, and increased vulnerability of ecosystems such as mangroves and nearshore zones. The growing demand for sand resources, coupled with inadequate monitoring and enforcement mechanisms, has intensified anthropogenic pressure on coastal systems. Although research on environmental monitoring and smart sensing technologies has expanded over the past decade, existing studies remain fragmented across technological, environmental, and governance domains, with limited integration of Artificial Intelligence of Things (AIoT) approaches for real-time detection and management. To address this gap, this study conducts a systematic review of AIoT-enabled environmental monitoring approaches for detecting coastal sediment disturbance. Publications indexed in the Scopus database between 2011 and 2026 were analysed following the PRISMA 2020 protocol. A total of 284 records were initially identified. After applying preliminary inclusion and exclusion criteria, 156 records were retained. Subsequently, duplicate entries and records with missing essential information were removed, resulting in 56 records for screening. Following title and abstract evaluation, 28 records were excluded due to irrelevance to sediment harvesting, lack of monitoring or AIoT components, and focus on unrelated environmental domains. Finally, 28 studies were included for qualitative and thematic analysis. Bibliometric mapping was further conducted to identify key research trends and thematic relationships. The analysis reveals four major thematic clusters: (i) sensor-based environmental monitoring systems, (ii) AI-driven detection and anomaly recognition techniques, (iii) coastal and marine ecosystem monitoring applications, and (iv) sustainability and governance challenges in resource management. The findings indicate a progressive shift from conventional monitoring approaches to real-time, multi-sensor AIoT systems capable of detecting sediment disturbances through parameters such as turbidity, vibration, and spatial activity patterns. However, several challenges persist, including limited system scalability, data reliability issues, energy constraints, and insufficient integration with policy enforcement mechanisms. By

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synthesizing current research trends and technological advancements, this study provides a structured knowledge map of AIoT-enabled coastal monitoring systems and identifies critical research gaps for future development. The findings contribute to advancing sustainable environmental monitoring strategies and support global sustainability goals related to climate action and coastal ecosystem protection.

1. Introduction

1.1 Global Context of Unsustainable Sediment Harvesting

Unsustainable sediment harvesting has rapidly evolved into a global environmental crisis, driven by unprecedented demand for construction materials and accelerated urbanization[1]. Sand and sediment are now the second most consumed natural resource after water, with global extraction reaching approximately 50 billion tons annually [2]. This scale of extraction far exceeds natural replenishment rates, with sediment being removed faster than ecosystems can recover, raising serious concerns about long-term resource depletion and environmental stability [3]. Alarmingly, projections suggest that at current consumption levels, the world could face critical shortages of construction-grade sand by 2050, highlighting the unsustainable trajectory of current practices. The United Nations Environment Program (UNEP) estimates that between 4 to 8 billion tons of marine sand are extracted annually, equivalent to nearly one million truckloads per day [4]. Such large-scale extraction has transformed sediment from a locally managed resource into a globally traded commodity, intensifying pressure on both coastal and inland ecosystems [5].

1.2 Environmental and Socio-Governance Implications

The environmental consequences of excessive sediment extraction are profound and far-reaching. Disruption of natural sediment balance leads to coastal and riverbank erosion, salinization of aquifers, and reduced natural protection against storm surges. In coastal ecosystems, particularly mangrove regions, sediment plays a critical role in maintaining ecological structure and resilience. Its removal destabilizes these systems, resulting in habitat degradation, biodiversity loss, and increased vulnerability of coastal communities to climate-related hazards [4]. The crisis is particularly acute in rapidly developing regions across Asia, where economic growth has significantly increased demand for sand resources. Global sand consumption has more than tripled since 1970, yet governance mechanisms have not evolved at the same pace. Weak regulatory frameworks, fragmented enforcement, and the rise of illegal sand mining networks have exacerbated the problem[6]. Furthermore, the transboundary nature of sediment trade complicates monitoring and enforcement, making it difficult for authorities to track and regulate extraction activities effectively. As a result, sediment harvesting has become not only an environmental issue but also a governance and policy challenge at both regional and global levels.

1.3 Technological Advances in Environmental Monitoring

In response to growing environmental concerns, research in environmental monitoring has expanded significantly, particularly with the advancement of Internet of Things (IoT) technologies, remote sensing, and artificial intelligence. Existing studies have explored sensor-based monitoring systems for measuring parameters such as turbidity, water quality, and sediment transport, as well as machine learning techniques for anomaly detection and predictive analysis [7]. However, these approaches remain largely fragmented. Many studies focus either on environmental impact assessment or isolated technological solutions without integrating them into comprehensive monitoring frameworks[8]. Although emerging tools, such as AI-driven vessel tracking systems, demonstrate the potential for detecting dredging and sediment extraction activities, their implementation remains limited[9]. The lack of integration between sensing technologies, data analytics, and real-time decision-making systems continues to hinder effective monitoring and enforcement[10].

1.4 Research Gap and Study Contribution

Despite increasing research efforts, there remains a significant gap in the development of integrated, real-time monitoring systems capable of addressing the complexity of sediment harvesting activities. In particular, the application of Artificial Intelligence of Things (AIoT), which combines IoT-based sensing with intelligent data analytics, remains underexplored in the context of coastal sediment disturbance detection. Existing systems often lack scalability, reliability, and alignment with governance and enforcement mechanisms [7].

The significance of addressing this gap is critical, as ineffective monitoring continues to enable unsustainable extraction practices, accelerating coastal degradation and increasing the vulnerability of ecosystems and communities. If current trends persist, coastal regions are expected to experience accelerated shoreline retreat, increased flood risks, and irreversible ecosystem damage within the next two decades. The degradation of sediment-dependent ecosystems, including mangroves and deltas, threatens both biodiversity and the livelihoods of millions of people [11]. Furthermore, global demand for sand is projected to reach 60 billion tons annually by 2030, intensifying pressure on already fragile environments [12].

Therefore, this study aims to systematically review and analyze AIoT-enabled environmental monitoring approaches for detecting sediment disturbances in coastal environments. By synthesizing current research trends and technological developments, the study seeks to provide a structured understanding of technological capabilities, identify key limitations, and highlight critical research gaps to support sustainable environmental management and policy enforcement.

2. Methodology

This study adopts a systematic review approach guided by the PRISMA 2020 framework to ensure a structured, transparent, and reproducible process of literature selection [13]. Given the interdisciplinary scope of sediment harvesting research, the study integrates thematic analysis, descriptive quantitative synthesis, and bibliometric analysis to provide a comprehensive evaluation of existing literature. Bibliometric mapping, conducted using tools such as VOSviewer, supports the visualization of keyword co-occurrence patterns and thematic relationships. The methodological process consists of three main stages: (i) literature identification and selection using PRISMA, (ii) thematic analysis to categorize research domains, and (iii) quantitative synthesis to identify trends and comparative patterns across studies.

2.1 Data Source and Search Strategy

The Scopus database was selected as the primary data source due to its broad coverage of peer-reviewed publications across environmental and technological disciplines. A structured search strategy was developed to identify relevant studies related to sediment extraction and monitoring technologies. The search query applied was:

TITLE-ABS-KEY (("sand mining" OR "sediment extraction") AND ("monitoring" OR "remote sensing")) AND PUBYEAR > 2010 AND PUBYEAR < 2027
AND (LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "COMP"))
AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "re"))
AND (LIMIT-TO (LANGUAGE, "English"))

This strategy ensures the inclusion of relevant studies within environmental monitoring and technological contexts.

2.2 Inclusion and Exclusion Criteria

To ensure relevance and quality, predefined inclusion and exclusion criteria were applied.

a. Inclusion criteria:
   i. Studies addressing sand mining, sediment extraction, or sediment disturbance
   ii. Research involving environmental monitoring, sensing technologies, or detection systems
   iii. Studies incorporating IoT, artificial intelligence, or remote sensing approaches
   iv. Publications between 2011 and 2026
   v. Peer-reviewed journal articles, conference papers, and review papers in English

b. Exclusion criteria:
   i. Studies focusing solely on general water quality or pollution without sediment context
   ii. Agriculture, vegetation, or unrelated ecological studies
   iii. Papers lacking monitoring or detection components
   iv. Duplicate records or studies with incomplete information

2.3 Study Selection Process

The study selection process was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a transparent and systematic approach to literature identification and screening. Initially, a total of 284 records were retrieved from the Scopus database based on the defined search strategy. Following the application of preliminary inclusion and exclusion criteria, 156 records were retained for further processing. Subsequently, duplicate entries and records with incomplete or missing information were removed, resulting in a refined dataset of 56 records for screening.

The screening process involved a detailed evaluation of titles and abstracts to assess relevance to the study scope. As a result, 28 records were excluded due to lack of alignment with sediment harvesting, monitoring technologies, or detection-related criteria. The remaining 28 studies satisfied all predefined eligibility requirements and were included in the final analysis. A comprehensive overview of the study selection process is presented in Figure 1:

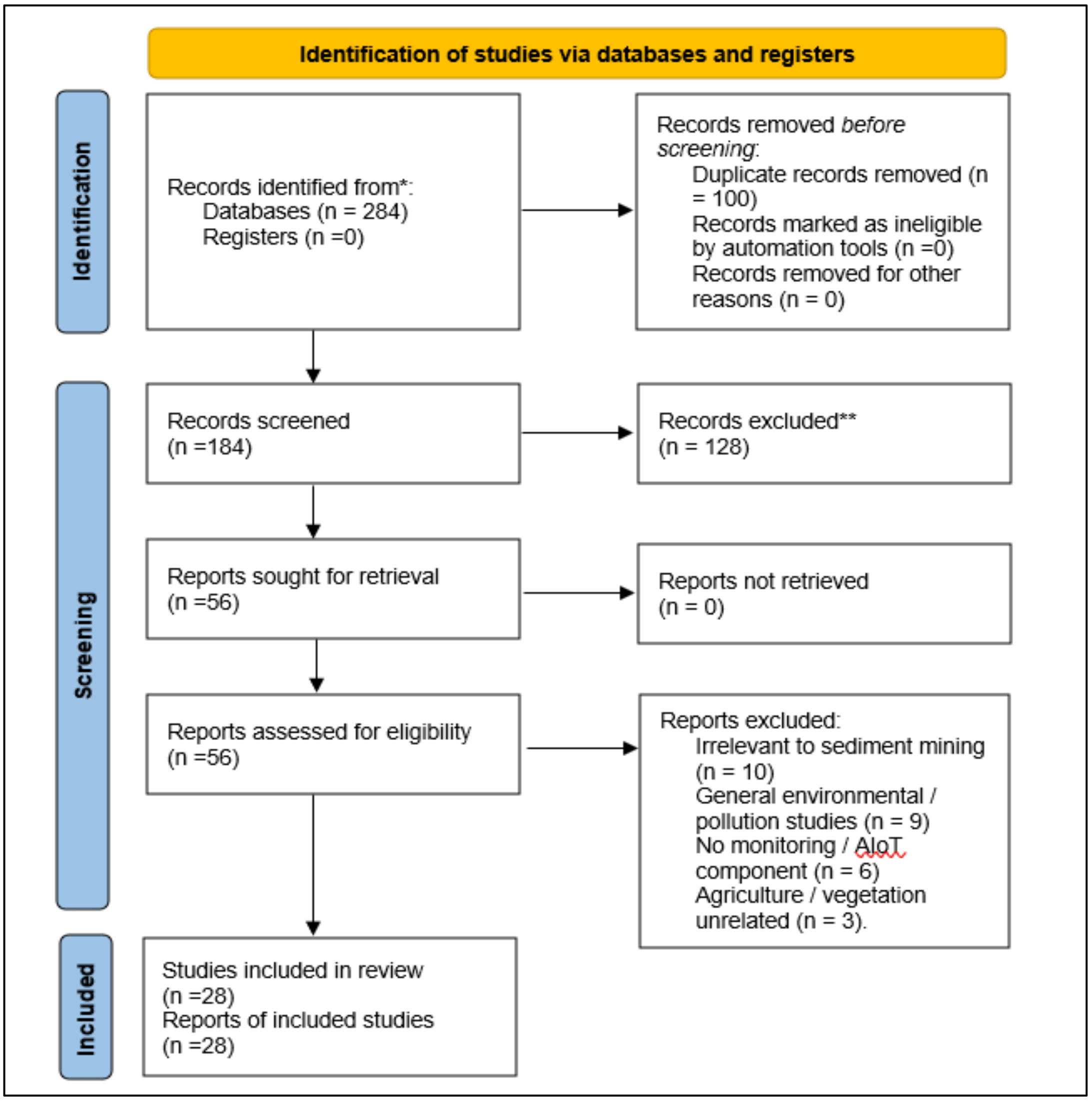

Fig. 1. PRISMA flow diagram of the study selection process

2.4 Thematic Analysis

A thematic analysis was conducted to classify the selected studies into key research domains. Each study was reviewed and coded based on its technological approach, monitoring characteristics, and application context [14]. This process enabled the identification of dominant themes and facilitated a structured understanding of research distribution across environmental and technological dimensions.

2.5 Descriptive Quantitative Synthesis

To complement the thematic analysis, a descriptive quantitative synthesis was performed. Key attributes, including technology type, monitoring approach, application domain, and detection capability, were extracted and systematically coded for each study. Frequency counts and percentage distributions were calculated to identify dominant trends and patterns across the selected literature. This approach supports structured comparison of different technological approaches and monitoring strategies.

The combination of thematic analysis and descriptive quantitative synthesis provides a structured framework for examining patterns, trends, and relationships within the selected studies. The outcomes of these analyses are presented and discussed in the following section.

3. Result and Discussion

3.1 Overview of Selected Studies

A total of 28 studies were included in the final analysis, covering publications from 2011 to 2026. The distribution of studies indicates a growing research interest in environmental monitoring and sediment-related issues, particularly in recent years. The selected literature spans areas such as water quality assessment, sediment dynamics, and mining impacts. Most studies focus on general environmental monitoring, with limited emphasis on sediment harvesting as a distinct domain. While sensor-based and remote sensing approaches are commonly adopted, the integration of AI-driven real-time monitoring remains relatively underexplored. Overall, the findings reflect a fragmented research landscape, highlighting the need for more integrated and intelligent monitoring frameworks.

3.2 Keyword Co-occurrence Network Analysis

The keyword co-occurrence network analysis was conducted to identify the underlying thematic structure of the selected studies, as illustrated in Figure 2. The analysis reveals four interconnected clusters that represent the dominant research domains within sediment harvesting and environmental monitoring literature. The first cluster corresponds to sensor-based environmental monitoring systems, characterized by keywords such as environmental monitoring, mining, air pollution, and soils [15]. This cluster forms the central core of the network, indicating that monitoring technologies are widely applied across environmental contexts, albeit in a generalized manner.

The second cluster reflects AI-driven detection and anomaly recognition techniques, although its representation within the network is relatively limited. The weak presence of advanced analytical terms suggests that intelligent, data-driven approaches for real-time sediment disturbance detection are still emerging within the research landscape [16]. The third cluster represents coastal and marine ecosystem monitoring applications, with keywords related to sediment, sand mining, river systems, and ecosystems. This cluster aligns closely with the core focus of the study, highlighting the environmental implications of sediment extraction activities within aquatic and coastal environments.

The fourth cluster captures sustainability and governance challenges in resource management, where terms associated with environmental impact, land use, and resource management appear [10]. This cluster reflects the broader implications of sediment harvesting, particularly in relation to policy, environmental sustainability, and regulatory frameworks [17]. Overall, the network structure indicates that while environmental monitoring is well-established, the integration of AI-driven techniques and governance-oriented approaches remains limited. The observed fragmentation across clusters further emphasizes the need for more cohesive and interdisciplinary research frameworks.

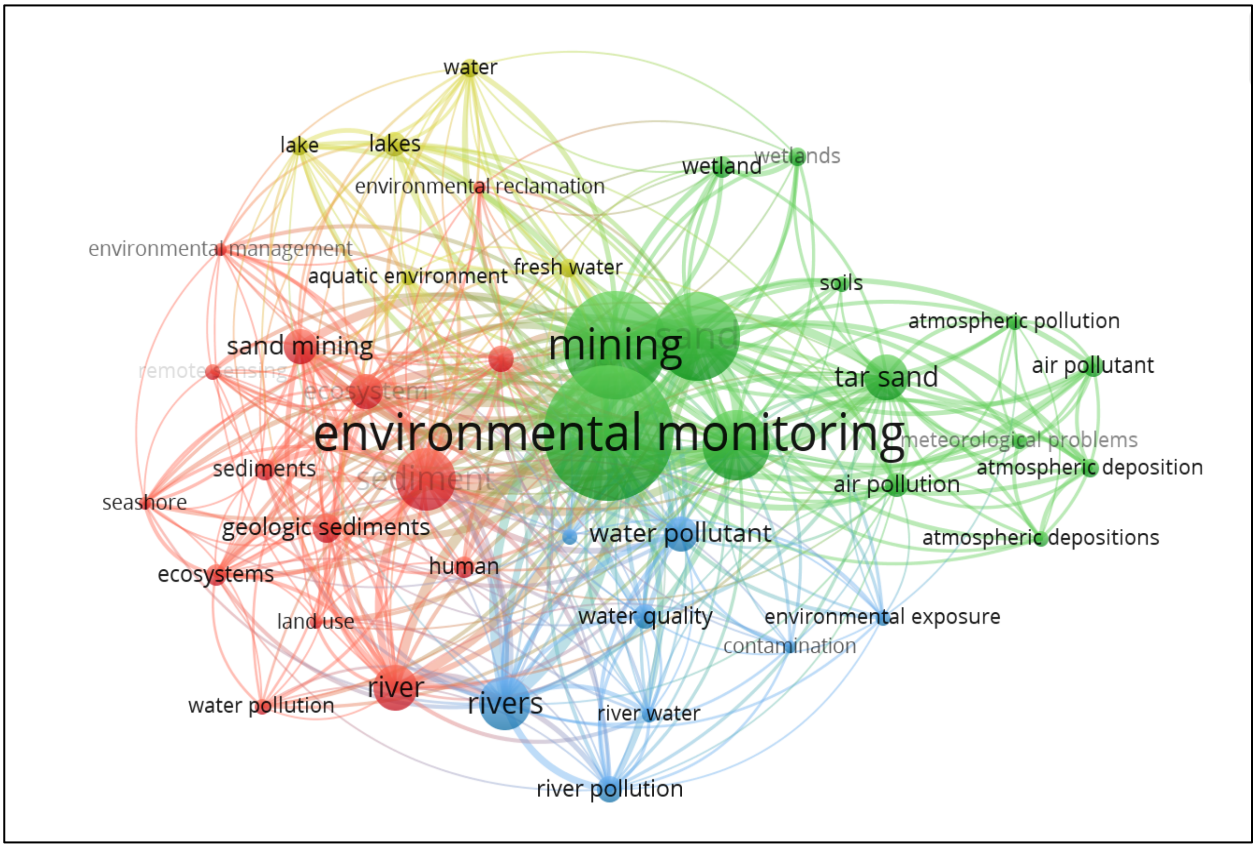

Fig. 2. Keyword co-occurrence network illustrating thematic clusters in sediment harvesting and environmental monitoring research

These findings highlight the dominance of general environmental monitoring themes while indicating limited integration of advanced AI-driven approaches, which is further examined through density-based analysis in the following section.

3.3 Density Visualization of Research Focus

The density visualization analysis provides an overview of the concentration and intensity of research topics within the selected literature, as illustrated in Figure 3. High-density areas, represented by warmer colours, indicate frequently occurring and strongly connected keywords, while lower-density areas reflect less explored topics [16]. The results show that *environmental monitoring* forms the most prominent and central focus within the research landscape, followed by related themes such as *mining*, *sediment*, and *water quality*. This indicates that existing studies are heavily concentrated on general environmental monitoring frameworks rather than specialized investigation of sediment harvesting activities [3].

Notably, the density map reveals limited representation of advanced analytical and intelligent monitoring approaches, particularly those associated with artificial intelligence and real-time detection systems. This suggests that while monitoring technologies are widely applied, their evolution toward integrated and intelligent AIoT-based systems remains insufficiently developed. Furthermore, the concentration of keywords around broad environmental domains highlights a tendency for sediment-related research to be embedded within wider environmental studies, rather than being addressed as a distinct and focused research area. This reinforces the fragmentation observed in the keyword co-occurrence network[8].

Overall, the density analysis confirms that current research efforts are unevenly distributed, with strong emphasis on general monitoring practices and comparatively limited attention to specialized, real-time sediment disturbance detection. These observations provide a basis for further examining the structural relationships and connectivity among research themes in the subsequent analysis.

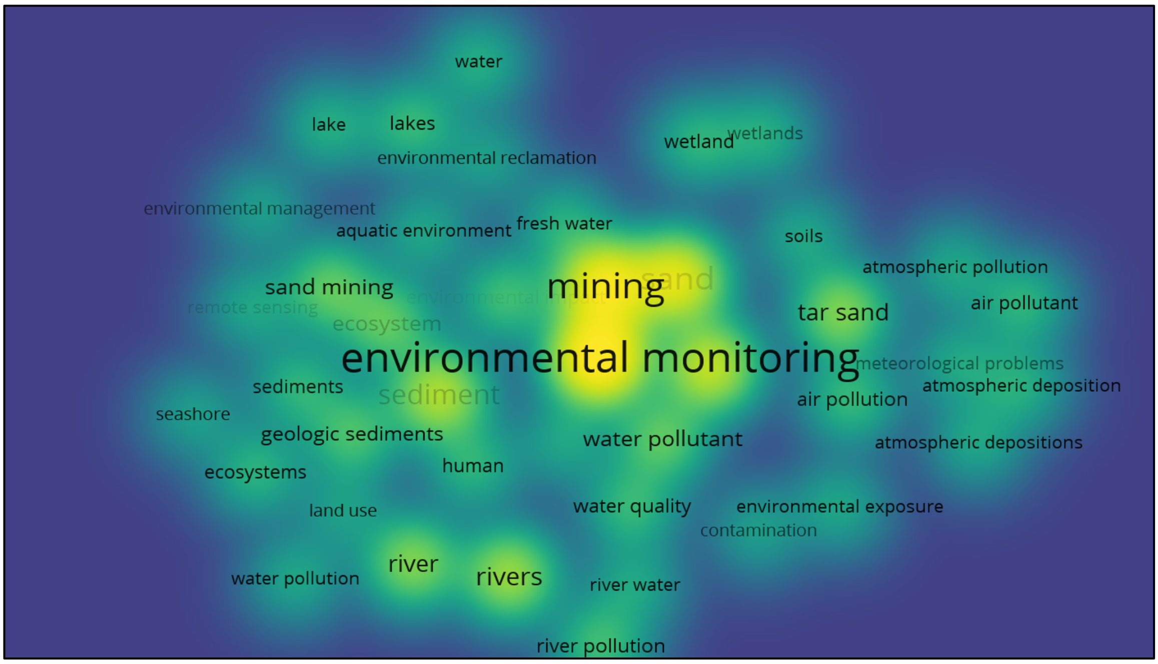

Fig. 3. Density visualization of keyword co-occurrence in sediment harvesting and environmental monitoring research

These patterns highlight the concentration of research within general monitoring domains while indicating limited development of intelligent detection approaches, which is further explored through network connectivity analysis in the following section.

3.4 Network Connectivity and Thematic Strength

The network connectivity analysis further examines the strength of relationships among keywords and the structural importance of different research themes, as illustrated in Figure 4. In this visualization, node size represents the frequency of keyword occurrence, while the thickness of connecting lines indicates the strength of co-occurrence relationships between terms. The results indicate that environmental monitoring functions as the most central and influential node within the network, exhibiting strong connections with key themes such as mining, sediment, and water-related systems. This highlights its role as the primary integrative domain within the research landscape [18].

In contrast, keywords associated with advanced analytical approaches and intelligent systems demonstrate weaker connectivity and smaller node prominence, indicating limited integration of AI-driven detection and anomaly recognition techniques [19]. This observation is consistent with earlier findings from the thematic and density analyses, which also revealed the underrepresentation of intelligent monitoring approaches. Moreover, the network structure reveals uneven connectivity across clusters, with strong internal linkages within general environmental and water-related domains, but weaker connections bridging these domains with sediment-specific and governance-related themes. This suggests a lack of cohesive integration across technological, environmental, and policy dimensions[20].

Overall, the connectivity analysis confirms a fragmented research structure, where dominant themes are well established, yet critical areas such as AIoT-based monitoring and governance integration remain weakly connected. These findings underscore the need for more integrated, interdisciplinary, and technology-driven approaches to effectively address sediment harvesting challenges.

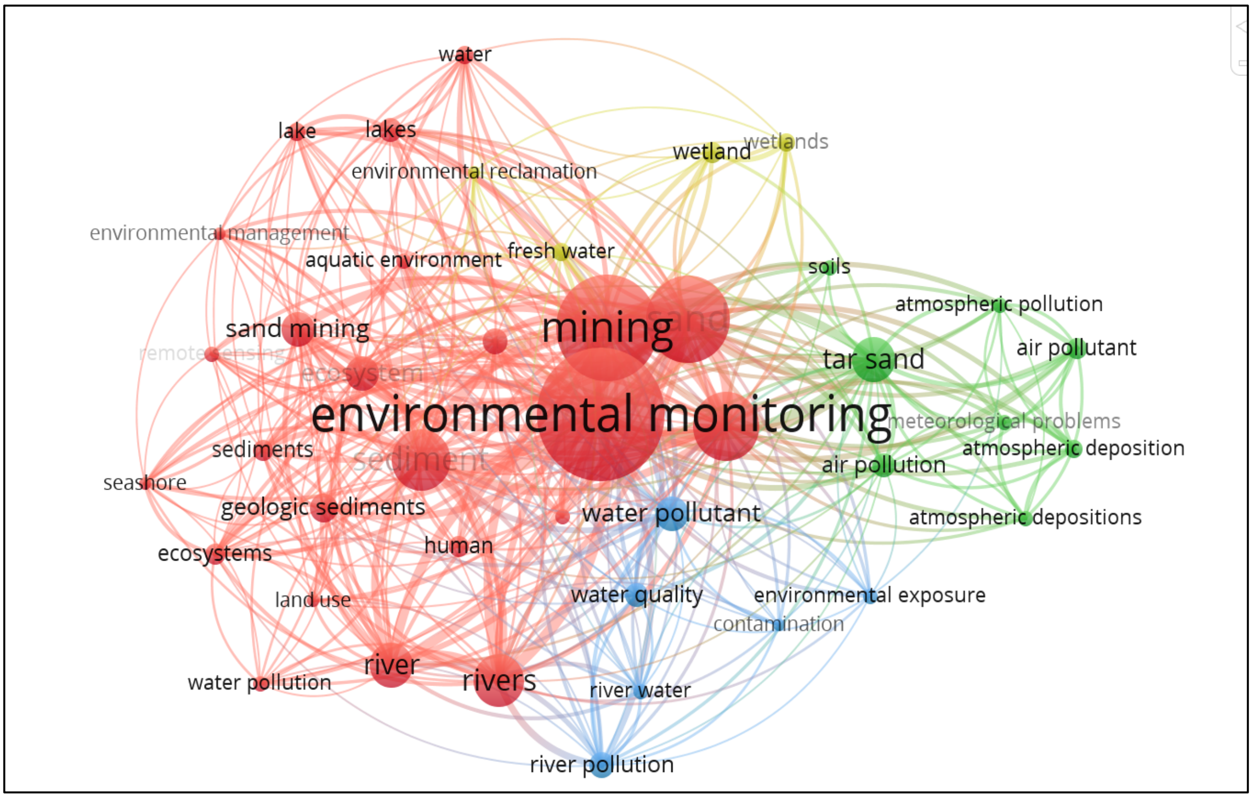

Fig. 4. Network visualization of keyword co-occurrence illustrating connectivity and thematic strength in sediment harvesting and environmental monitoring research

3.5 Quantitative Synthesis of Research Trends

To complement the bibliometric and thematic analyses, a descriptive quantitative synthesis was conducted to examine the distribution and characteristics of the selected studies (n = 28). This analysis focuses on key dimensions, including monitoring approaches, level of intelligence integration, system capability, and application domains. By quantifying these aspects, the study provides empirical evidence to support the thematic findings and enables a clearer understanding of dominant research trends, existing imbalances, and underexplored areas within AIoT-enabled environmental monitoring for sediment disturbance detection.

The quantitative distribution of monitoring approaches, as illustrated in Figure 5, indicates that sensor-based and field monitoring systems constitute the dominant methodology, accounting for approximately 50–55% of the reviewed studies. Remote sensing techniques, including satellite and aerial observations, represent around 30–35%, while hybrid and integrated monitoring systems remain limited. In terms of analytical capability. Figure 6 shows that only a small proportion of studies (less than 10%) incorporate artificial intelligence or anomaly detection techniques, with the majority relying on conventional data analysis methods. Furthermore, real-time or near real-time monitoring capabilities are observed in less than 20% of the studies, indicating a strong dependence on offline or periodic analysis. From an application perspective, most studies are concentrated in water and sediment-related systems (approximately 60%), with fewer studies addressing ecosystem or atmospheric domains. These quantitative patterns highlight a clear dominance of conventional monitoring approaches and reveal significant gaps in intelligent, real-time, and integrated monitoring systems.

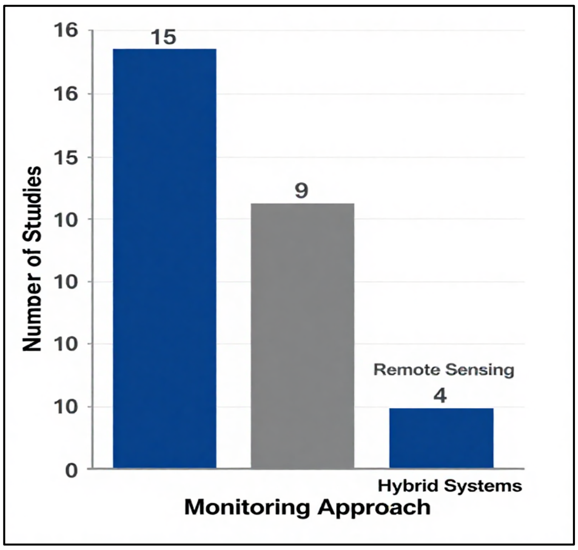

Fig. 5. Distribution of monitoring approaches in selected studies (n=28)

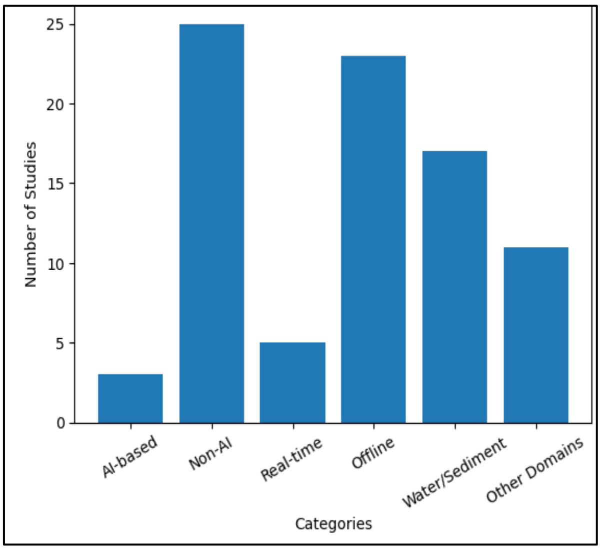

Fig. 6. Distribution of analytical capabilities and application domain in selected studies (n=28)

When examined in relation to the identified thematic clusters, the quantitative distribution of studies reveals a clear structural imbalance within the research landscape. The dominance of sensor-based monitoring approaches corresponds closely with the first thematic cluster, indicating that the field is heavily oriented toward data acquisition rather than intelligent analysis [21]. In contrast, the minimal representation of AI-driven techniques aligns with the limited presence of the second cluster, confirming that advanced detection and anomaly recognition remain underdeveloped.

Similarly, while a moderate proportion of studies focus on water and sediment-related applications, these are often embedded within broader environmental monitoring contexts, reflecting the partial representation of the third cluster. The weakest representation is observed in governance and sustainability-related studies, reinforcing the limited integration of policy and regulatory dimensions identified in the fourth cluster. Overall, this combined thematic and quantitative analysis indicates that the research domain remains fragmented, with insufficient integration across technological, environmental, and governance dimensions. This imbalance highlights the urgent need for comprehensive AIoT-based frameworks that bridge sensing, analytics, and policy to support effective and sustainable sediment monitoring.

Building on these findings, several critical research gaps are identified. These gaps reflect structural limitations in the current research landscape, particularly in relation to the integration of intelligent technologies, real-time monitoring capabilities, and governance frameworks. Table 1 summarizes the key gaps, supporting evidence derived from the analysis, and their implications for future research and practice.

Table 1
Evidence-based research gaps identified from integrated thematic and quantitative analysis

Gab category	Evidence from thematic & quantitative analysis	Affected dimension	Implication
Limited integration of AI-driven detection	Weak representation in AI-driven thematic cluster; <10% studies adopt AI-based approaches; low connectivity in network analysis	Technological (Analytics)	Inability to perform intelligent and automated sediment disturbance detection
Lack of real-time monitoring capabilities	<20% of studies support real-time or near real-time systems; dominance of offline analysis methods	Technological (System Capability)	Delayed response to sediment extraction activities and environmental changes
Dominance of sensor-based data acquisition over intelligent processing	Over 50% of studies focus on sensor-based monitoring; high centrality of environmental monitoring in network analysis	Technological (Data vs Intelligence)	Emphasis on data collection without actionable insights or decision support
Fragmentation across research domains	Weak connectivity between clusters in network analysis; separation of technological, environmental, and governance themes	Interdisciplinary Integration	Lack of cohesive frameworks integrating sensing, analytics, and policy
Limited focus on sediment-specific monitoring	Majority of studies embedded within general environmental or water monitoring (~60%); partial representation in thematic clustering	Application Domain	Absence of targeted solutions for sediment harvesting detection
Weak integration of governance and policy frameworks	Low representation of sustainability and governance cluster; minimal linkage in network connectivity analysis	Governance / Policy	Ineffective enforcement and lack of alignment between monitoring systems and regulatory actions

As shown in Table 1, the most critical weaknesses in the current research landscape lie in the limited adoption of AI-driven detection, the low prevalence of real-time monitoring systems, and the weak integration of governance considerations within technological frameworks. Although sensor-based monitoring is well represented, the evidence suggests that existing studies remain largely descriptive and fragmented, with insufficient progression toward intelligent, decision-support-oriented systems [22]. This imbalance reduces the practical effectiveness of current monitoring approaches for addressing complex sediment harvesting challenges, particularly in coastal environments where ecological sensitivity, regulatory enforcement, and climate-related risks are closely interconnected.

3.6 Thematic Implications for Sustainability and Research Priorities

The findings of this review indicate that the current research landscape on sediment harvesting remains methodologically uneven and conceptually fragmented. Although monitoring related studies have increased over time, the evidence synthesized in this study shows that the field is still dominated by conventional environmental observations approaches, with limited progression toward integrated, intelligent, and decision-oriented monitoring systems. This directly relates to the central aim of the present review, which was to examine how AIoT enabled monitoring approaches are being applied to detect sediment disturbances in coastal environments and to identify the limitations that continue to constrain their practical implementation. The results demonstrate that, while monitoring technologies are widely discussed, their application remains concentrated in descriptive sensing, remote observation. and post event analysis, rather than in real time, adaptive and enforcement-oriented systems.

A major implication of these findings is the existing body of research does not yet adequately reflect the operational complexity of unsustainable sediment harvesting. In practice, sediment extraction is not only a geomorphological or ecological issue, but also temporal, spatial, and governance problem [23]. It occurs, across riverine, estuarine, and coastal settings, often under conditions of weak regulation, limited surveillance, and delayed intervention. However, the literature remains heavily weighted toward environmental impact assessments and general monitoring applications, with comparatively few studies addressing intelligent detection, anomaly recognition. This imbalance suggests that research has made stronger progress in documenting environmental consequences than in designing system capable of preventing or rapidly identifying harmful extraction activities.

The thematic structure identified in this study further confirms that the field is distributed across four majors but insufficiently connected domains: sensor based environmental monitoring systems, Ai driven detection and anomaly recognition techniques, coastal and marine ecosystem monitoring applications, and sustainability and governance challenges in resource management. Each cluster reflects an important part of the problem, yet the weak integration among them highlights a critical limitation in the maturity of the field. Sensor based studies provides foundational data, but often without advanced analytical interpretation. Ai related studies offer methodological promise yet remain sparce and weakly embedded in environmental monitoring practice [24]. Ecosystem focused studies reveal the consequences of sediment imbalance but frequently do so without linking ecological assessment to technological surveillance [25]. Governance oriented studies acknowledge regulation and sustainability concerns, yet these dimensions are seldom operationalized within actual monitoring frameworks [26]. As a result, the literature does not yet support a sufficiently unified model for understanding, detecting, and managing sediment harvesting in a way that is simultaneously technical ecological and policy relevant. Table 2 summarizes the major thematic clusters, their current emphasis in the literature, the underexplored dimensions within each theme, and their broader relevance to sustainability-oriented sediment monitoring.

Table 2
Thematic synthesis derived from the reviewed literature

Thematic cluster	Evidence from current analysis	Observed pattern in the literature	Analytical implications
Sensor-based environmental monitoring systems	Strong presence in keyword clustering; dominant monitoring approach in	Research is concentrated on sensing and environmental	Monitoring is primarily oriented toward data acquisition rather

	quantitative synthesis	parameter observation	than intelligent interpretation
AI-driven detection and anomaly recognition techniques	Weak presence in thematic clustering; less than 10% of studies incorporate AI-based approaches	AI-related analytical methods remain limited in current sediment monitoring studies	Intelligent detection remains underdeveloped in the field
Coastal and marine ecosystem monitoring applications	Partial representation in thematic clustering; moderate focus on water and sediment-related systems	Sediment issues are often studied within broader environmental and aquatic contexts	Sediment harvesting is insufficiently addressed as a distinct monitoring domain
Sustainability and governance challenges in resource management	Weak representation in thematic clustering; limited policy linkage in connectivity analysis	Governance concerns are acknowledged, but not strongly integrated with monitoring systems	Regulatory and enforcement dimensions remain weakly connected to technical research

As shown in Table 2, the thematic implications of the reviewed literature extend beyond technical monitoring and point toward a broader need for integration across sensing, analytics, ecological protection, and governance implementation [27]. The identified priorities suggest that future progress in sediment monitoring will depend not only on technological advancements, but also on the extent to which monitoring systems can support sustainability-oriented decision making in both local and global context [17].

Taken together, these findings suggest that future progress in this field will depend on whether research can bridge the divide between environmental monitoring as an observational activity and AIoT enabled monitoring as an operational system for timely detection, interpretation and intervention. The present review therefore offers not only a synthesis of current knowledge, but also a conceptual foundation for strengthening future work in areas that remain weakly developed in both local and global contexts[28]. In doing so, it contributes to a broader understanding of how technological systems may be better aligned with sustainability objectives regulatory practice, and the growing need to protect sediment dependent ecosystems under conditions of intensifying human and climate pressure.

4. Conclusion

The review set out to examine the current state of AIoT enabled environmental monitoring approaches for detecting unsustainable sediment disturbances associated in coastal and aquatic environments. The synthesis of the selected literature shows that the field has expanded across environmental monitoring, sediment impact assessment, and detection related technologies, but remains uneven in its development and fragmented in its overall structure.

The review demonstrates that existing research is still dominated by conventional monitoring approaches, particularly sensor based and remote sensing applications, while intelligent analytical capability, real-time responsiveness and governance linked implementation remain comparatively limited. Thematic bibliometric and quantitative analysis consistently indicates that the literature is distributed across four major domains: sensor based environmental monitoring systems, AI driven detection and anomaly recognition techniques, coastal and marine ecosystem monitoring applications, and sustainable and governance challenges in resource management, yet these domains remain infusion integrated. As a result, the current research landscape provides stronger support for environmental observation and impact documentation than for coherent operational and implementation-oriented sediment monitoring.

This finding is academically significant because it clarifies that the principal limitation of the fields does not live in the absence of monitoring research, but in the weak convergence between technological capability, ecological relevance, and governance applications. Sediment harvesting is therefore revealed not merely as an environmental disturbance issue, but as a research domain that still lacks conceptual and functional integration. By bringing together thematic clustering, bibliometric structure, and quantitative synthesis, this review provides a clever understanding of how the field is currently positioned and where its most persistent weakness lies.

Overall, the review concludes that the present body of knowledge has not yet developed into sufficiently integrated framework for sediment disturbance monitoring that is intelligent, responsive, and practically aligned with environmental management needs. The value of this review lies in establishing that sustainable sediment monitoring must be understood as a connected technological, ecological and governance concern rather than as a set of isolated monitoring.

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