

Assessing the Importance of Biostatistics in Environmental Risk Assessment: Evidence from a Qualitative Study

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ABSTRACT

Purpose: The research aimed to explore environmental risk assessment and management from the perspectives of biostatistics and governance. It explored the role of biostatistical monitoring, public health risks, governance challenges, and environmental pollution in environmental decision-making. **Design/ method/ approach:** The present research used a cross-sectional research design and a qualitative research method using focus group discussions and semi-structured interviews. The study applied a multi-stakeholder framework by involving health experts, community stakeholders, NGO representatives, government officials, and environmental specialists. The study used purposive sampling to collect data from respondents. Descriptive interpretation and thematic analysis were used for the assessment of collected data. **Findings:** The results of the study revealed that biostatistical monitoring is important for evidence-based environmental management, trend analysis, and exposure assessment. The findings also revealed that poor waste management, industrial emissions, and water contamination increase public health and environmental risks. **Originality:** This research integrates biostatistical interpretation with environmental assessment to provide a comprehensive understanding of sustainable management practices.

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1. Introduction

Massive industrialization has created a situation where different natural resources like fossil fuels, air, soil, and water are becoming polluted. Moreover, all these resources are being exhausted at an alarming rate (Saxena, 2025). It creates a need to look for environmentally friendly solutions to the problems caused by processes creating environmental hazards for sustainable development. A number of inorganic, organic, and other pollutants have persisted in the environment and become part of food chains. Different kinds of heavy metals, microplastics, organic pollutants, and emerging contaminants are damaging human health (Gunjyal et al., 2023). They are the main causes of cardiovascular disorders, neurological disorders, allergies, and cancers, resulting in a large number of deaths at the global level. Therefore, in order to minimize the impact of different environmental hazards, a number of chemical-, plant-, and biological-based techniques have been developed. Two of these techniques include bioremediation and biostatistics, which focus on the utilization of algae and bacteria for the remediation process (Ganla et al., 2025).

All human activities impact the environment in one way or another. These impacts are worsened by product disposal, product usage, and production systems. Types of products that impact the environment include consumer infrastructure, consumer products, medicines, and food (Roberts et al., 2023). Environmental practices and policies designed to minimize the harmful effects on the environment must be based on assessments that include consideration of the properties of chemical elements and their possible negative effects on the environment (Roberts et al., 2023). It is important to consider all possible effects on the environment, including the areas that can be damaged, chances of exposure, the amount of waste generated, emissions produced, and the level of resource usage.

Therefore, there is a need for environmental risk assessment, as this era is marked by rapid climate change, urbanization, and industrialization (Bolan et al., 2024). Risk management approaches to environmental issues are being applied at an increasing rate at almost all levels, from policy and strategy to regulation and decision-making. The main

purpose is to ensure the protection of human health, address environmental issues at the global level, and preserve ecosystems with the purpose of shaping a more resilient and sustainable future. The scope of ecological risk assessment has expanded from accidental assessment and traditional chemical assessment to the inclusion of possible harm from the artificial introduction of different species, both genetically modified and natural, into an ecosystem (Liu et al., 2024). Therefore, important categories of ecological hazards include biostatistical, biological, physical, chemical, and their combinations. It is important to assess the relationship between human health and environmental exposures (Catapano et al., 2025).

Governance is considered a key factor in promoting sustainable environmental management and improving environmental risk assessment. Increasing environmental challenges, such as resource depletion, climate change, and pollution, have increased the need for effective governance to ensure proper environmental control and monitoring (Zhu & Li, 2025). A strong governance system helps institutions and organizations develop transparent policies, enhance accountability, and enforce environmental regulations in environmental practices (Thakkar, 2025). Additionally, governance supports informed decision-making and encourages stakeholder participation that improves the management and identification of environmental risks. Scholars suggest that effective governance strengthens environmental assessment processes and also enhances commitment toward environmental protection and sustainability (Newig et al., 2023).

In the last few decades, biostatistics has emerged as an important scientific discipline that supports the evaluation, interpretation, and systematic analysis of environmental data. Different biostatistical methods provide important tools to measure pollution levels, predict environmental hazards, and identify ecological patterns and pollution levels (Sakarna et al., 2025). The accuracy of environmental decision-making is improved through these quantitative approaches by transforming complex biological and environmental data into reliable evidence for management strategies and policymaking (Cooke et al., 2023). Moreover, biostatistical knowledge also enhances organizational responses, professional competencies, and environmental awareness regarding environmental threats. By examining environmental governance, professional practices, and stakeholder experiences, biostatistics provides deeper insights into the way it contributes toward a sustainable environment (Muthuswamy & Nijarubini, 2026). Therefore, it is important to assess the role of biostatistics in the assessment of environmental risks to understand its impact on environmental protection, risk communication, and hazard identification. Biostatistics contributes by supporting informed strategies to address contemporary environmental challenges, improving risk evaluation, and strengthening environmental awareness. The aim of this research is to examine the effect of biostatistics and governance on environmental risk assessment. The study also aimed to explore the impact of exposure to hazards on health and the need for sustainable management perspectives.

2. Literature Review

2.1 Environmental Risk Assessment

Studies have discussed risk as possible consequence of hazard in combination with their probabilities and likelihood. Risk is the possible negative outcome of any action (Council et al., 2003). The negative outcome can be loss of environment, employment, property, and livelihood. The nature and type of risk is important to determine. It is also important to assess that factors that are causing risk, is known as risk assessment. It is one of the key tools to develop strategies of disaster risk management involving ranking, estimating, and identifying the risk. Risk assessment is discussed as process that is used for the evaluation of outcomes of hazards and their probabilities and likelihoods. Risk management is the systematic process to look for options that can be opted to respond to risk and decide the option that can be implemented. Environmental risk assessment is the process that evaluates the chances of adverse impact on habitats, living organisms, and ecosystems due to natural hazards and human activities. It find out different environmental stressors like land use changes, pollutants and chemicals to guide management decisions and predict harms (Elsharkawy & Sharkawy, 2025). The important factor to handle the problems caused by climate change, industrialization, and urbanization in environmental risk assessment. A systematic framework is offered by environmental risk assessment for mitigating, assessing, and identifying risk when human activity has influence on public health and ecosystems (Gusti & Yurnal, 2019).

Risk assessment is the determination of chances that an adverse impact will cause from any exposure and include risk characterization, response assessment of dose, exposure assessment, and hazard identification (Sulsky et al., 2024). Since last five decades, risk assessment is applied progressively to examine and understand the effect of different factors impacting environment. The basic cause of it is linked to the impact of different insecticides on environment friendly species. Presently, term risk assessment is applied in a number of studies in a wide range of domains including industrial safety, transport, healthcare and finance (Zhou et al., 2025). Despite the fact that a number of studies have used the term risk assessment, there is alteration at the significant level regarding the way risk assessment is carried out depending on physical agents involved, organic agents involved, biochemicals and experts at the global level that create necessity of the assessment. Risk assessment is transparent, scientific, and layered process that can be repeated by the researcher at the

time of need. It is key to articulate information clearly regarding the magnitude and potential of risk to proceed with risk assessment (Jobst et al., 2025). Other factors needed for this purpose include reviewing the risks, reporting the risks, resources needed for risk assessment, authorities needed to initiate the assessment of risk, responsibility regarding risks assessment, techniques needed for assessment of risks, methods important for risk assessment, and objectives of the risk assessment (Gunjyal et al., 2023).

Environmental risk assessment is used in a number of different sectors including oil and gas sector, urban planning and many others in order to ensure that their standards comply with environmental protection and legal standards (Etim et al., 2026). Organizations can minimize the chances of environmental hazards and lower the impact by foreseeing hazards. When it comes to reduce and detect risk of health to people such as hazardous waste, poisons, pollutants, environment risk assessment is vital (Ostad-Ali-Askari, 2022). Evaluation of air quality in the areas that are close to industry can help people living there to overcome respiratory issues. Long term environmental harms like biodiversity loss, water pollution, and soil contamination can be mitigated by using environmental risk assessments (Manisalidis et al., 2020). Organizations can take different actions to protect ecosystems and biodiversity services by finding out threats to environment and ecosystem such as wetlands and forests. There is need of balance between economic growth and environmental preservation at the global level. For this purpose, it is vital to ensure that different development projects cause minimum environmental damage including renewable energy installations and infrastructure development. It will help in controlling different environmental disasters like oil spills, and chemical spills that often lead to legal actions and expensive cleanups (Rode et al., 2016).

2.2 Types of Risks

Studies mentioned that environmental risk assessments mostly evaluate different major types of environmental risk that vary based on certain context but mostly include project related risks, industrial risks, natural risks, biological risks, physical risks, and chemical risks (Giovagnoni et al., 2025). Chemical risks include exposure to different harmful substances such as volatile organic compounds, pesticides, industrial chemicals, and lead and mercury, that has the potential to contaminate soil, water, and air, causing serious threats to human health and ecosystems. On the other hand, physical risks are referred as non-chemical hazards such as urban heat islands caused because of dense concrete infrastructure, radiation from nuclear facilities, and industrial activities, all of which reduce quality of life and negatively impact the eco-system.

Biological risks include different kinds of threats from genetically modified organisms, infectious organisms, and invasive species, that can disrupt biodiversity, food chains, and ecosystems by outcompeting native species. Moreover, different types of natural risks include environmental hazards that are caused by natural disasters such as wildfires, earthquakes, droughts, and floods (Pettoello-Mantovani et al., 2021). Environmental risk assessment also examines the way human activities have the potential to intensify natural disasters. In the end, industrial risks often take place from large scale activities such as gas development, oil development, waste disposal, mining, that may lead to issues like acid mining drainage, groundwater contamination, and oil spills (Ciurean et al., 2019). Environmental risk assessment ensures that these mentioned risks are minimized, managed, and identified (Gorlenko et al., 2020).

2.3 Biostatistics

Literature has defined biostatistics as statistical methods that are applied by scientists for scientific problems (Rao & Richard, 2012). Biostatistics is the usage of different statistical tools on different biological problems, and derivation of results regarding that. In other words, biostatistics is the application of statistical techniques and mathematical principles for the purpose of scientific research in the field of medicine, biology, and public health (Zapf et al., 2020). Biostatistics is one of the specialized and evidence-based science involving collection, interpretation, and presentation of data with purpose to improve health outcomes and minimize illness. Knowledge regarding biostatistics play key role in different scientific methods considering the organization of data, description of data, analysis of data, and interpretation of data (Mishra & Khan, 2024). Knowledge regarding biostatistics helps scholars to determine the interpretation of data, analysis of tests, and validity of tests. In absence of biostatistical knowledge, it will be hard for scientists to make the judgement (D'Arrigo et al., 2024).

Studies mentioned that biostatistics is used to conduct clinical research based on comparative efficacy of certain treatment, organizing design for clinical trial, selection of number of patients, and other important protocols that are key for certain treatment. Biostatistics helps to determine the population of certain species, gene frequency, and is involved in every type of genetic problems. Biostatistics use theory and methodology of statistics and applies in health and life sciences (Sagar et al., 2023). Biostatistics mostly helps in testing drugs to develop recommendations for pharmaceuticals and environmental models. One of the basic tasks of biostatistics is to assess the reason why different diseases occur in any geographical area, and the reason why this disease does not occur in other areas (Kunnavil, 2022). This approach help to

resolve biological and environmental problems.

2.4 Biostatistics and Environmental Risk Assessment

Biostatistics play key role in assessment of environmental risks by identifying potential public health and ecological risks, and by providing scholars the foundation to analyze the environmental data (Molathoti et al., 2026). The application of biostatistical knowledge improves the ability to evaluate, interpret, and collect data linked to levels of pollutions, ecological hazards, resource consumption, waste disposal (Molathoti et al., 2026). By using different statistical analysis, organizations and individuals understand the patterns to environmental treats, make informed decisions, and assess exposure risks regarding environmental protection strategies. Scholars emphasized that biostatistical knowledge provide strength to environmental understanding by enabling analysis on the basis of data regarding environmental conditions (Burgos-Espinoza et al., 2025).

Environmental professionals and employees having strong biostatistical skills are better equipped to examine the effect of industrial activities, predict future risks, and monitor environmental changes. Studies highlighted that skills regarding data interpretation improves environmental risk identification and environmental awareness. Moreover, studies confirmed that expertise regarding biostatistics have positive effect on environmental risk assessment as it improves the accuracy regarding hazard evaluation. It also support evidence based environmental management decisions (Muthuswamy & Nijarubini, 2026).

Studies emphasized that statistics have significant effect on environmental research with the help of quantitative analysis of public health risks, ecological disturbances and pollution trends (Tomy et al., 2021). Scholars highlighted that different biostatistical methods like multivariate approaches, variance analysis, and regression models are used widely to support sustainable interventions and examine environmental degradation. Scholars demonstrated that statistical integration improves reliability and precision at significant level regarding assessment of trace metal pollution, allowing scholars to assess contaminated patterns and environmental consequences more effectively (Ogwu et al., 2025). Statistical synthesis including critical interpretative approaches, systematic reviews and others is important to understand ecological risks and evaluate environmental interventions. As a result of this methodological advancements, the validity regarding environmental policy recommendations is strengthened by supporting providing support to comprehensive investigations regarding environmental governance systems (Senerth et al., 2024).

Studies demonstrated that biostatistics is important driver of assessment of environmental risks (Mendes et al., 2024). It improves the accuracy of regarding environmental hazard analysis, strengthen both public and professional environmental awareness, support predictive modelling, and improves interpretation of environmental exposure. Studies also revealed that biostatistics contributes for better governance of environment by empowering all stakeholders having data driven insights (Ejaz et al., 2025).

2.5 Governance and Environmental Risk Assessment

Governance plays key role in assessment of environmental risks by providing managerial, institutional, and regulatory framework that is important for controlling, evaluating, and identifying environmental risks (Bennett & Satterfield, 2018). It is ensured by effective governance that environmental concerns are integrated into operational decision-making processes, strategic planning, and organizational policies. By clear monitoring systems, accountability mechanisms, and regulations, governance helps the organizations to improve sustainable practices and minimize environmental damage (Handoyo, 2024). Past studies demonstrated that strong governance structures improve stakeholders' participation and transparency, that later enhances the effectiveness and reliability of environmental assessments. Coordination is also promoted by it among local communities, industries, and government agencies, enabling good management of ecological threats and environmental uncertainties (Anyanwu et al., 2025).

Furthermore, governance mechanism helps in compliance with standards regarding environment, encouraging organizations to use corrective and preventive measures against different environmental hazards (Zhu et al., 2022). Studies argued that organizations having effective governance system are likely to implement details risk assessments regarding environment because governance enhances long term environmental planning, policy enforcement, and resource allocation (Newman et al., 2024). Additionally, participatory governance provide strength to trust and communication among different stakeholders, that facilitates informed environmental decision making. Thus, governance is important factor to improve process of environmental risk assessment (Newig et al., 2023). It also helps in effective environment protection outcomes, organizational responsibility and environmental sustainability in different industries and sectors.

3. Methodology

The current study utilised a qualitative cross-sectional research design for the environmental risk assessment from bio-statistical interpretation and management perspectives. The researcher integrated semi-structured interviews and the

focus group discussion approach to acquire comprehensive insight regarding environmental governance, environmental hazards, exposure patterns, management practices and the assessment of environmental risk using a bio-statistical approach.

It was considered appropriate to use a qualitative research design because it enabled the researcher to get an in-depth understanding of participants' perceptions, experiences, institutional responses and sustainable environmental concerns within the context of the study.

Furthermore, the study adopted a framework of multi-stakeholder participation, ensuring the inclusion of environmental managers, scientific experts, affected members of the community and policy experts in the process of assessment.

The current study was conducted in environmentally sensitive settings, including industrial zones where environmental degradation, exposure to pollution, and issues of waste management or issues related to sustainability were evident. Study area selection was based on environmental pollutants exposure, environmental vulnerability, environmental management agencies, and relevant stakeholders' accessibility. Participants included biostatisticians, environmental scientists, industrial managers, and sustainability officers, residents, community leaders and stakeholders affected by environmental problems.

Purposive sampling technique was used for the selection of the participants having professional experience, relevant expertise, or direct exposure to environmental risk and respective management. To ensure the diversity in institutional, professional and community perspective, maximum variation sampling was applied additionally.

Inclusion of the participants were based on their direct involvement in environmental monitoring, environmental governance or in the initiatives of environmental sustainability, moreover, willing to voluntarily participate in the study. The individual who unwilling to provide informed consent and without relevant environmental involvement were excluded from the study. Data was collected through Semi-Structured Interviews and focus group discussions. This methodological triangulation enhanced the depth and the credibility of research findings. For exploration of institutional experiences, management responses, environmental concerns, role of biostatistical interpretation and collective perceptions in the decision making and monitoring of environment, focus group discussions were conducted.

For the meaningful interaction and ensure thematic consistency, participants were distributed into two distinct groups, stakeholder and specialist groups. The group of specialists consisted of sustainability officers, biostatisticians, environmental scientists, health professionals and academic researchers.

These groups examined scientific predictive management strategies, environmental exposure statistical trends, environmental risk dimensions, environmental hazards disease prevalence. The group of stakeholders included local residents, community members, NGO representatives, industrial workers, local government representatives, and small business owners, having strong understanding about the challenges of environment effecting the community, perceived social and health impacts, management authorities' effectiveness and give policy recommendation for the improvement of sustainable practices and environmental governance.

Each focus group consisted of 10 participants for effective facilitation and thematic saturation. Discussion was conducted in accessible and neutral location under the leadership of trained moderator using discussion guide developed according to relevant literature and the objective of study. Before the start of the discussion, procedure of study and the objective were explained to the participants and obtained the informed consent.

Discussion sessions lasted for sixty-five to eighty minutes and was recorded with permission of participants. Notes were taken to capture, group dynamics, non-verbal responses and contextual observation. Moderator done an excellent job by maintaining neutrality and ensuring balanced participation throughout the discussion and led the participants towards the ultimate issues related to environmental risk assessment and management. The moderator ensured balanced participation, maintained neutrality throughout the discussions, and guided participants toward issues directly relevant to environmental risk assessment and management.

Furthermore, researcher conducted semi-structured interviews from the informants possessing technical expertise, administrative authority, environmental management policy involvement. Participants were industrial safety officers, municipal administrators, public health administrators, environmental monitoring officers, NGO directors, researchers, biostatisticians, researchers and sustainability coordinators.

An interview guide was used for conducting the interviews. Interview guides contain open ended questions for the exploration of institutional preparedness, environmental monitoring systems, challenges associated with environmental sustainability, risk management practices, statistical interpretation of environmental data and policy implementation.

Through virtual communication platform, face to face interviews were conducted depending upon the accessibility, availability of the participants. Each interview lasted for 20 to 30 minutes and with the consent of participants interviews were audio recorded. Verbatim transcription was done soon after the completion of interviews to ensure completeness and data accuracy.

For the analysis of qualitative data thematic analysis was done. Audio recording from Semi structured interviews and focus group discussions were transcribed and reviewed repeatedly to achieve authentic reliable data. From recurring

perceptions, experiences and concepts about the environmental risks and management, initial codes were generated.

Similar codes were grouped into boarder themes and sub themes, that represent the key dimensions of environmental governance, environmental risk assessment, management effectiveness, exposure patterns and sustainability concerns. By the comparison of findings across stakeholder groups, specialist groups, and interview participants, data triangulation was performed, to increase the reliability and validity of findings.

With the qualitative interpretation complimentary biostatistical analysis was conducted to enhance the understanding about exposure trends and environmental risk indicators. Descriptive technique of statistics including percentages and frequency distribution was used to quantify the patterns of environmental exposure and findings related with management strategies. Ingratiation of biostatistical interpretation with qualitative insight led to comprehensive identification of exposure severity, environmental hazard, sustainability challenges and management effectiveness indicators within the study setting.

To ensure the trustworthiness and methodological rigor, various strategies of quality assurance were implemented. These included peer review of coding, methodological triangulation, member checking, maintenance of field notes and thematic interpretation, and audit trails. Furthermore, to enhance transferability and credibility of findings detailed contextual descriptions were used. Ethical principles governing environmental and social research were observed throughout the process of study. Anonymity and confidentiality of participants' information was maintained. Informed consent was obtained from the participation of the study before data collection. Collected data was solely used for research and academic purpose.

4. Data Analysis

Total 100 respondents participated in the research process, including experts of public health, representatives of NGOs, municipal authorities, and stakeholders of community.

4.1 Descriptive Analysis

Using percentages, standard deviation, frequency distribution, mean values, researcher conducted the descriptive analysis for the summarization of risk perception of the environment and participants' characteristics.

For the identification of participants, exposure patterns, report about management related observations, environmental concerns descriptive analysis was performed.

4.1.1 Demographic Characteristics

The demographic findings indicated that most of the participants were of the age between 30 to 40 years, that is 35%. While the largest participating groups were community stakeholders and environmental specialists. 20% were the environmental specialist 15% were management officials 11.7% were health experts, 13.3% were NGO representatives, 26.7% were community stakeholders, while 13.3% were government officials. 60% were male respondents and 40% were female respondents. 24.2% respondents had less than 4 years of experience, 38.3% had 4 to 10 years of experience, and 37.5% respondents had more than 10 years practical experience in their relevant field.

4.1.2 Environment Risk Perception

Risks identified by the participants were air pollution 76.7%, water contamination 70%, improper waste disposal 65%. Industrial emission 61.7%. Noise pollution 46.7%, soil degradation 40.8%, chemical exposure 56.7%, and public health hazards 67.5%. Thus, the water contamination and air pollution were perceived as the most significant environmental risk in the context of current study. Moreover, it was also highlighted by the respondents that industrial emission and waste disposal significantly contribute towards public health issues and degradation of environment.

4.1.3 Perception about the Effectiveness of Environmental Risk Management Systems

Respondents were asked to evaluate the effectiveness of monitoring systems and risk management strategies. In the opinion of 35% participants, the policies are ineffective, 33% slightly effective, 23% moderately effective and 9% highly effective. Therefore, findings revealed significant dissatisfaction with respect to governance mechanisms, monitoring systems and policy complementation.

4.1.4 Environmental Sustainability Awareness

When the participants were asked about their awareness regarding environmental sustainability, 30% had a high level of awareness, 42% had a moderate level of awareness and 27% had a low level of awareness. Thus, finding indicates that most of the participants had moderate level of awareness about environmental sustainability. Furthermore, a significant proportion demonstrates a low level of environment sustainability awareness. This indicates the requirement of public awareness initiatives and environment education.

4.2 Environmental Exposure: Biostatistical Interpretation

Increasing trends of environmental exposure was evident in the biostatistical descriptive Interpretation. These indicators include respiratory illness, health complaints related to pollution, chemical exposure risk, waterborne diseases. Five points Likert scale was used for the record of response 1: Very low to 5: Very High

Air pollution exposure has a mean 4.13 and standard deviation 0.84, Water contamination exposure has a mean value 3.95 and a standard deviation of 0.77, waste related average 3.89 and standard deviation 0.90. Chemical risk exposure average 3.72 and standard deviation 0.70, noise pollution average 3.26 and standard deviation 0.73. Thus, results indicate a relatively high level of exposure to air pollution and water contamination. This indicates the elevation of public health and environmental vulnerability within the area of study.

5. Thematic Analysis

From the interviews and the focus group discussion, the researcher obtained qualitative data and analyzed it with the help of thematic analysis. This analysis enabled the researcher to identify the repeated patterns, experiences, perceptions and environmental and risk concerns. It involved, transcription recording, data familiarization, coding, codes categorization, development of themes and thematic relationship interpretation

5.1 Codes and Themes Development

Researcher generated five major themes, sub-themes and codes from the thematic analysis.

5.1.1 Theme#1: Environmental Pollution and Increasing Exposure Risk

Participants emphasized the growth and intensity of environmental pollution, its effect on ecological sustainability, and the health of the public.

Related Codes:

EP1: Contaminated sources of water

EP2: Leakage of chemical

EP3: Impure drinking water

EP4: Smoke emissions of industries

EP5: Weak conditions of sanitation

EP6: Growth of respiratory diseases

EP7: Solid waste Accumulation

Statements of Participant:

“In residential areas, industrial emissions significantly affected the quality of air.”

“For community health, contaminated water has become an intense issue”

5.1.2 Theme # 2: Poor Governance of Environment and Implementation of Policy

It was highlighted by the participants that the monitoring system of the environment is very weak, insufficient regulation enforcement, and limited accountability of institutions.

Related codes:

EG1: limited environmental inspections

EG2: Negligence of Institutional governance

EG3: Poor regulatory enforcement

EG4: Weak policies of waste management

EG5: Policy implementation delay

EG6: Administrative and Corruption barriers

EG7: Lack of monitoring systems

Participants' Statements:

“Laws related to Environmental sustainability exist, unfortunately weak implementation plan.”

“Monitoring of industrial waste disposal is insufficient.”

5.1.3 Theme#3: Environmental Risk and Significance of Biostatistical Monitoring

Specialists highlighted the significant role of bio-statistical tools for the identification of exposure, trends and disease associated with the environment

Related codes:

BS1: Trend analysis
 BS2: Data monitoring
 BS3: Statistical assessment of environmental exposure
 BS4: Risk forecasting models
 BS5: Pattern identification of disease
 BS6: Quantifying indicators of the environment
 BS7: Decision-making based on data
 Statements of Participant:
 "Environmental monitoring should rely more on scientific data analysis."
 "Environmental monitoring system must be based on scientific data"

5.1.4 Theme 4: Community Vulnerability and Public Health

Participants of the community emphasized the social, psychological, and physical impacts of environmental degradation on public well-being and daily life

Related codes:
 Associated Codes:
 CV1: Skin diseases
 CV2: Problems of Respiration
 CV3: Waterborne infections
 CV4: quality of life reduction
 CV5: Vulnerable populations
 CV6: Mental stress
 CV7: Occupational exposure risks
 Statements of Participant:
 "The most affected segment of the population due to environmental pollution is elderly individuals and children."
 "Residents of industrial zones or nearby experience more health problems."

5.1.5 Theme 5: Dire Need for Sustainable Environmental Management Strategies

Participants highlighted the need for stronger campaigns of public awareness, environmental governance, and sustainable management practices for the reduction of environmental risk.

Related Codes:
 EMS1: Awareness programs for the public
 EMS2: Environmental education
 EMS3: Public participation
 EMS4: Green environmental policies
 EMS5: Preventive monitoring systems
 EMS6: Sustainable waste management system
 EMS7: Inter-agency collaboration
 Statements of Participant:
 "For environmental sustainability, public awareness is mandatory."
 "Public and community integration is essential for effective environmental management."

Table 1: Thematic Analysis Coding Framework

Themes	Subthemes	Codes
Polluted Environment	Sources of Pollution	Toxic chemicals, accumulation of waste, and emission of smoke
Poor Governance	Failure of Policy	Weak monitoring, Poor enforcement, and action delay
Significance of Biostatistics	Interpretation of data	Exposure prevalence, Trend analysis, and risk indicators
Poor Health of the Public	Impacts on health	Respiration problem, stress, and infections
Sustainable Management Practices	Strategies to prevent	Sustainable planning, awareness, and participation of the community and government

6. Integrating Qualitative and Quantitative Findings

Integrating the thematic analysis and descriptive statistics, the researcher found that practical experience and

statistical trends converge. Quantitative analysis revealed high level of perception about the existence of environmental risk and discontentment about the management system. On the other hand, qualitative results demonstrate underlying social, institutional, and managerial elements contributing to environmental hazard.

Furthermore, the qualitative observations were supported by biostatistical interpretation by identification of increased exposure patterns related to contamination, pollution, and risk of environmental health. Overall, results highlighted the urgent requirement of data-driven environmental governance, and an integrated monitoring system to overcome the challenges of environmental protection effectively and efficiently.

7. Discussion

This study explores role of biostatistics and other factors in environmental risk assessment by using qualitative methodology. Results of the study revealed that increase in the environmental pollution is one of the serious concern for public health and environmental sustainability (Giovagnoni et al., 2025). Respondents mentioned that poor sanitation, chemical leakages, contaminated water sources, and smoke emissions are continuously increasing environmental risks withing different communities. Results indicate that environmental degradation is not only damaging the ecology, infact it plays key role in creating waterborne diseases, different respiratory illnesses, and other severe health challenges. The availability of impure drinking water accumulation of solid waste increase vulnerability to environmental hazards and worsen living conditions.

Respondents are of the opinion that ineffective environmental governance, weak waste management systems, and uncontrolled industrialization increase environmental exposure and pollution risk. Contaminated water sources and industrial emissions negatively impact community health and reduce environmental quality. Likewise, chemical pollutants and poor sanitation infrastructure are important contributor to chronic health problems and respiratory diseases. These results also support that environmental sustainability in absence of ensuring safe waste disposal practices, improving sanitation systems, and controlling pollution sources. So, sustainable strategies to control pollution, strict industrial regulation, and effective environmental monitoring are important to reduce public health risks and maintaining ecological balance.

Study findings also demonstrated that weakness in governance structure is one of the cause of environmental weaknesses. As per the views of respondents, pollution is one of the major threats to environmental sustainability. Other factors that impact environmental sustainability is inability of controlling environmental harmful activities, and inability of responsible institutions to properly regulate and monitor environmental activities. Respondents noted that practices related to industrial waste are not properly monitored, whereas environmental inspections remain irregular and limited. Findings further indicated that delay in implications of policies in combination with administrative corruption and barriers, reduce effectiveness and credibility of environmental governance systems.

These observations of respondents are also supported by previous studies which focused on weak governance and its negative influence on environmental protection efforts (Zhu et al., 2022). Weak enforcement capacity, lack of accountability, and poor institutional coordination create serious issues in environmental policies. It is also argued that environmental regulations are considered as ineffective when monitoring systems are not adequate and different regulatory bodies are not able to conduct regular inspections. Additionally, bureaucratic inefficiencies and corruption is identified as important factor that weaken waste management practices and discourage compliance with environmental standards. Thus, results suggest that ensuring strict policy enforcement, enhancing institutional transparency, and strengthening governance quality are important to minimize ecological risks.

Results of the study further reflects that biostatistical monitoring is important to understand environmental risks and for the protection of public health. Study participants revealed that environmental assessment should be based on statistical and scientific approaches for accurate evaluation and monitoring rather than relying on observational practices. Results further illustrate that different biostatistical tools help in identification to forecast potential environmental risks, assess the level of environmental risks, and identify disease patterns through evidence-based analysis. Continuous monitoring of data and trend analysis are important to detect alteration in environmental conditions and measuring the impact of these alterations on ecological systems and human health.

These results are consistent with literature focusing the importance of data based environmental management systems. Past studies mentioned that biostatistical techniques helps in improving precision regarding environmental risk assessment by enabling policy makers and researchers to identify emerging threats, and quantify environmental indicators (Muthuswamy & Nijarubini, 2026). Results of the study further noted that different forecasting models provide support to timely decision making and assist organizations to develop preventive environmental strategies. Additionally, scientific monitoring systems strengthen effectiveness of environmental interventions and provide reliable evidence for policy formulation. Thus, the study shed light on the integration of biostatistical monitoring to enhance risk prediction, support

sustainable decision-making, and improve environmental surveillance.

The respondents further mentioned that overall well-being of communities is adversely affected by environmental degradation. They stressed that people who are living in industrial zones are mostly affected by environmental degradation. Results revealed that unhealthy environmental conditions, contaminated water, and polluted air are increasing different type of physical illnesses including waterborne infections, skin diseases, and respiratory complications. Other than physical illnesses, respondents further associated environmental problems with declining quality of life, fear regarding health safety, and mental stress. Results further revealed that the effect of environmental risks is different on different age group people. Workers, children, and elderly individuals who are exposed to different industrial activities are most vulnerable groups within their communities.

These results corresponds with past studies that mentioned environmental degradation as major contributors to vulnerability of public health (Anyanwu et al., 2025). Results also demonstrated that continuous exposure to polluted environment has negative effect on health and cause several disorders like infectious illnesses, skin related diseases, and respiratory disorders. Different environmental hazards affect vulnerable population because of prolonged exposure to hazardous conditions, limited healthcare access, and weaker physical resistance. Furthermore, environmental insecurities have negative effect on the well-being by reducing life satisfaction, creating uncertainty, and stress.

Findings further showed that there is urgent need of sustainable and long-term environment management strategies. Participants of the study are opined that environmental risks cannot be controlled only through regulation unless communities are engaged and educated regarding environmental protection activities. Environmental education and public awareness campaigns are considered as important tool to change the behavior of public and to promote environmental friendly practices. Respondents also stressed that there is need of collaborative efforts among environmental institutions, communities, and government agencies to establish sustainable waste management mechanisms.

Results further indicate that sustainable environmental management need an integrated approach where environmental responsibility, public participation, and governance operate collectively. Past studies argues similarly that environmental sustainability becomes achievable when communities are actively involved and informed regarding the processes of environmental decision making (Newman et al., 2024). Results further suggested that awareness initiatives encourage behavior that is environmentally friendly. It also improves compliance with policies for sustainability. Additionally, policy effectiveness is further enhanced through inter-agency coordination by implementation efficiency, resource management, and information sharing. Sustainable waste management and preventive monitoring systems practices have been recognized as important strategy to maintain ecological balance, and reduce environmental degradation.

8. Limitations and Recommendations

This section points out few limitations and recommendations of the study. This study adopted qualitative research methodology for the purpose of analysis. It is suggested that future studies may use quantitative research methodology in future. Moreover, the main focus of the study was on role of biostatistics to and assess risk assessment. It is suggested that future studies may use other factors like role of green management and supply chains to improve environmental sustainability. Furthermore, present study used purposive sampling technique to collect data from the respondents. It is proposed to use stratified random sampling in future for more structured data collection procedure. Additionally, themes were developed and descriptive statistics were used for the analysis of collected data. It is proposed that studies in future may use other qualitative techniques like observation method to gather response of participants.

9. Theoretical and Managerial Contribution

This research contributes theoretically to the literature of environmental sustainability by explaining the way environmental pollution, biostatistical monitoring, public vulnerability, and weak governance influence environmental risk management. The research further extends qualitative understanding of environmental exposure by integrating data driven environmental assessment, health vulnerability, and governance within a single framework. The results also enrich literature of environmental management by highlighting important of sustainability monitoring practices and community participation. In terms of managerial contribution, results provide practical guidance for local administration, environmental agencies, and policymakers to strengthen environmental monitoring systems, promoting public awareness programs and improve regulatory enforcement. These results can be used by researchers and scholars for their future research.

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