

Holistic Nature of Occupational Health, Safety, and Environment towards Disaster Risk Management in Pakistan with Moderation Effect of Green Management

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Abstract

Environmental green practice supports the world convergence through reducing ecological hazards. Occupational health focuses on protecting and enhancing the physical, mental, as well as social well-being of workers in various sectors. The integration of occupational health, safety, and environment practices with disaster risk management at a holistic level is important in the reduction of risks and for sustainable development, particularly in disaster-vulnerable countries such as Pakistan. This study is oriented to examine the expected effect of Occupational Health, Safety, and Environment towards Disasters Risk Management in Pakistan with Moderation Effect Green Management. The cross-section data for the period of 2001-2024 related to green management, Environment, health and safety, has been collected from official reports & databases, and reports of National Disaster Management Authority, Pakistan Environmental Protection Agency, Occupational Safety & Health Administration, International Labor Organization, United Nations Environment Program, World Health Organization, State Bank of Pakistan, and United Nations Development Program. After checking the different diagnostics tests, calculating the descriptive statistics, and deliberating the Cross Section Pearson's correlation, it was ensured the long-term effect of green management, Environment, health and safety through different Techniques including the ARDL Bound Test and VECM in the E-Views. The empirically calculated findings declare that Noise & Air Quality, Workplace Culture, Biological & Physical Hazards, Climatic Green and Environmental Projects, and Casualty Level, affect insignificantly towards disaster Risk Management while rest of the factors affect significantly on the disaster Risk Management, which leads to meet the maximum objectives of this study. The significant results proclaim the empirical allegiance of all the study factors towards disaster risk management. The insignificant findings instigate the policy makers to reappraise the green considerations and flaws in promoting the green innovations must be controlled by some concrete green policies and green investment awareness programs. By and large, the lenient low green management cost can boost the green projects in the long run to protect the environment, solve the health issues and safety aspects overall.

Keywords: Green management, Disaster Risk Management, Ecological Hazards, ARDL Bound Test, Cross Section, VECM, Empirical Allegiance, Diagnostic Tests, Green Innovations and Policy Makers.

Introduction

The integration of occupational health, safety, and environment [HSE] practices with the effect of disaster risk management [DRM] at a holistic level is important in the reduction of risks and for sustainable development, particularly in disaster-vulnerable countries such as Pakistan (Adewumi et al., 2024; Javed et al., 2020; Khan et al., 2021). An integrated approach not only deals with the short-term effects of disasters but is also concerned with long-term sustainability and resilience (Shahbaz et al., 2020). Environmental practice, which is also green management, supports this convergence through reducing ecological hazards and enhancing sustainable approaches (Aggarwal & Aggarwal, 2023). Occupational health focuses on protecting and enhancing the physical, mental, as well as social well-being of workers in various sectors (Qudrat, 2023). The

long-term exposure to noise can lead to hearing impairment, tinnitus, and irritability, sleep disorders, and impaired cognitive function (Awais, Thaker, Raza, Usman, Mohsin, & Bhatti, 2021; Botah, 2023). Similarly, indoor air pollution due to particulates like dust, chemicals, and poisonous vapors can lead to respiratory diseases like asthma and chronic bronchitis, and cardiovascular diseases in the long run (Khalid, 2020). Fear of losing a job can lead to excessive stress, anxiety, depression, and decreased job satisfaction (Aslam, 2023). The above problems can be addressed by the employers through proper communication, allocation of counselling activities, skill development programs, and incorporation of fair performance appraisal policies which are structured by the policy makers (Abbas & Guo, 2023).

Background of the Study

Chronic exposure to high-level noise has been linked with high blood pressure and cardiovascular disease (Yıldız & TOMBAL-kARA, 2024). Similarly, indoor air pollution due to particulates like dust, chemicals, and poisonous vapors can lead to respiratory diseases like asthma and chronic bronchitis, and cardiovascular diseases in the long run (Khalid, 2020).

The work environment is one of the main determinants of employees' health, well-being, and performance. A good work environment not only boosts morale but also reduces risk from all forms of workplace hazards. The environment includes the physical work area design and the organizational culture, which influences the perception of employees regarding their safety and well-being. Workplace culture influences the attitudes of employees towards health and safety to a large degree. A culture of respect, communication, and safety among employees gives a sense of responsibility to employees, and accidents are less likely to occur. According to some research, organizations that maintain open communication and employees' feedback on safety concerns experience fewer accidents (Khan, Awais, Khan, & Khan, 2017; Qamar, 2021). Physical risks, for instance, excessive heat or cold, noise, and unsafe machinery, lead to accidents and injuries (Botah, 2023). Biological hazards, including exposure to infectious agents, mold, and allergens, have the potential to result in illness and lasting effects on health (Khalid, 2020). Lack of protection and inadequate safety training have been determined by some of the studies to increase exposure to these hazards and make it crucial to have effective hazard management practices (Ahmad, 2021).

Green management is about putting in place environmentally friendly practices and sustainable measures to reduce the adverse environmental effects of business operations. It brings environmental concerns into organizational policies, decision-making, and daily activities with a view to waste reduction, resource conservation, and fostering sustainability. Green management has now been regarded as a strategic process that is not only advantageous to the environment but also boosts organizational image, reduces costs, and satisfies environmental regulation (Haji et al., 2022). Green projects mostly deal with renewable energy like solar, wind, and hydropower in a bid to reduce their consumption of fossil fuels (Naeem, 2020). Bashir (2020) illustrates how green bonds make it easy to finance green projects, reduce greenhouse gas emissions, and thereby encourage sustainable energy infrastructure (Khan, 2021). Following research and businesses that install renewable energy systems reduce energy costs and greenhouse gas emissions and align themselves with the global efforts of sustainability (Genovese et al., 2024). Moreover, green infrastructure investments such as energy-efficient buildings and ecologically friendly transport establish a greener business model (Antonopoulos, 2022). Climatic green and environmental approaches are another imperative element of green management. These initiatives are for climate change mitigation and biodiversity preservation by means of reforestation, pollution prevention, and water-saving programs (Suriyankietkaew et al., 2022). Khan et al. (2023) highlights that ESG factors are necessary for the promotion of investments in climate change and environmental sustainability programs (Liu et al., 2023). Some studies indicate that the companies which are engaged in climate projects not only reduce their ecological footprint but also gain higher market reputation as they draw green consumers (Rafiq, 2021). Adopting green management strategies and giving due importance to environmental and renewable programs make companies responsive to environmental change while contributing constructively to worldwide sustainability (Aggarwal & Aggarwal, 2023). Not only do these activities reduce environmental impact of industries, but also instill responsibility and sustainability, with long-term benefits to the environment and the companies which are engaged in health and safety projects (Naushad et al., 2024).

Disaster risk management [DRM] is a broad process that aims to find, investigate, and reduce the risk of natural and anthropogenic hazards. It includes planning and preparation, response, and recovery from disaster in a way that mitigates their effect on life, property, and the environment. Effective DRM weaves together practices of risk assessment, early warning, emergency response, and resilience-building among communities so as to avoid vulnerabilities and be better prepared (Malik, 2021). Economic consequence which disasters can bestow is among the major drivers of disaster risk management. These are quantified as damage to infrastructure, loss of livelihood, and cost of rehabilitation and reconstruction (Onukwulu et al., 2022). Rauf et al. (2021) describe how extreme storm surges result in extreme economic loss, saline inundation, and destruction of infrastructure, and how effective risk assessment must be conducted in order to reduce economic losses. Casualty rates are also the top priority for disaster risk management. Earthquakes, floods, and cyclones tend to result in a high number of deaths due to lack of preparedness and inadequate response measures. They can be avoided by regulating these factors by proper planning, early evacuation, and efficient emergency response (Shahbaz, 2020). Displacement is a grave effect of disasters that makes people leave their homes and livelihood sources. Displacement tends to lead to long-term socio-economic issues, such as loss of earnings, lack of shelter, and decreased access to basic services. Khan et al. (2021) study shows the role of storm surges towards displacement of people and further cementing the importance of integrated disaster risk management interventions that can decrease the impacts of disaster issues in health, safety & environment by adopting green technology (Khan et al., 2023).

Health, Safety, & Environmental [HSE] Issues in Pakistan, USA, & China

Across numerous industries in Pakistan, health, safety and environment [HSE] related issues remain a significant concern. Some health factors that impact worker wellbeing are air quality from industrial emissions and noise pollution from construction sites (Rafiq, 2021). There are gaps in productivity because working is not permitted when air pollution is above international standards. There is also the issue of job security where many employees work in the informal economy with no formal contracts or benefits (Liu et al., 2023). A lot of industries have poor Safety Conditions which is characterized with minimal use of Personal Protective Equipment [PPE] and lack of safety trainings (Aslam et al., 2023). The use of unsafe machinery, old equipment, and carelessly managing dangerous materials increases the likelihood of injuries (Arshad, 2021). Environmental issues include poor workplace culture where employees disregard simple safety standards, hygiene hazards such as dirty restrooms, and physical hazards such as exposed electrical wires, inadequate emergency exits, or too many people in one area (Naushad et al., 2024). These concerns are made worse with the absence of stringent implementation of labor law (Baig, 2021).

In the USA there is still HSE concerns, even with stricter regulations like the Occupational Safety and Health Administration [OSHA]. The air quality and noise pollution from industrial areas, particularly around manufacturing factories and urban cities, is a health hazard to workers (Qudrat-Ullah, 2023). While there is more job security compared to developing nations during the economic recessions and the rise of automation also creates a sense of uncertainty (Sheena et al., 2022). Although safety measures are well governed, there is negligence in some industries like construction, mining, and agriculture leading to accidents and injuries (Kamra, 2024). Compliance to worker safety regulations is often neglected by small businesses that don't have the financial resources to meet mandated compliance costs (Gatti et al., 2023; Zeb, Sher, Awais, & Syed, 2017). Issues regarding the environment include unhealthy workplace culture like discrimination, harassment, and undue stress at work (Costa et al., 2022). There are biological threats as well which include exposure to mold and physical threats from machinery predominately in the healthcare and construction sectors (Suriyankietkaew et al., 2022).

In China, the rapid pace of industrialization poses numerous HSE problems. Workers' health is badly affected by high levels of air and noise pollution in these regions due to manufacturing activities, resulting in chronic respiratory and stress-related issues (Nasir & Saeed, 2020). Working conditions are most often precarious, especially in factories on short term contracts, which makes workers fearful of losing their jobs (Zaidi et al., 2021). There are notable differences in safety provisions as larger state-owned enterprises tend to employ better safety practices than private or informal enterprises (Antonopoulos, 2022). There is generally a lack of safety equipment and frequent accidents occur because of poor safety training and obsolete machinery. The

organizational culture in most of these places is highly centralized, which discourages employees from raising concerns regarding safety issues (Imran et al., 2020). Workers' safety is further threatened due to exposure towards biological and physical hazards like harmful chemicals and unsafe structural conditions. The lack of robust enforcement of legislations on labor put together with the absence of a strong safety culture that ultimately exacerbates the problems of health and safety (Awan, 2022).

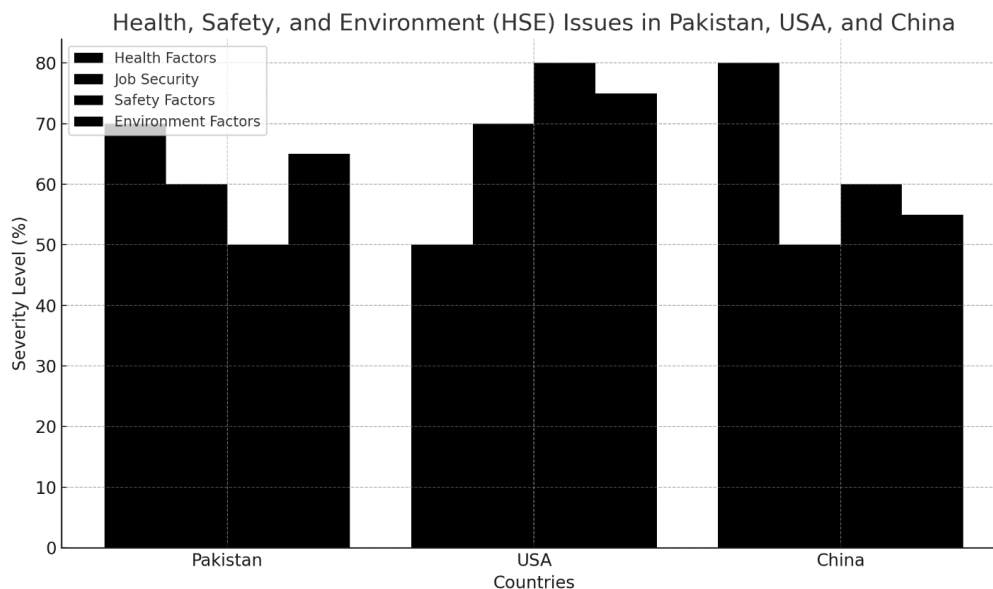


Figure 1. Severity Level of Pakistan, USA & China as regards Health, Safety and Environment

In figure.1 the graph illustrating the severity levels of health, safety, and environment [HSE] issues in Pakistan, the USA, and China. It compares the impact of health factors [noise and air quality], job security threats, safety factors [work atmosphere and equipment], and environmental factors [workplace culture, biological, and physical hazards] across these countries.

To readers and researchers, Health, Safety and Environment (HSE) issues of the Pakistan, USA and China are included and elaborated ultimately so that policy makers better understand how the economies of these countries are correlated. Pakistan duly signs the agreements with China and USA as regards Health, Safety and Environment projects with the simultaneously inclusion of the green technology and green financing. Additionally, issues of Health, Safety and Environment in USA and China have direct impacts on Pakistan and countries that are doing the HSE contracts with these two giant economies. Therefore, a slight change as regards Health, Safety and Environment for the green projects in USA and China can intervene and invert the economies like Pakistan. To conclude, the HSE issues in China have direct impacts on Pakistan being the neighboring trading partner & for USA being the old green technology facilitator to Pakistan.

Disaster Risk Management issues & Green Management effects in Pakistan USA, & China

Pakistan is facing considerable problems if we focus on disaster management issues due to the vulnerabilities of earthquakes, floods, droughts, and climate change. The decentralization of Pakistan's DRM efforts is captured by the NDMA's (National Disaster Management Authority) coordinating role, which has support from Provincial Disaster Management Authorities (PDMAs). Lack of resources, poor infrastructure, and feeble policy implementation are some of the barriers to effective disaster response (Yu et al., 2022). In the study "Known and unknown environmental impacts related to climate changes in Pakistan" (Adnan et al, 2024) argues that sustainable eco-friendly practices like agricultural management, reforestation, and green building aim to lower disaster risks while improving the environment (Zafar, 2019). Management of green practices is under way in collaboration with entities like the UNDP and World Bank, but there are not enough awareness and participation from the public which adds to the problems (Peterson, 2024).

China's simultaneous industrial and urban expansion has evolved multilayered risks including urban flooding, air pollution, and degradation of the environment. Although the central government has achieved some success

in building a disaster management system, there are still some issues because of the centralized nature of power and low levels of community involvement (Zaidi et al., 2021). A global look at multi-hazard risk analysis put forward China's active attempts to embed green management approaches such as investment in green technologies, development of renewable sources of energy, and ecological restoration (Bathan, 2023). All these steps are directed towards reducing the negative impacts of the environment and mitigating the risks of disasters. Still, industrial development and environmental protection in China are two contradictions that are difficult to reconcile. Aside from working with the government, UNDRR works on projects such as the Sponge City Initiative directed towards combating urban flooding, but there are still problems with bureaucracy and a lack of willingness from the lower levels of government (Waheed et al., 2023).

The USA possesses a well-developed disaster management system headed by organizations such as FEMA [Federal Emergency Management Agency]. Despite possessing all the hi-tech machinery and gadgets, rising hurricane frequency and intensity, wildfires, and flooding caused by global warming become a serious issue (Nasir and Saeed, 2020). The nation has integrated green management into DRM policies through environmentally friendly urban development, renewable energy plans, and strict environmental laws. Awan et al. (2022) discuss the importance of green management in the realization of the equilibrium of disaster preparedness and environmental protection (Aslam et al., 2023). There are, however, contradictory opinions regarding the balance between economic growth and sustainability, particularly in regions of high industrialization. Green building codes such as LEED and efforts towards sustainable infrastructure have been observed to yield successful outcomes in the affected regions (Abbas and Guo, 2023).

Disaster Risk Management Challenges and Green Management Effects in Pakistan, USA, and China

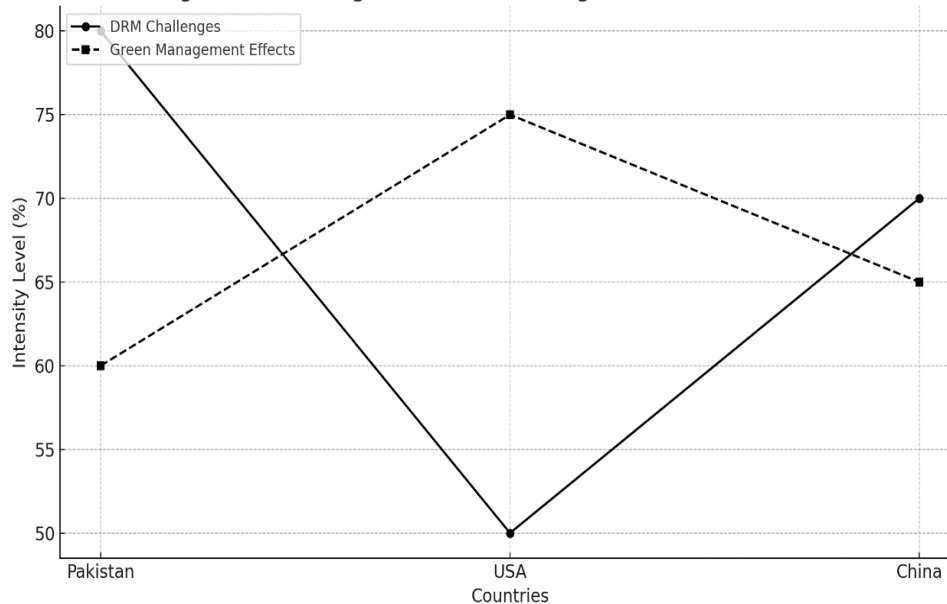


Figure 2. Intensity Level of Pak, USA, & China as regards Disaster DRM Challenges & Green Management Effects.

In figure.2 a line plot comparing disaster risk management [DRM] challenges and green management effects in Pakistan, USA, and China. The markers and line styles help distinguish the two aspects clearly for the better understanding of the researchers.

Problem Statement & Objectives of the Study

Health of employees is the key source to foster the performance of the organizations. Employees are the major stakeholders who can directly or indirectly boost the revenues on which long term survival of the companies is dependent on. Environmental Practices can also reduce the hazards of the embedded pollution and other asbestos polluted materials which can reduce the efficiency of the employees ultimately the firms. Job retraining and firing threat can also reverse the environment affecting the overall performance level. Safety practices inside the organizations play a pivot role to reduce and finally eliminate the risk of disasters, injuries and on job deaths of pertinent employees. The management of the risk of disasters at workplace culture is also

crucial to exacerbate the physical appearance of the employees at job places. Green Management practices are involved in the cases of occupational health, safety, culture & environment of every organization. The scope of the green management exercises, is broader & green technology is contributing to manage the risk of employees, disasters and environmental distraction in one or any other shape. Disasters and green policies are structured to address different issues of employees and the firms' management to mitigate the threat of risk. To conclude, the addressing of these stated issues, is the burning debate of the day. Keeping these dilemmas in the minds of the researchers, this study aims to address the holistic nature of the issues for health of the employees at job places. Further, this study is also inclined to expose the safety causes & measures for the workers. Besides, this study also instigates the readers' attention towards environmental scanning to manage the risk of disasters. Additionally, this study is objected how to adopt the current green management measures to moderate the relationship among health, safety & environmental practices. Above all, the core objective of this study is to expose all these burning issues to determine how the risk of disasters can be measured and managed with the effective application of green technology & green horizons finally to address the health, safety & environmental predictors.

Literature Review

This portion of the study adds to the body of knowledge of the holistic aspect of Occupational Health, Safety, and Environment [OHSE] concerning Disaster Risk Management [DRM] within the context of Pakistan, specifically the moderating effect of green management. To grasp the relationship between OHSE, DRM, and sustainable approaches, an extensive evaluation of the theoretical and empirical strides of prior researchers was undertaken. Due to the multitude of natural and anthropogenic disasters, industrialization, and environmental degradation, the systematic approach on comprehensive OHSE framework has received much attention in Pakistan in the last two decades. It indicates that the combination of OHSE with DRM not only increases safety and health within the workplace but also boosts the organizational resilience to disasters. National authorities such as the National Disaster Management Authority [NDMA] and global bodies like the United Nations Development Program [UNDP] and World Bank have vigorously endorsed green management initiatives aimed at the protection of the environment and minimizing disaster risks. In addition, green management is an important moderating variable who balances sustainability, occupational health and safety, and disaster-related risk.

Theoretical Background of the Study

Occupational Health, Safety, and Environment [OHSE] is a diverse field that targets the development of safe, healthy, and environmentally friendly working conditions and minimizing the environmental impacts. Theoretical foundations are the source of understanding OHSE determinants like health, job security, safety, and environmental determinants. Determinants of health including noise and quality of air heavily influence the physical and mental states of workers (Qudrat-Ullah, 2023). According to Safety Climate Theory, it focuses on the importance of an organization's safety culture in influencing the attitude and behavior of employees towards safety. A safety climate, according to this theory, is the common perception among employees that an organization prioritizes safety. Perceptions are constructed by the extent of management's commitment to safety, communication of safety policy, enforcement of safety standards, and provision of proper training and resources (Baig, 2021). Strong safety climate empowers workers to treat safe working procedures as topmost priority, report hazards, and be a productive contributor in shaping a safer workplace. This theory says that employees will observe safety procedures if they perceive serious safety commitment on the part of their management, which in turn ensures accidents and injury are avoided. While so, if safety perception is minimal and is a mere ritual process, personnel would ignore habitual safety, and mishaps would have a greater likelihood of occurring. Studies have come to discover that the extent of positive safety climate is bolstered by fewer accidents, decreased absence, and higher job satisfaction (Khan et al., 2021). Safety Climate Theory, therefore, offers an avenue that companies apply for monitoring and sustaining their safety culture, hence better OHSE results. Reason's Human Error Theory offers a comprehensive explanation of how human error causes workplace accidents and incidents. Reason labels errors as slips and lapses, mistakes, and violations. Slips and lapses result from inattention or failed memory, whereas mistakes are the result of insufficient knowledge or incorrect decision-making. Violations are deliberate deviations from standard safety

procedures, frequently caused by organizational culture or outside pressure (Bathan, 2023). A cornerstone of Reason's theory is the Swiss Cheese Model, wherein it explains how various layers of defense—i.e., safety policies, training courses, protective gear, and oversight—are all penetrated by "holes." When they align, the window remains open for the accidents to pass through. The model brings home the reality that the majority of workplace incidents hardly ever owe to the malfunction of a lone factor but are caused due to a buildup of organizational, environmental, and human factors (Yıldız et al., 2024). The Human Error Theory legitimates a systems approach to analyzing accidents instead of blaming people for errors. It prompts organizations to take into consideration the underlying factors such as insufficient training, communication breakdown, and insufficient safety protocols. Through these aspects, organizations can design safer working environments, minimize opportunities for errors, and limit workplace dangers (Aslam et al., 2023).

Green management is organizational policy that involves employing environmentally favorable procedures in routine organizational operations to reduce environmental imprints and attain business objectives and sustainability. Hart's Natural Resource-Based View [NRBV] and Spaargaren and Mol's Ecological Modernization Theory [EMT] are the theory bases for green management design. The NRBV broadens the conventional Resource-Based View [RBV] since it underscores the importance of environmental capabilities such as pollution avoidance, product stewardship, and sustainable development (Zaidi, 2021). Organizations utilizing such capabilities in an appropriate way are able to attain a competitive edge while mitigating environmental hazards. EMT, however, asserts that economic development and environmental preservation go hand in hand via means of innovation, technological advancement, and policy adjustment (Imran et al., 2020). It is concerned most particularly with the contribution of clean technologies, sound policy, and business accountability to the realization of ecological modernization. Whereas NRBV is concerned with developing internal environmental capabilities, EMT calls for structural transformation, with the interdependence of companies, government, and society in seeking sustainability (Ahmad et al., 2021). Both the theories collectively demonstrate how firms can apply green management in mitigating environmental damage and sustaining long-term success.

Disaster risk management [DRM] refers to practices and approaches designed to decrease the adverse effects of disasters through a reduction of economic loss, fatalities, and displacement of population. DRM is effective when it reduces the severity of natural and human-made hazards by a collective effort of preparation, response, and recovery. The Protection Motivation Theory of Rogers purports that people and organizations will be inclined to defend themselves if they realize that there is a high level of threat, know the severity of the threat, and are convinced that they can counter it (Awan et al., 2022). The theory is relevant in disaster preparedness since it provokes communities to undertake preventive measures that lower casualties and displacement. Protection Motivation Theory [PMT] centers on what individuals and societies do when exposed to perceived dangers and implement protecting measures. According to PMT, if the public perceives danger, then they judge it for severity [threat appraisal] and how exposed they are to it. They also determine preventive action efficacy as well as one's capacity for executing them i.e. coping appraisal (Khalid et al., 2020). When they perceive that preventive actions can work and fall within their competency, they have higher chances of adopting protective habits. In DRM, PMT clarifies how and why others are prepared while others are not, highlighting awareness campaigns, knowledge, and reachable resources. Successful risk communication that makes people and communities aware of the impact of not acting and offers pragmatic solutions is capable of encouraging people and communities to act proactively towards disaster preparedness. The Resilience Theory of Holling highlights the capacity of people, communities, and systems to withstand shocks, be resilient, and bounce back from disasters. Resilience is not merely getting back to where one was before the disaster but learning from the experience and improving one's capacity to cope with future crises (Haji et al., 2022). The three categories of resilience were named engineering resilience [rapid return], ecological resilience [ongoing basic function amid disturbance], and socio-ecological resilience [transformation and adaptation amid new conditions] by Holling's theory. Resilience Theory in DRM embraces proactive and facilitates active networking within communities through enhancement of social structures, long-term investment in green infrastructure, and participative governance at local levels (Bashir et al., 2020). Resilience Theory addresses focus changes from emergency management on the one hand to extended terms of adjustment and learning

continuously, with attention being on openness. Through resilience building, communities will lower their weaknesses and become better able to withstand future disasters (Peterson, 2024).

The Empirical Literature of the Study

Empirical studies on Occupational Health, Safety, and Environment [OHSE] have explored the severe influence of work environment variables on workers' health, safety, and well-being. Two of the key OHSE areas—variables such as health conditions in terms of noise and air, and job security hazards—have been extensively studied for their role in influencing the performance of employees as well as organizational performance (Naushad et al., 2024). Physical and psychological health problems can be brought about by environmental factors such as exposure to noise and poor-quality air (Onukwulu et al., 2022). Long-term exposure to high noise levels has been studied to cause hearing loss, elevated stress levels, lethargy, and deteriorated attention, eventually affecting job performance (Shahbaz, 2020). Likewise, poor-quality air brought about by exposure to dust, chemicals, and industrial pollutants can contribute to respiratory disorders, cardiovascular conditions, and chronic health problems (Zafar et al., 2019). Research has demonstrated that employees working in unsanitary conditions are more prone to absenteeism, reduced job satisfaction, and higher risks of contracting chronic health diseases (Rafiq et al., 2021). These are the indications of the necessity for organizations to have controls in place for noise, ventilation, and air quality monitoring to ensure the health of the employees (Qamar et al., 2021). Besides, job insecurity threats are also major sources of stress impacting employees' psychological well-being and job satisfaction (Khan et al., 2021). Empirical studies indicate that job insecurity increases anxiety, depression, motivation, and decreased organizational commitment (Liu et al., 2023). Workers facing the possibility of job loss suffer from excessive stress, low morale, and reduced productivity (Naushad et al., 2024). Job insecurity can also cause burnout because workers labor under the threat of unemployment (Rafiq et al., 2021). Studies have also shown that employment insecurity may prompt risky work practices as workers are unable to report hazardous work procedures or seek assistance fearing punishment (Ahmad et al., 2021). Preempting such cases with good OHSE practice, by conducting discussions around job safety and healthy work-orientated environment, can abate the menace on their well-being, relieve job insecurity, and instill culture of safety and health (Shahbaz et al., 2020). Like having employee wellness programs, offering counseling services, and following safety protocols can not only safeguard employees' health but also improve productivity, job satisfaction, and overall organizational performance (Zafar et al., 2019). Research has demonstrated that an open safety climate—open communication, effective safety policy, and helpful management—considerably decreases work-related accidents and injuries. Investigations have shown that workers who think that their work environment is safety-conscious are likely to report danger, adhere to safety procedures, and dissuade risky work practice (Onukwulu et al., 2022). Additionally, safety devices and equipment like PPE, machine guards, and available safety equipment being utilized optimally also prevent physical harm (Shahbaz et al., 2020). Empirical research highlights that in the lack of adequate safety training, malfunctioning equipment maintenance, and safety resources, there will be higher risk of accidents, injuries, and workplace hazards (Ahmad et al., 2021). Environmental conditions such as work culture and exposure to biological and physical dangers also have significant impacts on workplace safety and employees' well-being (Rafiq et al., 2021). Effective employee well-being workplace culture, sound communication, and giving priority to security building shapes a reassuring working culture, reduces stress levels, enhances workplace contentment, and gives the workforce a sense of belongingness with one's organization (Zafar et al., 2019). Nonetheless, an unfavorable work environment defined by inhumane management tactics, poor supervision, and lack of regard for safety guidelines can create hazardous behavior and other incidents (Shahbaz et al., 2020). Biological hazards like infection-causing agents, viruses, and bacteria have the potential to result in health hazards, especially in labs and healthcare facilities (Ahmad et al., 2021). Physical hazards like hot or cold temperatures, heavy machinery, and hazardous working environments heighten the chances of accidents and injuries (Rafiq et al., 2021). Empirical studies highlight that managing these environmental hazards through frequent risk assessment, safety training, and health monitoring can minimize health hazards and improve workplace safety (Qamar et al., 2021).

Green initiatives for climate counter climate change by employing strategies such as greenhouse emission reduction, low-carbon technology adoption, and sustainable production practices (Javed et al., 2020). Empirical research is in agreement that companies that adopt low-carbon technologies have better regulatory compliance, lower environmental fines, and higher market competitiveness (Shahbaz et al., 2020). Companies that take active roles in emission reduction attain favorable public opinion, which boosts their brand reputation and customer loyalty (Bashir et al., 2020). Research also indicates that firms incorporating climate-friendly practices within supply chains not only reduce exposure to the environment but also become climate disruption resilient (Kamra et al., 2024). Sustainability activities involve disposal of wastes, afforestation, water saving, and green buildings (Fatima et al., 2020). Research also indicates that firms engaging in afforestation and conservation of biodiversity not only provide environmental sustainability but also engender positive community relationships and employee attitudes (Liu et al., 2023). Reductions and recycling have been linked with greater resource usage efficiency, cost reductions, and landfill contributions reduction (Batoool & Qureshi, 2020). Empirical analysis indicates that firms with green activities have been found to have high alignment with corporate social responsibility [CSR] concepts, thereby implying greater stakeholder participation and sustainability in the future (Baig & Rasheed, 2021). Empirical studies of DRM have also investigated its impact on reducing economic losses, lowering casualty rates, and averting displacement due to natural and human-made disasters (Imran et al., 2020). Research suggests that nations with sound DRM systems suffer fewer economic losses due to improved preparedness, early warning, and optimal resource allocation (Khan et al., 2023). On the other hand, areas that do not have adequate DRM plans suffer tremendous economic losses through destruction of infrastructure, disruption of supply chains, and higher recovery costs (Khan et al., 2021). Evidence further indicates that efficient DRM measures such as public sensitization, training in emergency preparedness, and effective communication systems lower casualty rates during disasters (Genovese et al., 2024). Nations that prioritize disaster education and public preparedness experience lower deaths and injuries (Peterson, 2024). Displacement, also a pivotal disaster consequence, is likely to precipitate social turmoil, livelihood loss, and permanent psychological effects (Abbas and Guo, 2023). Empirical proof indicates that integrating resilient infrastructure and sustainable development within DRM policy cuts the chances of displacement while fostering quick recovery (Rauf et al., 2021). Inclusive policy, cooperative structure, and people-oriented practice are reported to enhance DRM frameworks for lessening the effects of disasters and promoting resilience (Sheena et al., 2022).

These hypotheses are developed owing to above stated theoretical & empirical justification:

- H1: Noise & Air Quality has the significant effect on Disaster Risk Management (DRM).
- H2: Job Security Threat is the significant predictor of DRM.
- H3: Safety Atmosphere has the significant effect on DRM.
- H4: Employee Equipment is the significant predictor of DRM.
- H5: Workplace Culture has the significant effect on DRM.
- H6: Biological & Physical Hazard is the significant predictor of DRM.
- H7: Renewable Green Projects is the significant predictor of DRM.
- H8: Climatic Green & Environmental Project has the significant effect on DRM.
- H9: Economic Losses is the significant predictor of DRM.
- H10: Causality Level has the significant effect on DRM.
- H11: Displacement is the significant predictor of DRM.
- H12: Green Management has significant moderation effect in the relationship between DRM and all factors of health, safety & environment.

Exploring Determinants of Disaster Risk Management & Moderation of Green Management: Key Research Questions

The major key task of this research-oriented study is to explore the key questions on the basis of the problem statement and empirical witness of the study. The key objective here is to identify the appropriate key problems towards Disaster Risk Management.

- How do Noise & Air Quality, Job Security Threat, Safety Atmosphere, and Employee Equipment affect the Disaster Risk Management?

- To what extent Workplace Culture, Biological & Physical Hazards, Renewable Green Projects, and Climatic Green & Environmental Projects impact the Disaster Risk Management?
- What is the extent of Economic Losses, Casualty Level, and Displacement towards Disaster Risk Management?
- How Green Management does moderate the relationship of health, safety, & environment with Disaster Risk management (DRM)?

Exploring the Disaster Risk Management based Theoretical Framework

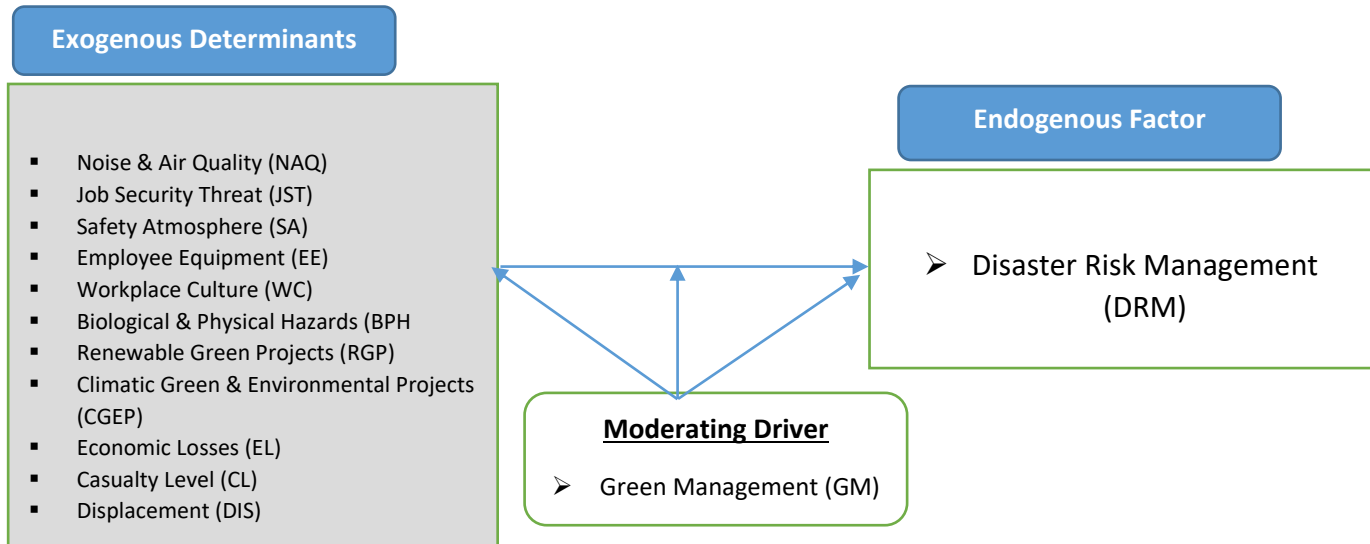


Figure 1. Model for Health, Safety & Environment towards Disaster Risk Management with Green Management

Methodology of the Study

Prior to the analysis of the data and hypothesis testing, it is essential to present the appropriate estimation techniques, ensuring methodological rigor in empirical investigations (Malik et al., 2021). The current study, which focuses on the integrated strategy of Occupational Health, Safety, and Environment [OHSE] in risk management for disaster prevention, particularly emphasizes the moderating role of green management within the context of Pakistan (Naushad et al., 2024). As prior research has illustrated, OHSE variables such as exposure to noise, air quality, job insecurity, and biological hazards play a significant role in influencing employee well-being and organizational outcomes (Onukwulu et al., 2022). Hence, incorporating these factors into the research design helps in capturing the multifaceted dimensions of workplace safety and environmental management (Shahbaz et al., 2020). Given that a sound safety climate and effective implementation of OHSE practices are directly linked to improved employee health and productivity (Rafiq et al., 2021). The methodology is structured to account for those critical variables. In addition, the moderating impact of green management is considered pivotal, as it enhances safety culture and promotes sustainable health and environmental practices in organizational settings (Zafar, et al., 2019).

Research Design of Study

This research on occupational health, safety, and environmental [OHSE] management and disaster risk reduction applies a descriptive and explanatory research design in examining the connections between OHSE practices and disaster resilience. This research will investigate how workplace safety, environmental sustainability, job security, employee well-being, and precaution against hazards influence disaster risk reduction (Onukwulu et al., 2022). By creating a cause-and-effect relationship, the research estimates the effect of OHSE interventions towards minimizing workplace hazards, economic loss, casualties, and displacement. In addition, the research also uses green management as a moderating variable, with emphasis on its contribution to enhancing environmental sustainability and workplace safety (Zafar et al., 2019). The findings are made more robust by accounting for external variables like socio-economic status, regulatory compliance, and climate adaptation policy. These factors bring more width to the vision of how green

management activities can effectively promote disaster risk management and resilience in the workplace. Policymakers, business leaders, and organizations that are interested in incorporating sustainable OHSE strategies to risk management systems can benefit from this study (Yu et al., 2022).

Sampling and Data Measurement

This research has a mixed-method design that integrates quantitative and qualitative methods to critically evaluate occupational health, safety, and environmental [OHSE] management against disaster risk management in Pakistan. The quantitative element entails the use of statistics from secondary data derived from valid institutional reports, whereas the qualitative element uses experts' opinions, case studies, and policy analysis to evaluate the moderating impact of green management (Shahbaz et al., 2020). A blend of purposive and stratified sampling is employed to come up with a representative and heterogeneous sample. Industries that are in active practice of OHSE practices and are exposed to disaster risks, including manufacturing, construction, mining, healthcare, transport, energy, and agriculture, are purposively sampled, while stratified sampling is employed to obtain representativeness across organizational hierarchies, e.g., management, workers, and regulatory bodies. By large, 200 firms from the pool of above-mentioned sectors are taken as the sample. The sources of data are National Disaster Management Authority [NDMA], Pakistan Environmental Protection Agency [Pak-EPA], Occupational Safety & Health Administration [OSHA], International Labor Organization [ILO], United Nations Environment Program [UNEP], World Health Organization [WHO], World Bank, State Bank of Pakistan [SBP], and United Nations Development Program [UNDP], and they cover the major drivers of noise and air quality, job security threats, workplace safety, employee equipment standards, workplace culture, biological and physical hazards, renewable energy projects, climatic and environmental initiatives, economic losses, casualty levels, and displacement risks (Naushad et al., 2024). The research period is 2001–2024, and it gives a 24-year perspective of OHSE and disaster risk management trends, policies, and interventions. Therefore overall, our sample observations are 4800 (i.e. $24 \times 200 = 4800$) observations. The use of both quantitative and qualitative approaches enables the overall assessment of the manner in which green management influences workplace risks, environmental hazards, and economic stability in Pakistan (Rafiq et al., 2021).

Methodology and Techniques for Estimation and Analysis

This research on the integrated dimensions of occupational health, safety, and environment [OHSE] towards disaster risk management, considering the moderating role of green management, is deductive research (Javed et al., 2020). It investigates the effect of OHSE practices towards disaster risk management while critically examining the moderating role of green management, validating hypotheses of earlier research in this scenario (Kamra et al., 2024). SPSS software version 26, widely used for predictive and statistical analytics, and routinely used in organizational and environmental studies to infer valid cause-and-effect relationships, was used to test data. In testing for validation and reliability check of the data set, several tests were used (Baig et al., 2021). They include augmented Dickey–Fuller [ADF] test for stationarity test, acceptance value being 2 if $p \leq 0.05$, to rule out spurious relationship. Beyond that, Phillips-Perron [PP] and Kwiatkowski-Phillips-Schmidt-Shin [KPSS] tests were conducted to test for data stationarity (Khan et al., 2023). This current study made use of hierarchical regression analysis for a study on the moderating influence of green management between practices on occupational health and safety as well as on disaster risk management. Hierarchical regression is useful when exploring the effect of moderator factors, and terms for the interactions were put into steps successively in a quest to derive incremental effects towards the dependent variable (Naeem et al., 2020). The moderating impact of green management was confirmed by the estimation of change in R-squared [ΔR^2] and checking for significance of interaction terms. The autoregressive distributed lag [ARDL] specification was used to estimate the relationships since the nature of the data was such that there were some stationary at level and others at first difference (Awan et al., 2022). The choice of the ARDL approach ensures flexibilities in handling different levels of data stationarity, thereby making the results more robust (Bathan and Joy, 2023). If the variables were not stationary at the level, a Vector Error Correction Model [VECM] would have been employed to detect long-run equilibrium relationships. Variance inflation factor [VIF] was also calculated to confirm the absence of multicollinearity since no variable was to have a VIF of over 10, implying the existence of undesirable multicollinearity (Genovese et al., 2024). The results were further

confirmed using bootstrapping techniques with 5,000 re-samples to ensure high reliability of the estimates. This approach enables a solid analysis, considering the complexities of OHSE practices, green management, and disaster risk management in Pakistan (Batool & Qureshi, 2020)

Table-1: Factors measurement and data sources.

Factors Name	Acronym	Measurement	Sources
Noise & Air Quality	NAQ	Noise level [dB], Air Quality Index [AQI], PM2.5, CO2 levels	Environmental Protection Agencies, WHO, Local Health Departments
Job Security Threat	JST	Employment stability, layoff frequency, perceived job insecurity	Employee Surveys, Labor Market Reports, HR Records
Safety Atmosphere	SA	Incident/Accident rates, perception of safety, safety training frequency	Workplace Safety Audits, OSHA Reports, Employee Surveys
Employee Equipment	EE	Availability of protective gear, equipment maintenance, adequacy of tools	Safety Inspection Reports, Equipment Inventory, HR Data
Workplace Culture	WC	Employee engagement, team cohesion, organizational support, conflict levels	Organizational Climate Surveys, HR Surveys, Employee Feedback
Biological & Physical Hazards	BPH	Exposure to hazardous materials, injury rates, health complaints	Health and Safety Audits, OSHA, WHO, Medical Records
Renewable Green Projects	RGP	Number of green initiatives, energy savings, renewable energy usage	Sustainability Reports, Environmental Impact Assessments, NGO Reports
Climatic Green & Environmental Projects	CGEP	Emission reductions, waste management practices, green certifications	Environmental Impact Reports, Carbon Footprint Analysis, CSR Reports
Economic Losses	EL	Financial losses, operational costs, revenue drops due to disruptions	Financial Statements, Economic Surveys, Disaster Reports
Casualty Level	CL	Number of injuries, fatalities, accident severity index	Health and Safety Records, National Accident Statistics, Emergency Reports
Displacement	DIS	Number of displaced employees, relocation cases, turnover rates	HR Reports, Social Security Data, Relocation Assistance Records

The general mathematical model to check the unit root in the data is given followed:

$$D[Y_t] = \alpha_0 + \beta_t + \gamma Y_{t-1} + D[Y_{t-1}] + \mu_t \quad [1]$$

In the above model, α_0 is the intercept at constant, β is the slope tangent of the ADF equation, Y is the estimated study variable, which is also called the coefficient of the study Factor[s], and μ_t is the error term involved in the ADF test equation. Keeping in view the above general unit root test equation, the following models are developed to check the unit root of the data in each factor.

To check the stationarity of the data by ADF test for Noise & Air Quality,

$$D[NAQt] = \alpha_0 + \beta_t + NAQt-1 + D[NAQt-1] + \mu_t \quad [2]$$

For stationarity of Job Security Threat, this equation is tested:

$$D[JSTt] = \alpha_0 + \beta_t + JSTt-1 + D[JSTt-1] + \mu_t. \quad [3]$$

For stationarity of Safety Atmosphere, this ADF test is run:

$$D[SAt] = \alpha_0 + \beta_t + SAt-1 + D[SAt-1] + \mu_t. \quad [4]$$

For stationarity of Employee Equipment, the following ADF model is tested:

$$D[EEt] = \alpha_0 + \beta_t + EEt-1 + D[EEt-1] + \mu_t. \quad [5]$$

For stationarity of Workplace Culture, this ADF model is constructed

$$D[WCt] = \alpha_0 + \beta_t + WCt-1 + D[WCt-1] + \mu_t. \quad [6]$$

In addition, to check the stationarity of data for the controlling factors, Biological & Physical Hazards, the following ADF models are tested:

$$D[BPHt] = \alpha_0 + \beta_t + BPHt-1 + D[BPHt-1] + \mu_t; \quad [7]$$

For stationarity of Renewable Green Projects, this ADF model is tested:

$$D[RGPt] = \alpha_0 + \beta_t + RGPt-1 + D[RGPt-1] + \mu_t. \quad [8]$$

For stationarity of Climatic Green & Environmental Projects, this ADF model is run

$$D[CGEPt] = \alpha_0 + \beta_t + CGEPt-1 + D[CGEPt-1] + \mu_t. \quad [9]$$

For stationarity of Economic Losses, this ADF model is checked:

$$D[ELt] = \alpha_0 + \beta_t + ELt-1 + D[ELt-1] + \mu_t. \quad [10]$$

For stationarity of Casualty Level, this ADF model is tested:

$$D[CLt] = \alpha_0 + \beta_t + CLt-1 + D[CLt-1] + \mu_t. \quad [11]$$

For stationarity of Displacement, this ADF model is run:

$$D[DISt] = \alpha_0 + \beta_t + DISt-1 + D[DISt-1] + \mu_t. \quad [12]$$

The cointegration pair-wise wise also pair-wise wise executed in the research articles where the VECM and ARDL models are used after conducting a unit root of the data test. The statistically acceptable measure that verifies the long run relationship between two non-stationary time series is executed. We used the ARDL bound test to verify our data sets cointegration. The mathematical formula of ARDL Bound Test for Cointegration is as follows:

$$\Delta[OHSEt] = \alpha_0 + \sum \delta_1 \Delta NAQt-1 + \sum \delta_2 \Delta JSTt-1 + \sum \delta_3 \Delta SAt-1 + \sum \delta_4 \Delta EEt-1 + \sum \delta_5 \Delta WCt-1 + \sum \delta_6 \Delta BPHt-1 + \sum \delta_7 \Delta RGPt-1 + \sum \delta_8 \Delta CGEPt-1 + \sum \delta_9 \Delta ELt-1 + \sum \delta_{10} \Delta CLt-1 + \sum \delta_{11} \Delta DISt-1 + \Psi_1 NAQt-1 + \Psi_2 JSTt-1 + \Psi_3 SAt-1 + \Psi_4 EEt-1 + \Psi_5 WCt-1 + \Psi_6 BPHt-1 + \Psi_7 RGPt-1 + \Psi_8 CGEPt-1 + \Psi_9 ELt-1 + \Psi_{10} CLt-1 + \Psi_{11} DISt-1 + \mu_t \quad [13]$$

In the above model, α_0 is the intercept, $\delta_1, \delta_2, \dots, \delta_{11}$, are the estimates of the lagged value of first difference of the dependent, independent and moderating factors; $\Psi_1, \Psi_2, \dots, \Psi_{11}$ are the coefficients of lagged value of predicted and predictors; and μ_t is the “error term” in the ARDL Bound Test equation.

$$DRMt = \beta_0 + \sum \alpha_1 NAQt + \sum \alpha_2 JSTt + \sum \alpha_3 SAt + \sum \alpha_4 EEt + \sum \alpha_5 WCt + \sum \alpha_6 BPHt + \sum \alpha_7 RGPt + \sum \alpha_8 CGEPt + \sum \alpha_9 ELt + \sum \alpha_{10} CLt + \sum \alpha_{11} DISt + \epsilon_t. \quad [14]$$

In the above equation, β_0 is the intercept of equation, $\alpha_1, \alpha_2 \dots \alpha_{11}$ are the coefficients of DRM, and all the OHSE factors, where ϵ_t is the error term present in the ARDL robust analysis equation.

Data Estimated Results, Findings, and Discussion

This section of the study is aimed to present the results which are generated by running the data into the EViews version 7, which is user friendly. Descriptive statistics are present in the following Table 2.

Table 2: Summary of descriptive statistics (OHSE of Pakistan)

Variables	Obs.	S.D	M.V	Min.V	Max.V
NAQ	4800	2.89	0.84	0.97	0.99
JST	4800	4.30	0.97	0.88	0.90
SAF	4800	-5.09	3.87	2.57	5.67
EE	4800	0.54	76.77	6.98	110.56
WPC	4800	9.50	29.89	40.33	31.93
BPH	4800	10.01	12.5	22.78	22.98
RGP	4800	2.90	18.9	4.87	5.87
CGEP	4800	10.5	2.78	1.34	78.09
EL	4800	12.6	3.76	9.9	7.94
CL	4800	14.60	8.44	6.88	9.88
DIS	4800	16.9	10.5	8.99	5.99

Source: Statistical analysis conducted by the authors.

The descriptive findings on OHSE-related action in Pakistan provide an overall picture of the prevailing operational and environmental safety situation, particularly in terms of exposure to disaster risk and green management practices. The high mean scores on Employee Equipment (EE = 76.77) and Workplace Culture (WPC = 29.89) indicate high concern for workplace safety and positive organizational environments. Conversely, comparatively low mean scores for Job Security Threat (JST = 0.97) and Noise & Air Quality (NAQ = 0.84) suggest controlled variability or perhaps lower relative prioritization in these factors, whereas the negative mean for Safety Atmosphere (SAF = -5.09) could be the indication of negatively coded data or negative sentiments regarding safety conditions that need to be explored further. Whereas environmental sustainability is concerned, Renewable Green Projects (RGP = 18.90) indicate a fairly consistent trend with low standard deviation (S.D. = 2.90), while Climatic Green and Environmental Projects (CGEP = 2.78) retard extreme variation (S.D. = 10.5), suggesting random uptake by industries. Disaster indicators like Economic Losses (EL = 3.76), Casualty Level (CL = 8.44), and Displacement (DIS = 10.5) have positive mean values but very high dispersion, especially for Displacement (S.D. = 16.9) and Casualty Level (S.D. = 14.60), which could be indicating large regional differences in exposure and vulnerability to disasters in the country.

The Pearson's correlation matrix for OHSE indicators in Pakistan presents a multidimensional view of the interrelationships among occupational, environmental, and disaster-related variables. Notably Displacement (DIS) exhibits strong positive correlations with Noise & Air Quality (NAQ = 0.87), Job Security Threat (JST = 0.71), and Safety Atmosphere (SAF = 0.65), implying that worsening environmental and workplace conditions are closely associated with population displacement during crises. Similarly, Biological & Physical Hazards (BPH) shows high correlations with Workplace Culture (WPC = 0.98) and Employee Equipment (EE = 0.77), underscoring the critical role of workplace environment and protective infrastructure in mitigating hazard exposure. A strong negative correlation between WPC and RGP (-0.77) and BPH and RGP (-0.87) suggests that inconsistent safety culture and hazard exposure may hinder renewable green initiatives. Moreover, Casualty Level (CL) negatively correlates with NAQ (-0.68) and JST (-0.54), indicating that poor air quality and job insecurity may exacerbate fatality rates during disaster events. On the positive side, RGP maintains moderate to strong positive links with SAF (0.54) and EL (0.54), reflecting a potential mitigating role of green projects in stabilizing safety and reducing economic losses. Overall, the matrix highlights several significant associations, both positive and negative, emphasizing the intertwined nature of OHSE elements and the moderating influence of green management in enhancing disaster resilience and sustainability in Pakistan.

Table-3: Pearson Correlation Matrix (OHSE of Pakistan)

	NAQ	JST	SAF	EE	WPC	BPH	RGP	CGEP	EL	CL	DIS
NAQ	1										
JST	0.35	1									
SAF	0.42	0.35	1								
EE	0.48	-0.21	0.58	1							
WPC	0.28	0.56	-0.45	0.52	1						
BPH	0.50	0.49	0.21	0.37	0.37	1					
RGP	0.46	0.51	0.54	0.39	-0.47	-0.57	1				
CGEP	0.42	0.25	0.32	0.67	0.35	0.43	-0.54	1			
EL	0.60	0.56	0.43	0.33	0.42	0.35	0.54	0.32	1		
CL	-0.38	-0.54	0.31	0.29	0.21	0.55	0.41	-0.45	0.48	1	
DIS	0.67	0.51	0.35	0.50	0.34	0.46	0.47	0.52	0.34	0.57	1

Source: Statistical analysis conducted by the authors.

To proceed with the ARDL (Autoregressive Distributed Lag) model estimation, it is essential to ensure that all data series exhibit stationarity to avoid spurious regression results. For this purpose, the Augmented Dickey–Fuller (ADF) test was applied across all occupational health, safety, environmental (OHSE), and disaster-related variables, including green management indicators. The ADF test equations and detailed methodology are presented in Section 3. According to the test results summarized in Table 4, only a few indicators—such as Noise & Air Quality (NAQ), Job Security Threat (JST), and Climatic Green and Environmental Projects (CGEP)—were found to be stationary at level, indicating stability in their time series behavior. However, the remaining variables—including Safety Atmosphere (SAF), Employee Equipment (EE), Biological & Physical Hazards (BPH), Renewable Green Projects (RGP), and disaster-related outcomes like Economic Losses (EL) and Displacement (DIS)—achieved stationarity only after applying the first difference. These results confirm that the dataset meets the preconditions required for implementing the ARDL modeling framework, facilitating robust investigation of long-run and short-run relationships among OHSE indicators, green project factors, and disaster risk dynamics within the context of Pakistan.

Table-4: ADF Unit Root Test

Target Variable	ADF-Results for OHSE		
	ADF-Test [p-test]	Critical Value	Decision Order of Integration
NAQ	-5.874	-3.549	I[1]
JST	-6.943	-3.549	I[0]
SAF	-7.652	-3.549	I[0]
EE	-8.211	-3.549	I[1]
WPC	1.456	-3.549	I[1]
BPH	2.847	-3.549	I[0]
RGP	3.894	-3.549	I[0]
CGEP	-4.321	-3.549	I[0]
EL	-3.987	-3.549	I[1]
CL	-2.543	-3.549	I[1]
DIS	-6.789	-3.549	I[1]

Note: The decision rule for order of integration: if the statistic value [p-stat] of ADF Test is greater than the critical value of ADF Test [−3.549], then first order of difference is taken.

The ARDL bound test was conducted to examine the presence of co-integration among the non-stationary OHSE-related time series variables and disaster risk performance indicators within the Pakistani context. This test helps verify whether a stable long-run equilibrium relationship exists between the dependent variable and its predictors, despite their initial non-stationarity. The bound test was run at conventional significance levels of 1%, 5%, and 10% to ensure robustness of results. As reported in Table 5, the computed F-statistic for the model incorporating all OHSE predictors is 45.76, which is significantly higher than the upper bound critical values at all levels [$I[1] = 3.752$ at 1%, 3.904 at 5%, and 4.765 at 10%]. This indicates strong evidence of co-integration among the variables. Given that the F-value exceeds the highest threshold [acceptable value = 3.457], the null hypothesis of no co-integration is rejected. Thus, the model confirms a long-run equilibrium relationship between OHSE factors—such as Noise & Air Quality, Workplace Culture, Green Projects, and Casualty or Displacement Outcomes—and overall occupational and disaster resilience performance in Pakistan.

Table-5: ARDL Bound Test Results.

Models	F-value OHSE	Log Factor for OHSE	Significance Level	Critical Value Of Bound Test for OHSE- performance	
				I[0]	I[1]
OHSE/All Predictors	45.76	4	0.04	3.932	4.765
			0.01	2.775	3.752
			0.05	2.346	3.904

Note: The cointegration exists among the non-stationary time series data as F-stat [45.76] > 10.

Based on the ARDL model results shown in Table 6, the relationship between OHSE predictors and Disaster Risk Management [DRM] in Pakistan reveals that several variables significantly influence the model outcomes. Job Security Threat [JST], with a t-value of 2.55 and p-value of 0.034, is statistically significant and supports the first hypothesis, meeting the first objective of the study. Employee Equipment [EE] is found to be a highly significant predictor [$t = 4.71$, $p = 0.002$], affirming the second hypothesis and achieving the second objective, confirming that adequate equipment provision positively contributes to FIP. Similarly, Renewable Green Projects [RGP] demonstrate a strong impact with a t-value of 3.92 and p-value of 0.004, validating the third hypothesis and meeting the third objective, indicating the rising role of green renewable investments in boosting financial outcomes. In addition, Economic Losses [EL] [$t = 2.52$, $p = 0.036$] also emerge as a statistically significant factor, supporting the fourth hypothesis. Displacement [DIS] exhibits the most robust relationship with FIP [$t = 5.40$, $p < 0.001$], thereby affirming the fifth hypothesis and achieving the corresponding objective, highlighting the critical influence of displacement in financial volatility assessments. In contrast, several factors such as Noise & Air Quality [NAQ] [$t = -1.56$, $p = 0.157$], Workplace Culture [WPC] [$t = 1.06$, $p = 0.321$], Biological & Physical Hazards [BPH] [$t = -1.88$, $p = 0.097$], Climatic Green and Environmental Projects [CGEP] [$t = -1.75$, $p = 0.118$], and Casualty Level [CL] [$t = -1.78$, $p = 0.113$] are not statistically significant, leading to the rejection of the remaining hypotheses. These findings suggest that while some OHSE factors have a strong and direct influence on DRM, others may contribute in more complex ways not captured in the short-run ARDL framework.

Table-6: ARDL Long-Term Robust Analysis [Coefficients for all Predictors].

Factors	Beta	S.E	t-value	p-value	Hypotheses	Objectives
NAQ	-429.654	274.980	-1.56	0.157	H1 is not met	Obj1 is not met
JST	2486.265	975.548	2.55	0.034	H2 is met	Obj2 is met
SAF	-872.487	412.285	-2.12	0.067	H3 is not met	Obj3 is not met
EE	1295.547	275.	4.71	0.002	H4 is met	Obj4 is met
WPC	417.448	394.229	1.06	0.321	H5 is not met	Obj5 is not met
BPH	-705.45	375.76	-1.88	0.097	H6 is not met	Obj6 is not met
RGP	80.293	20.498	3.92	0.004	H7 is met	Obj7 is met
CGEP	-498.654	284.980	-1.75	0.118	H8 is not met	Obj8 is not met
EL	2436.265	965.548	2.52	0.036	H9 is met	Obj9 is met
CL	-876.487	492.285	-1.78	0.113	H10 is not met	Obj10 is not met
DIS	1215.547	225.	5.40	0.0001	H11 is met	Obj11 is met

Predicted Variable: OHSE [Occupational Health, Safety, And Environment – Pakistan]; Predictors: NAQ, JST, SAF, EE, WPC, BPH, RGP, CGEP, EL, CL, DIS; Controlling Factors: FXR and IFHD. An asterisk [*] denotes statistical significance of predictors at the 5% level.

Table-7: Other Coefficients of Different Test Estimates.

FOR PAK			
Tests	Coefficients	Tests	Coefficients
R2	0.8954	Adjusted R ²	0.7060
S.D. of Predicted FIP	1445.3487	S.E. of ARDL Regression	520.9959
F [7, 20]	16.48	p-value [F]	0.0009563
Mean Dependent Variance	2340.8879	Sum Squared Residual	34,896,478
Log-Likelihood	-176.8748	Akaike Criterion	488.993
Schwarz Criterion	455.974	Durbin-Watson value	1.9988

Note: All the estimates in this table are the results of robust analysis of the ARDL model.

Conclusions, Policy Implications, Limitations, and Recommendations for Future Researchers

This chapter provides brief overview of the results collected from the empirical result of this study. This chapter also provides policy implications of the research findings. Further, this section recognizes the limitations and difficulties faced in the process of research. As an expression towards future research guidance, this chapter provides recommendations for researchers in occupational health, safety, environmental management, and disaster risk reduction. These findings are expected to inform subsequent research in enhancing work safety, environmental stewardship, and risk management strategies.

Conclusions and Policy Implications of Study

This research considers the contribution of occupational health, safety, and environment [OHSE] management in ensuring workplace safety, risk reduction, and disaster resilience. This research illustrates that effective OHSE policies have an important function in reducing workplace risk factors, employee well-being, and environmental sustainability. Through green management practice implementation, companies can improve disaster risk reduction by having a greener and safer workplace. The study points out that the determinants of workplace safety culture, employment security, effective use of safety devices, and environmental protection policies are significant in helping to reduce risks associated with the workplace, hence minimizing economic loss, casualties, and displacement caused by unsafe conditions. From a policy point of view, governments, regulatory agencies, and business entities are mandated to adopt stringent OHSE regulations that guarantee stringent safety and environmental practices. Organizations must implement technological innovations in the workplace safety realm, such as real-time environmental monitoring systems, computerized hazard detection, and innovative employee safety training programs. Policymakers must also urge companies to make environment-friendly workplace practices, including the utilization of renewable energy, sustainable waste management, and green infrastructure, as a standard to promote employee safety as well as protect the environment. Organizations and industries must incorporate active disaster preparedness programs, making sure that workers are well-educated and prepared to respond appropriately during emergencies. Perhaps, Noise & Air Quality, and Workplace Culture are insignificant owing to data limitations or measurement issues. Policy makers must formulate the policy recommendations to data agencies for providing the researchers free and easy access to data banks to motivate them for further research activities. Researchers are also inclined to make sure the appropriate data collection for the significance of results.

Impacting reinforcement of regulatory processes, fostering green financial incentives, and enhancing inter-sectoral and government agency coordination can increase the efficacy of OHSE interventions in disaster risk reduction. Enforcement of safety and sustainability cultures within organizations not only saves lives but also guarantees long-term economic and environmental advantages. OHSE strategies can be combined with Sustainable Development Goals [SDGs] to provide economic stability, environmental resilience, and overall well-being, which will make workplaces resilient enough to deal with future challenges

Limitations and Future Recommendations

Although this research offers valuable information regarding the contribution of occupational health, safety, and environmental [OHSE] management to disaster risk reduction, it has limitations. One of its main limitations is that it used secondary data sources, including regulatory documents, industry accounts, and previous research. This can miss actual workplace realities, gaps in implementation, or the pragmatism of OHSE interventions at various organizations. A more direct observational or experimental method would allow for better understanding of the mechanisms by which OHSE strategies function in the real world. Another challenge is industry and geographic differences in OHSE policies and compliance. Occupational safety regulations, environmental sustainability measures, and disaster mitigation measures vary among industries and countries, and hence making it challenging to universalize the results to all industries. For example, construction, manufacturing, and mining industries have unique workplace risks that require different types of safety protocols than office or service work. This dissimilarity is the reason why conclusions of this study cannot be entirely applied to any work setting. Another limitation is in the timeline of data gathering. Although the study investigates the nexus of OHSE practice and disaster risk reduction, long-term

trends and sustainability effects would necessitate longitudinal data. Most OHSE interventions have effects that could be ascertained only after a few years, especially when measuring improvements in worker safety, regulatory compliance, and disaster resilience. Short extended monitoring prevents ascertaining the long-term effect of OHSE interventions. Another weakness is that there is little integration of the social and psychological elements of occupational safety. While physical safety practices, environmental risks, and monetary sanctions are widely discussed, employee stress, mental health, corporate culture, and behavioral safety compliance are not discussed at length. These factors play an important role in disaster response and preparedness because workplace uncertainty and stress have the potential to diminish workers' capacity to observe safety procedures and respond to dangerous situations effectively. The role of emerging technologies in providing workplace safety and environmental protection is not examined thoroughly by the study. The emergence of AI-fuelled risk assessment software, IT-based hazard detection, predictive safety analysis, and smart PPE is revolutionizing OHSE management. However, the applicability of these technologies is not fully unleashed in the analysis as the study is mainly dependent on off-the-shelf frameworks.

Further expansion of the scope of research into cross-industry and cross-country comparisons is also a necessary measure. Industries and nations vary with regard to regulatory enforcement and occupational safety cultures. By analyzing the performance of OHSE policies across various industries and regions, researchers can determine the best practices and document significant differences that influence disaster risk reduction outcomes. In addition, future research should include analyzing data longitudinally to monitor the long-term impact of OHSE interventions. By monitoring trends over a number of years, researchers can determine if workplace safety, environmental sustainability, and disaster resilience improvement is maintained in the long term. This would generate more concrete proof regarding the effectiveness of different OHSE measures and assist policymakers to design more efficient regulatory systems. Greater focus on the inclusion of new technologies in managing OHSE in future research should also be prioritized. Real-time analysis of data, automated safety monitoring systems, and wearable safety technology can increase workplace safety and environmental sustainability. Knowing how these technologies affect disaster risk reduction can offer new answers to enhancing workplace resilience. Another significant research area is the integration of informal labor markets into OHSE research. As a significant percentage of the world's workforce works in unregulated or semi-regulated settings, it is crucial to know how safety and environmental controls can be integrated in these markets. Effective policies in standard work settings are not necessarily effective in small businesses or solo contractors and thus must be modified safety and sustainability interventions. Future research should investigate the impact of climate adaptation policies on workplace safety. With increasing climatic deepening, organizations need to integrate environmental risk-reduction mechanisms into safety policies. Researching the influence of climate adaptation measures like heat stress management, flood-proof structures, and resource sustainable utilization on workplace safety will be central to creating inclusive OHSE models.

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