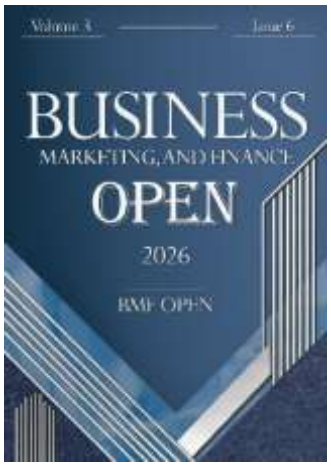
# Financial Risk Assessment of Environmental Degradation Caused by the Sudden Release of Toxic and Explosive Gases from Petrochemical Compounds in Ilam City




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**Abstract:** This study sought to examine the financial risk assessment of environmental degradation caused by the sudden release of toxic and explosive gases from petrochemical compounds in Ilam. In terms of objective, the present study was applied research, and regarding the method of data collection, it was classified as a qualitative study. The statistical population included university faculty members, expert specialists from the Environmental Protection Organization, and experienced managers of the Ilam Petrochemical Company. The sample size was determined based on the theoretical saturation criterion. Through this process, 15 experts were considered sufficient for conducting the interviews. In the qualitative section, data were collected through interviews. In the present study, semi-structured interviews were employed to identify the dimensions of the financial risk of environmental degradation resulting from the sudden release of toxic and explosive gases from petrochemical compounds, with an emphasis on creative accounting and the modeling of its consequences in Ilam. The qualitative section of the study was analyzed using thematic analysis. The findings indicated that 50 indicators within the framework of 10 components (environmental risk, public health risk, economic and social risk, reputational risk, market risk, insurance risk and legal liabilities, operational risk, safety and crisis risk, political and regulatory risk, and social risk and public trust) and 4 dimensions (environmental and health dimension, economic and financial dimension, operational and safety dimension, and political and social dimension) constitute the dimensions of financial risk assessment of environmental degradation caused by the sudden release of toxic and explosive gases from petrochemical compounds in Ilam. The model for assessing the financial risk of environmental degradation caused by the sudden release of toxic and explosive gases in the petrochemical industries of Ilam demonstrates that this issue is a multidimensional phenomenon with extensive consequences for the environment, economy, public health, industrial safety, and social policies.

**Keywords:** Financial risk assessment, environmental degradation, sudden release of toxic and explosive gases, Ilam petrochemical industries

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## 1. Introduction

Natural resources have long been regarded as one of the most important drivers of economic growth, industrial development, and financial stability in both developed and developing economies. Countries endowed with abundant oil, gas, and mineral reserves generally possess significant opportunities for industrial expansion, export

diversification, and technological advancement. However, despite these advantages, many resource-rich economies continue to experience structural economic instability, institutional inefficiency, environmental degradation, and financial vulnerability. This paradox, commonly referred to as the "resource curse," has attracted substantial scholarly attention in recent decades [1, 2]. The increasing complexity of global commodity markets, geopolitical uncertainty, and environmental risks associated with extractive and petrochemical industries have intensified the necessity for multidimensional analyses of financial and environmental risks in resource-dependent economies. Studies have shown that dependence on natural resources may increase macroeconomic volatility, reduce economic complexity, and weaken institutional quality, particularly in economies where governance systems are fragile or underdeveloped [3-5].

In recent years, the expansion of petrochemical industries has significantly contributed to economic growth and industrial productivity in many oil-exporting countries. Petrochemical industries generate substantial revenues, create employment opportunities, and stimulate industrial linkages across multiple sectors. Nevertheless, the operations of petrochemical facilities are associated with severe environmental and financial risks, especially when accidents involving toxic and explosive gases occur. Sudden releases of hazardous gases can result in catastrophic environmental degradation, destruction of ecosystems, public health crises, industrial shutdowns, legal liabilities, and extensive financial losses. Such incidents not only threaten ecological sustainability but also undermine financial market stability, investor confidence, and regional socioeconomic development. Environmental disasters in industrial regions have increasingly become a critical concern for policymakers, financial institutions, insurance companies, and local communities because their consequences extend beyond environmental dimensions and directly affect economic and financial systems [6, 7].

Environmental degradation resulting from industrial pollution has emerged as a major global challenge that influences sustainable development, social welfare, and financial resilience. Petrochemical industries are among the largest contributors to air, water, and soil pollution due to the release of toxic substances and hazardous chemical compounds. Industrial accidents involving petrochemical facilities can generate long-term ecological damage through contamination of groundwater resources, destruction of biodiversity, and deterioration of agricultural lands. Moreover, toxic emissions can severely affect public health through respiratory diseases, skin disorders, cancer risks, and psychological stress among local populations. The economic burden of these consequences includes increased healthcare expenditures, reduced labor productivity, loss of property value, and migration from affected areas. Previous studies have emphasized that environmental degradation in resource-rich economies is strongly associated with weak institutional quality, inadequate regulatory systems, and insufficient environmental governance mechanisms [7-9]. Institutional quality therefore plays a critical role in determining whether natural resources function as an engine of sustainable development or become a source of economic and environmental instability [10, 11].

The relationship between natural resources, institutional quality, and financial development has become increasingly important in modern economic literature. Strong institutions can mitigate environmental risks by enforcing environmental regulations, improving transparency, strengthening accountability, and promoting sustainable industrial practices. Conversely, weak institutions may intensify corruption, reduce regulatory effectiveness, and increase the likelihood of environmental crises. Research has demonstrated that institutional quality significantly affects financial development, economic growth, and resource management efficiency in developing economies [12-14]. Furthermore, institutional weaknesses may amplify the economic consequences of environmental accidents by reducing governments' capacity to respond effectively to industrial crises. In this

regard, the interaction between financial market risk, environmental degradation, and institutional quality has become a central issue in studies of resource-rich economies [12, 15].

Another important issue associated with resource-dependent economies is the volatility of commodity markets. Oil and energy markets are highly interconnected with industrial metals, precious metals, and financial markets. Fluctuations in energy prices can create substantial volatility spillovers across global markets, thereby affecting investment decisions, industrial costs, and economic stability. Studies investigating volatility transmission mechanisms have shown that oil price shocks significantly influence commodity returns, financial market uncertainty, and industrial production costs [16-18]. In addition, geopolitical risks and economic policy uncertainty contribute to increased commodity price volatility and market instability [19, 20]. Industrial accidents involving petrochemical facilities may intensify these risks by reducing investor confidence, disrupting supply chains, and increasing operational uncertainty. Consequently, environmental disasters are not isolated ecological events but rather multidimensional phenomena with significant financial and economic implications.

The concept of economic complexity has recently gained prominence as an important determinant of sustainable development and industrial competitiveness. Economic complexity reflects the productive capabilities, technological sophistication, and knowledge intensity of an economy. Economies with higher levels of complexity are generally more resilient to external shocks and possess greater capacities for innovation and diversification. However, excessive dependence on natural resources may reduce incentives for technological development and industrial diversification, thereby limiting economic complexity [1, 21]. Several studies have identified a significant relationship between institutional quality, natural resource management, and economic complexity [3, 22]. Resource-rich economies with stronger institutional frameworks are more capable of transforming natural resource revenues into productive investments, technological progress, and sustainable industrial development [23, 24]. In contrast, economies characterized by institutional inefficiency and environmental mismanagement often experience industrial stagnation, financial instability, and environmental deterioration.

Financial market risks associated with environmental degradation have become increasingly complex due to globalization and interconnected commodity markets. Volatility spillovers between oil, energy, and metal markets have intensified under conditions of geopolitical uncertainty and environmental crises. Research indicates that commodity market interconnectedness can amplify systemic financial risks during periods of environmental or economic instability [25-27]. Environmental accidents in petrochemical industries may therefore trigger broader market reactions through increases in insurance costs, declines in stock prices, disruptions in trade flows, and reductions in foreign investment. Furthermore, industrial pollution and environmental crises can influence public administration quality and policy effectiveness, particularly in developing economies where governance systems may already face structural challenges [6, 15].

In addition to financial and environmental consequences, industrial pollution can produce serious social and political implications. Public dissatisfaction resulting from environmental degradation may increase social protests, reduce trust in industrial institutions, and intensify political pressures on governments and policymakers. Communities residing near petrochemical facilities are particularly vulnerable to the adverse effects of toxic emissions because of their direct exposure to contaminated air, water, and soil. These conditions may generate long-term socioeconomic inequalities, health disparities, and migration patterns that negatively affect regional development. Previous studies have emphasized that natural resource dependence can contribute to social inequality and economic disparities when institutional systems fail to distribute resource revenues effectively [28].

Moreover, environmental degradation may weaken social cohesion and public trust, thereby increasing political instability and regulatory uncertainty [4, 9].

The petrochemical sector in Iran represents one of the country's most strategic industrial sectors due to its major contribution to export revenues, industrial employment, and economic growth. However, petrochemical industries in Iran also face substantial environmental and operational risks because of aging infrastructure, sanctions-related technological constraints, and high dependence on fossil fuel resources. Industrial regions such as Ilam are particularly exposed to these risks due to the concentration of petrochemical facilities and the proximity of residential areas to industrial zones. Despite the significance of environmental and financial risks associated with petrochemical industries, limited studies have comprehensively examined the multidimensional financial consequences of environmental degradation caused by toxic gas releases in Iran. Most previous research has focused either on macroeconomic relationships among natural resources, institutional quality, and economic growth or on financial volatility in commodity markets [2, 11, 13]. Consequently, there remains a substantial research gap concerning the integrated assessment of environmental, financial, operational, social, and political risks arising from petrochemical accidents.

The increasing importance of sustainability, environmental governance, and financial risk management has created a growing need for comprehensive risk assessment models capable of addressing multidimensional industrial risks. Effective financial risk assessment models can assist policymakers, industrial managers, insurance institutions, and environmental organizations in identifying critical vulnerabilities and designing preventive strategies. Such models may improve crisis management, strengthen environmental accountability, enhance public trust, and reduce the long-term financial consequences of industrial disasters. Moreover, the integration of environmental risk assessment with financial and institutional analysis can contribute to more sustainable industrial development and more resilient economic systems. Given the strategic importance of petrochemical industries in Iran and the environmental sensitivity of industrial regions such as Ilam, understanding the dimensions of financial risk associated with environmental degradation is essential for effective policymaking and sustainable regional development [1, 3, 12].

Accordingly, the present study aims to identify and model the dimensions of financial risk associated with environmental degradation caused by the sudden release of toxic and explosive gases from petrochemical compounds in Ilam.

## 2. Methodology

The present study was applied research in terms of objective and qualitative in nature regarding the method of data collection. The statistical population consisted of university faculty members, expert specialists from the Environmental Protection Organization, and experienced managers of the Ilam Petrochemical Company in Ilam. The sample size was determined based on the theoretical saturation criterion. Through this process, 15 experts were considered sufficient for conducting the interviews. Data collection in the qualitative section was conducted through interviews. In the present study, semi-structured interviews were employed to identify the dimensions of the financial risk of environmental degradation caused by the sudden release of toxic and explosive gases from petrochemical compounds, with an emphasis on creative accounting and the modeling of its consequences in Ilam. The qualitative section of the study was analyzed using thematic analysis.

## 3. Findings and Results

Using the results of the semi-structured interviews during the coding stage, as well as insights derived from the theoretical and empirical literature on the subject, the identified codes were categorized into the following themes: examining the effects of environmental emergencies and the duration of contamination; modeling pollutant dispersion and predicting its impacts on different regions; assessing environmental tolerance thresholds; evaluating public health costs and the economic burden of diseases; analyzing financial damages to petrochemical industries and other related industries; calculating lost value in economic sectors; analyzing health-related problems and the state of public health; evaluating psychological and social consequences, particularly concerning mental health; examining social problems resulting from environmental changes and declining quality of life; evaluating technical risks and establishing preventive measures; using advanced technologies to simulate crisis scenarios; analyzing security systems and methods for reducing explosion and fire hazards; analyzing legal frameworks and compliance with environmental regulations; evaluating the potential for legal claims and compensation; and examining legal conditions and laws related to environmental liabilities.

**Table 1. Classification of Identified Codes Related to the Main Phenomenon**

| Identified Codes | Experts | Frequency |
|---|---|---|
| Level of air pollution caused by toxic chemical compounds | P1, P3, P4, P5, P7, P13, P14 | 7 |
| Level of contamination of surface and groundwater due to chemical emissions | P1, P2, P8, P9, P11, P13, P15 | 7 |
| Destruction of vegetation cover and forests in the affected area | P1, P2, P3, P4, P5, P6, P7, P14 | 8 |
| Impact on wildlife and extinction of biological species | P1, P2, P3, P4, P5, P6, P10, P12, P14 | 9 |
| Environmental cleanup and restoration costs after the incident | P1, P2, P3, P4, P5, P8, P14, P15 | 8 |
| Increase in respiratory diseases such as asthma and bronchitis | P2, P6, P7, P8, P9, P10, P11, P15 | 8 |
| Incidence rate of skin and eye diseases caused by air pollution | P1, P2, P3, P6, P7, P8, P11, P14 | 8 |
| Increase in hospital visits due to chemical poisoning | P1, P2, P6, P7, P8, P9, P10, P12, P14 | 9 |
| Mortality rate resulting from exposure to toxic gases | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Treatment and rehabilitation costs of patients affected by pollution | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Extent of shutdown or reduced productivity of industrial units after the incident | P1, P2, P3, P4, P5, P6, P7, P8, P9, P10 | 10 |
| Damage to industrial equipment and infrastructure | P1, P2, P3, P4, P5, P6, P10, P12, P14 | 9 |
| Impact of the incident on the supply chain and distribution of petrochemical materials | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Replacement and repair costs of damaged equipment | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Need to halt production for inspection and process reconstruction | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Increase in insurance premiums for petrochemical companies | P1, P2, P3, P4, P5, P8, P14, P15 | 8 |
| Probability of legal penalties for environmental pollution | P2, P6, P7, P8, P9, P10, P11, P15 | 8 |
| Number of lawsuits against polluting industries | P1, P2, P3, P6, P7, P8, P11, P14 | 8 |
| Amount of compensation determined for damages to affected individuals | P1, P2, P6, P7, P8, P9, P10, P12, P14 | 9 |
| New requirements for obtaining environmental and industrial licenses | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Decline in employment in the region due to impacts on dependent industries | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Decline in property and land values around contaminated areas | P1, P2, P3, P4, P5, P6, P7, P8, P9, P10 | 10 |
| Reduction in the income of local businesses affected by the incident | P1, P2, P3, P4, P5, P6, P10, P12, P14 | 9 |
| Increased migration from the region due to pollution and declining quality of life | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Compensation costs for affected residents | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Number of casualties and injuries caused by the incident | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Capacity and efficiency of rescue teams in responding to the incident | P1, P2, P3, P4, P5, P8, P14, P15 | 8 |
| Firefighting costs and hazardous material response equipment expenses | P2, P6, P7, P8, P9, P10, P11, P15 | 8 |
| Time required to control and contain toxic gas emissions | P1, P2, P3, P6, P7, P8, P11, P14 | 8 |
| Capacity of urban infrastructure to address similar incidents in the future | P1, P2, P6, P7, P8, P9, P10, P12, P14 | 9 |
| Decline in the credit rating of petrochemical companies after the incident | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |

| | | |
|---|---|---|
| Difficulties in obtaining financial and banking facilities for future projects | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Increase in interest rates and financing costs for polluting industries | P1, P2, P3, P4, P5, P6, P7, P8, P9, P10 | 10 |
| Restrictions on international contracts due to reputational decline | P1, P2, P3, P4, P5, P6, P10, P12, P14 | 9 |
| Reduced willingness of suppliers to cooperate with high-risk industries | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Enforcement of stricter regulations for toxic gas emissions | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Increase in environmental taxes for polluting units | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Possibility of revoking or suspending the operating licenses of some industrial units | P1, P2, P3, P4, P5, P8, P14, P15 | 8 |
| Impact of public protests on policymakers' decisions | P2, P6, P7, P8, P9, P10, P11, P15 | 8 |
| Changes in government support policies toward petrochemical industries | P1, P2, P3, P6, P7, P8, P11, P14 | 8 |
| Decline in demand for petrochemical products due to environmental concerns | P1, P2, P6, P7, P8, P9, P10, P12, P14 | 9 |
| Fluctuations in the prices of raw materials and final petrochemical products | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Changes in export and import trends of petrochemical materials from the region | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Decline in the stock value of petrochemical companies in the stock market | P1, P2, P3, P4, P5, P6, P7, P8, P9, P10 | 10 |
| Withdrawal of investors from high-risk industries due to concerns about their future | P1, P2, P3, P4, P5, P6, P10, P12, P14 | 9 |
| Decline in public trust in petrochemical industries and increased public dissatisfaction | P1, P3, P4, P5, P7, P9, P12, P13 | 8 |
| Increase in environmental complaints and protests by local residents | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Negative impact on the brand image and reputation of petrochemical companies | P1, P2, P8, P9, P10, P11, P14 | 7 |
| Costs required to gain public satisfaction and engage with the local community | P1, P2, P3, P4, P5, P8, P14, P15 | 8 |
| Obligation to implement corporate social responsibility projects to rebuild public image | P2, P6, P7, P8, P9, P10, P11, P15 | 8 |

As shown in Table 1, the experts referred to a wide range of factors in the 15 conducted interviews in response to the research question. In order to summarize and identify the main categories (codes), the identified concepts are presented in Table 2. By comparing the various concepts (codes), greater areas of commonality can be identified, thereby enabling the classification of similar concepts into unified categories. The outcome of this stage of the process was the formation of the components presented below.

**Table 2. Codes (Identified Concepts) Derived from Expert Interviews (Axial Coding)**

| No. | Axial Code | Open Coding |
|---|---|---|
| 1 | Environmental Risk | Level of air pollution caused by toxic chemical compounds |
| | | Level of contamination of surface and groundwater due to chemical emissions |
| | | Destruction of vegetation cover and forests in the affected area |
| | | Impact on wildlife and extinction of biological species |
| | | Environmental cleanup and restoration costs after the incident |
| 2 | Public Health Risk | Increase in respiratory diseases such as asthma and bronchitis |
| | | Incidence rate of skin and eye diseases caused by air pollution |
| | | Increase in hospital visits due to chemical poisoning |
| | | Mortality rate resulting from exposure to toxic gases |
| | | Treatment and rehabilitation costs of patients affected by pollution |
| 3 | Operational Risk | Extent of shutdown or reduced productivity of industrial units after the incident |
| | | Damage to industrial equipment and infrastructure |
| | | Impact of the incident on the supply chain and distribution of petrochemical materials |
| | | Replacement and repair costs of damaged equipment |
| | | Need to halt production for inspection and process reconstruction |
| 4 | Insurance Risk and Legal Liabilities | Increase in insurance premiums for petrochemical companies |
| | | Probability of legal penalties for environmental pollution |
| | | Number of lawsuits against polluting industries |
| | | Amount of compensation determined for damages to affected individuals |
| | | New requirements for obtaining environmental and industrial licenses |
| 5 | Economic and Social Risk | Decline in employment in the region due to impacts on dependent industries |

| | | |
|---|---|---|
| | | Decline in property and land values around contaminated areas |
| | | Reduction in the income of local businesses affected by the incident |
| | | Increased migration from the region due to pollution and declining quality of life |
| | | Compensation costs for affected residents |
| 6 | Safety and Crisis Risk | Number of casualties and injuries caused by the incident |
| | | Capacity and efficiency of rescue teams in responding to the incident |
| | | Firefighting costs and hazardous material response equipment expenses |
| | | Time required to control and contain toxic gas emissions |
| | | Capacity of urban infrastructure to address similar incidents in the future |
| 7 | Credit Risk | Decline in the credit rating of petrochemical companies after the incident |
| | | Difficulties in obtaining financial and banking facilities for future projects |
| | | Increase in interest rates and financing costs for polluting industries |
| | | Restrictions on international contracts due to reputational decline |
| | | Reduced willingness of suppliers to cooperate with high-risk industries |
| 8 | Political and Regulatory Risk | Enforcement of stricter regulations for toxic gas emissions |
| | | Increase in environmental taxes for polluting units |
| | | Possibility of revoking or suspending the operating licenses of some industrial units |
| | | Impact of public protests on policymakers' decisions |
| | | Changes in government support policies toward petrochemical industries |
| 9 | Market Risk | Decline in demand for petrochemical products due to environmental concerns |
| | | Fluctuations in the prices of raw materials and final petrochemical products |
| | | Changes in export and import trends of petrochemical materials from the region |
| | | Decline in the stock value of petrochemical companies in the stock market |
| | | Withdrawal of investors from high-risk industries due to concerns about their future |
| 10 | Social Risk and Public Trust | Decline in public trust in petrochemical industries and increased public dissatisfaction |
| | | Increase in environmental complaints and protests by local residents |
| | | Negative impact on the brand image and reputation of petrochemical companies |
| | | Costs required to gain public satisfaction and engage with the local community |
| | | Obligation to implement corporate social responsibility projects to rebuild public image |

In the selective coding stage, the common dimensions of the components derived from the previous stages were identified and organized into broader and more limited categories based on their similarities. In the first stage, numerous themes were obtained. Through the integration and analysis of these themes using an iterative data analysis process, the complete set of initial codes was reduced to a smaller number of codes. In this process, in order to avoid repetition, all repetitive or conceptually similar initial codes were grouped into a unified set, thereby generating concepts that formed the categories. The results of this stage are presented in Table 3.

**Table 3. Identified Main Themes (Selective Coding)**

| No. | Selective Dimension | Axial Categories | Conceptual Codes |
|---|---|---|---|
| 1 | Environmental and Health Dimension | Environmental Risk | Level of air pollution caused by toxic chemical compounds |
| | | | Level of contamination of surface and groundwater due to chemical emissions |
| | | | Destruction of vegetation cover and forests in the affected area |
| | | | Impact on wildlife and extinction of biological species |
| | | | Environmental cleanup and restoration costs after the incident |
| | | Public Health Risk | Increase in respiratory diseases such as asthma and bronchitis |
| | | | Incidence rate of skin and eye diseases caused by air pollution |
| | | | Increase in hospital visits due to chemical poisoning |
| | | | Mortality rate resulting from exposure to toxic gases |
| | | | Treatment and rehabilitation costs of patients affected by pollution |

| | | | |
|---|---|---|---|
| 2 | Economic and Financial Dimension | Economic and Social Risk | Decline in employment in the region due to impacts on dependent industries |
| | | | Decline in property and land values around contaminated areas |
| | | | Reduction in the income of local businesses affected by the incident |
| | | | Increased migration from the region due to pollution and declining quality of life |
| | | | Compensation costs for affected residents |
| | | Credit Risk | Decline in the credit rating of petrochemical companies after the incident |
| | | | Difficulties in obtaining financial and banking facilities for future projects |
| | | | Increase in interest rates and financing costs for polluting industries |
| | | | Restrictions on international contracts due to reputational decline |
| | | | Reduced willingness of suppliers to cooperate with high-risk industries |
| | | Market Risk | Decline in demand for petrochemical products due to environmental concerns |
| | | | Fluctuations in the prices of raw materials and final petrochemical products |
| | | | Changes in export and import trends of petrochemical materials from the region |
| | | | Decline in the stock value of petrochemical companies in the stock market |
| | | | Withdrawal of investors from high-risk industries due to concerns about their future |
| | | Insurance Risk and Legal Liabilities | Increase in insurance premiums for petrochemical companies |
| | | | Probability of legal penalties for environmental pollution |
| | | | Number of lawsuits against polluting industries |
| | | | Amount of compensation determined for damages to affected individuals |
| | | | New requirements for obtaining environmental and industrial licenses |
| 3 | Operational and Safety Dimension | Operational Risk | Extent of shutdown or reduced productivity of industrial units after the incident |
| | | | Damage to industrial equipment and infrastructure |
| | | | Impact of the incident on the supply chain and distribution of petrochemical materials |
| | | | Replacement and repair costs of damaged equipment |
| | | | Need to halt production for inspection and process reconstruction |
| | | Safety and Crisis Risk | Number of casualties and injuries caused by the incident |
| | | | Capacity and efficiency of rescue teams in responding to the incident |
| | | | Firefighting costs and hazardous material response equipment expenses |
| | | | Time required to control and contain toxic gas emissions |
| | | | Capacity of urban infrastructure to address similar incidents in the future |
| 4 | Political and Social Dimension | Political and Regulatory Risk | Enforcement of stricter regulations for toxic gas emissions |
| | | | Increase in environmental taxes for polluting units |
| | | | Possibility of revoking or suspending the operating licenses of some industrial units |
| | | | Impact of public protests on policymakers' decisions |

| | |
|---|---|
| | Changes in government support policies toward petrochemical industries |
| Social Risk and Public Trust | Decline in public trust in petrochemical industries and increased public dissatisfaction |
| | Increase in environmental complaints and protests by local residents |
| | Negative impact on the brand image and reputation of petrochemical companies |
| | Costs required to gain public satisfaction and engage with the local community |
| | Obligation to implement corporate social responsibility projects to rebuild public image |

A total of 50 indicators within the framework of 10 components (environmental risk, public health risk, economic and social risk, credit risk, market risk, insurance risk and legal liabilities, operational risk, safety and crisis risk, political and regulatory risk, and social risk and public trust) and 4 dimensions (environmental and health dimension, economic and financial dimension, operational and safety dimension, and political and social dimension) were considered by the researcher to ensure sufficient adequacy for selecting the main categories in examining the responses related to the research questions. Based on the components and indicators identified by the participants, the proposed research model was designed.

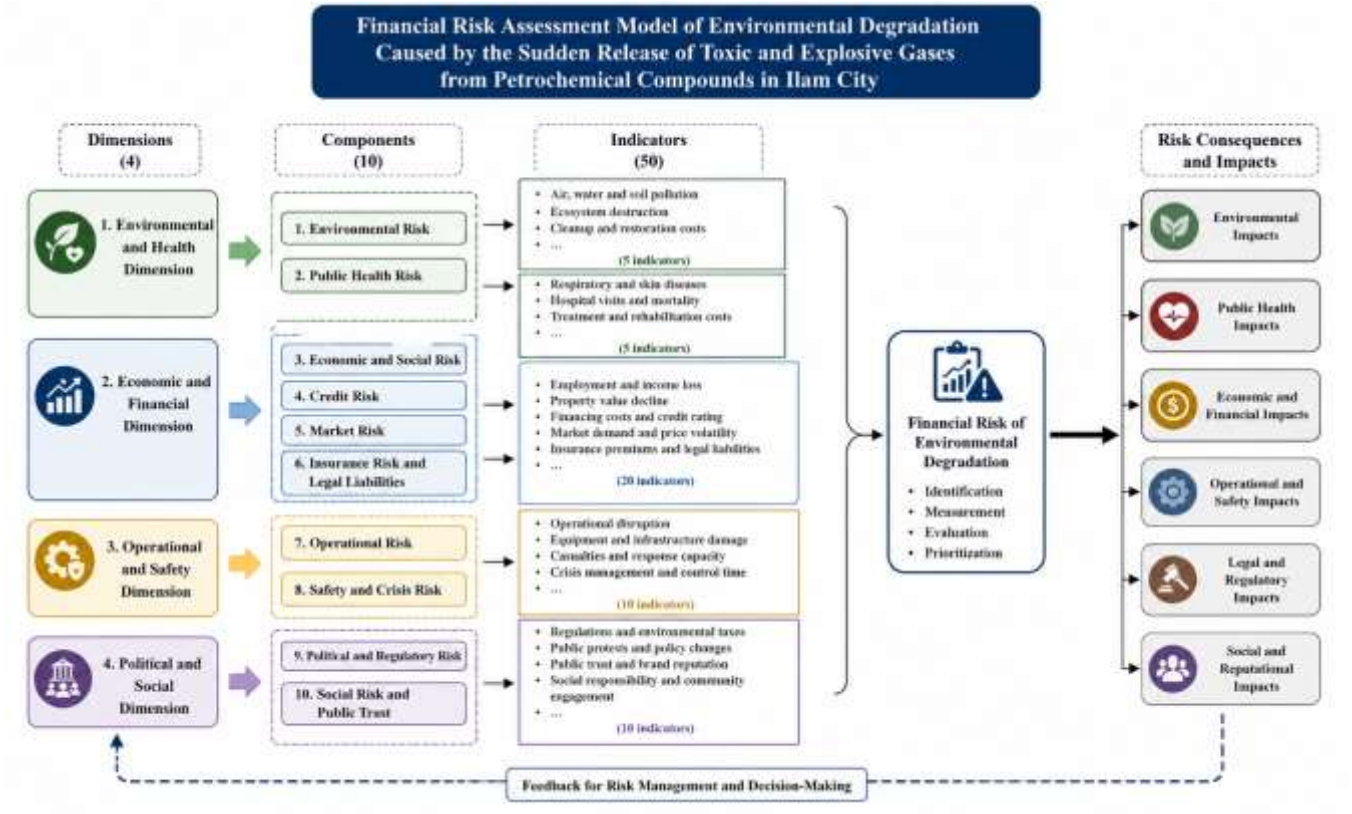



**Figure 1. Financial Risk Assessment Model of Environmental Degradation Caused by the Sudden Release of Toxic and Explosive Gases from Petrochemical Compounds in Ilam**

## 4. Discussion and Conclusion

The findings of the present study demonstrated that the financial risk assessment of environmental degradation caused by the sudden release of toxic and explosive gases from petrochemical compounds in Ilam is a multidimensional phenomenon consisting of 50 indicators organized into 10 components and 4 major dimensions, including environmental and health, economic and financial, operational and safety, and political and social dimensions. The results indicate that environmental degradation resulting from petrochemical incidents extends beyond ecological destruction and directly influences financial stability, public health, industrial productivity, institutional performance, market confidence, and social trust. The identified dimensions collectively reveal that environmental crises in petrochemical industries possess systemic characteristics and create interconnected risks across environmental, economic, and governance systems. These findings are consistent with studies emphasizing that environmental degradation in resource-rich economies is strongly linked to institutional quality, economic instability, and financial market vulnerability [6, 7, 9].

The findings related to the environmental risk component revealed that air pollution, water contamination, destruction of vegetation, loss of biodiversity, and environmental restoration costs are among the primary consequences of sudden toxic gas releases. These results indicate that petrochemical accidents can produce extensive ecological damage that may persist over long periods and impose significant financial burdens on governments and industries. The results align with the findings of [8], who argued that economic activities dependent on natural resources often intensify environmental pressures and undermine sustainability when environmental governance mechanisms are insufficient. Similarly, [7] found that resource-rich economies with weak institutional systems experience higher levels of environmental degradation because industrial expansion is not adequately accompanied by environmental protection policies. The present findings also support the arguments of [3], who emphasized that institutional quality significantly influences the environmental outcomes of natural resource exploitation. In the context of the present study, environmental degradation was not merely an ecological issue but also a major source of financial risk because environmental restoration, compensation, and regulatory penalties generate substantial economic costs for petrochemical industries.

The public health dimension of the findings demonstrated that toxic gas emissions substantially increase respiratory diseases, skin disorders, mortality rates, and healthcare expenditures while simultaneously increasing pressure on healthcare systems. These findings suggest that environmental crises in petrochemical industries create direct and indirect economic burdens through declining workforce productivity, increased medical costs, and reduced quality of life. The results are consistent with studies emphasizing the socioeconomic consequences of environmental degradation in industrial regions [7, 28]. The findings also support the arguments of [6], who concluded that volatility in natural resource sectors significantly affects public administration quality and social welfare. In the present study, the relationship between environmental degradation and public health risks highlights the interconnected nature of ecological and economic systems. Public health deterioration caused by industrial pollution may further reduce regional productivity, increase migration, and intensify public dissatisfaction with industrial and governmental institutions.

The findings concerning the economic and financial dimension indicated that environmental degradation caused by petrochemical incidents significantly affects employment, local business revenues, property values, investment flows, and financial credibility. The study identified credit risk, market risk, and insurance and legal liabilities as critical components of financial vulnerability following industrial accidents. These findings are highly consistent

with the literature on resource-dependent economies and financial instability. [12] demonstrated that financial market risk and institutional quality significantly influence the relationship between natural resource revenues and financial development. Similarly, [13] found that excessive dependence on oil revenues increases economic vulnerability and weakens long-term growth stability. The present study extends these findings by demonstrating that environmental crises themselves may act as catalysts for financial instability through increased insurance premiums, reduced investor confidence, declining stock values, and higher financing costs.

The findings related to market risk revealed that environmental incidents reduce demand for petrochemical products, increase price volatility, and negatively affect stock market performance. These results are supported by studies investigating volatility spillovers and market interconnectedness in energy and commodity markets. [17] showed that oil price shocks generate significant volatility spillovers across industrial metal markets, while [18] found strong time-varying volatility transmission between oil and precious metal prices. Likewise, [26], [27], and [29] emphasized that interconnected commodity markets amplify financial uncertainty during periods of economic or geopolitical instability. The present findings indicate that environmental accidents in petrochemical industries may intensify such market volatility by increasing uncertainty regarding future production, environmental liabilities, and regulatory responses. Furthermore, the withdrawal of investors from high-risk industries observed in the findings reflects the increasing importance of environmental risk in shaping financial market behavior and investment decisions.

The findings concerning operational and safety risks demonstrated that industrial shutdowns, infrastructure damage, supply chain disruptions, and emergency response challenges are among the major operational consequences of petrochemical accidents. These findings suggest that environmental crises substantially reduce industrial efficiency and create long-term operational vulnerabilities. The results align with studies emphasizing the importance of productive capacities, industrial diversification, and economic complexity in reducing vulnerability to external shocks [23, 24]. Economies with stronger productive structures and diversified industrial systems are generally more resilient to industrial disruptions and environmental crises. Conversely, excessive dependence on resource-intensive industries may increase systemic vulnerability and reduce adaptive capacities. The present study demonstrates that petrochemical accidents can disrupt entire industrial ecosystems through production interruptions, logistical failures, and increased operational uncertainty.

Another important finding of the study was the identification of political and regulatory risks associated with environmental degradation. The results revealed that stricter environmental regulations, increased environmental taxes, license suspensions, public protests, and policy changes are among the major political consequences of industrial pollution. These findings support the arguments of [15] and [20], who concluded that economic policy uncertainty and geopolitical risks significantly affect resource-rich economies through institutional and regulatory channels. The findings also align with [4], who argued that resource-rich economies often resist institutional reforms due to structural dependence on natural resource revenues. In the present study, environmental degradation created substantial pressures on policymakers and regulatory institutions because industrial pollution generated social dissatisfaction and increased demands for stricter environmental governance. This finding highlights the importance of institutional quality and policy effectiveness in managing environmental and financial risks.

The findings related to social risk and public trust revealed that environmental degradation reduces public confidence in petrochemical industries, damages corporate reputation, and increases social dissatisfaction and environmental protests. These results are highly important because they demonstrate that industrial pollution

affects not only environmental and economic systems but also social legitimacy and institutional trust. The findings are consistent with [28], who emphasized that unequal distribution of resource-related benefits and environmental burdens may intensify social inequality and dissatisfaction. Similarly, [9] highlighted the role of institutional quality in mediating the social consequences of resource dependence. In the present study, reduced public trust emerged as a critical risk factor because reputational damage may reduce investor confidence, increase regulatory pressures, and undermine long-term industrial sustainability. The requirement for corporate social responsibility projects identified in the findings further indicates that petrochemical industries must actively engage with local communities to restore public legitimacy and social acceptance.

The findings of the present study also support the theoretical literature on economic complexity and resource dependence. Several studies have argued that economies heavily dependent on natural resources often experience lower levels of economic complexity, technological diversification, and institutional development [1, 21, 22]. The multidimensional risks identified in the present study indicate that petrochemical dependence may expose regional economies to severe environmental and financial vulnerabilities if diversification and institutional strengthening are neglected. Moreover, [5] emphasized that institutional quality mediates the relationship between natural resource utilization and economic complexity. The present findings reinforce this argument by demonstrating that institutional inefficiencies may intensify environmental degradation, operational instability, and financial vulnerability in petrochemical industries.

Another important implication of the findings is the interconnected relationship between environmental degradation and financial market behavior. Studies such as [16], [25], and [30] have demonstrated that commodity market interconnectedness and volatility spillovers significantly increase during periods of uncertainty. The present study extends this literature by showing that environmental crises themselves may become major drivers of financial instability through their effects on industrial production, investor confidence, insurance costs, and regulatory risks. Environmental disasters in petrochemical industries therefore should not be viewed solely as environmental incidents but rather as systemic economic and financial events capable of influencing broader market dynamics.

Overall, the findings of the present study indicate that the financial risk assessment of environmental degradation caused by the sudden release of toxic and explosive gases from petrochemical compounds requires an integrated and multidimensional analytical framework. Environmental degradation, public health crises, operational disruptions, financial instability, political pressures, and social distrust are deeply interconnected and mutually reinforcing. The study therefore highlights the necessity of strengthening institutional quality, improving environmental governance, enhancing industrial safety systems, and developing sustainable industrial policies in resource-rich economies. These measures are essential for reducing environmental vulnerability, improving financial resilience, and promoting sustainable economic development in industrial regions such as Ilam.

One of the limitations of the present study was the reliance on qualitative data collected through expert interviews, which may involve subjective interpretations and personal experiences. Additionally, the study focused specifically on petrochemical industries in Ilam, and therefore the generalizability of the findings to other industrial regions or countries may be limited. Another limitation was the difficulty of accessing comprehensive financial and environmental data related to industrial accidents due to confidentiality concerns and institutional restrictions. Furthermore, the multidimensional nature of environmental and financial risks made it challenging to examine all potential variables influencing environmental degradation and financial vulnerability simultaneously.

Future studies are recommended to employ mixed-method or quantitative approaches to validate and statistically examine the relationships among environmental degradation, financial risk, institutional quality, and industrial performance. Comparative studies between different petrochemical regions or countries could provide broader insights into the influence of governance systems and regulatory frameworks on environmental risk management. Researchers are also encouraged to investigate the role of technological innovation, artificial intelligence, and predictive modeling systems in reducing environmental and operational risks in petrochemical industries. In addition, future research could examine the long-term socioeconomic impacts of environmental degradation on local communities, migration patterns, labor markets, and public trust.

Policymakers and industrial managers should develop integrated environmental risk management systems that combine financial assessment, environmental monitoring, and crisis response mechanisms. Petrochemical companies should strengthen industrial safety standards, improve emergency preparedness, and invest in advanced technologies for detecting and controlling toxic gas emissions. Regulatory institutions should enhance environmental supervision, enforce stricter pollution control policies, and improve transparency in reporting environmental incidents. Moreover, petrochemical industries should increase their investment in corporate social responsibility initiatives and establish effective communication channels with local communities to rebuild public trust and reduce social tensions. Finally, financial institutions and insurance companies should incorporate environmental risk indicators into investment evaluations and risk assessment frameworks to improve financial resilience against industrial environmental crises.

**Authors' Contributions**

Authors equally contributed to this article.

**Ethical Considerations**

All procedures performed in this study were under the ethical standards.

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**Conflict of Interest**

The authors report no conflict of interest.

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