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RISK ASSESSMENT AND DECISION-MAKING IN GEOLOGY-DRIVEN PROJECTS: A MANAGEMENT PERSPECTIVE

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SUMMARY

Executing many civil projects is arduous due to the many associated dangers. Risk Assessment (RA) is crucial for selecting building projects and managing construction activities. RA examines adverse events in the preparation and scheduling phases of building projects. Construction risk refers to the vulnerability to possible losses. Given the construction sector's significance to a nation's economy, it is imperative to investigate and analyze diverse risk identification and management solutions. This paper presents a methodology developed through a real-time case study to assess risk in building projects. Risk can be described as determining the probability, intensity, and exposure of all hazards related to a building phase. The research advocates for a combined approach for risk evaluation in building projects utilizing RA and the Geological Information System (GIS) for decision-making. The research identifies various hazards in building projects via the study of the literature research and the formulation of surveys. The suggested study documents the replies from diverse building projects to the specified surveys. The findings of the proposed study identify the primary hazards in building projects. The research advocates for a comprehensive spatial risk evaluation and a GIS-based approach for diverse building projects.

Key words: *risk assessment, decision-making, geology, management.*

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INTRODUCTION

Risk Management (RM) involves identifying, classifying, mitigating, and tracking risks [1]. It is crucial to monitor the quality of project goods and outcomes, prevent schedule and cost overruns, and mitigate environmental and occupational hazards. RM is a cost-effective and systematic strategy for addressing building hazards. The construction sector is the most hazardous of all industries. Effective RM techniques are essential to guarantee the project's achievement concerning time, money, quality, security, and the sustainability of the environment [2]. RM is regarded as a crucial element and has gained international prominence in the building sector due to significant attention from scholars. This new tool necessitates additional effort to provide efficient characteristics that mitigate the adverse effects of risks on the advancement of building projects [3].

In financial or economic contexts, risk is defined as the likelihood of actual benefit deviating from anticipated gain. It entails the possibility of losing a portion or all of the savings. Risks encompass several categories, including commercial risk, risk related to politics, national risk, risk associated with investments, medical risk, industry risk, catastrophe risk, construction risk, and worldwide risk. Construction risk is characterized as a susceptibility to potential losses. Building tasks entail several dangers, mainly on-site [24]. These dangers are categorized as external or internal. The United Nations International Strategies for Disaster Relief (UNISDR) characterizes disaster risk as "the possibility of life, harm, or destruction/damage to assets that affect an organization, community, or society within a defined timeframe, assessed logically based on hazard, contact, and ability."

Uncertain risks result in scientific, financial, social, and human losses [5]. Diligent project tracking and proactive risk detection are essential to mitigate these potential losses. Completion of the project on schedule and within financial constraints signifies its fulfillment. Project uncertainty leads to delays and subsequent cost delays. In the construction industry, risk is the uncertainty of events that lead to dangers, financial loss, and physical harm. An individual inflicts harm upon herself or others in the workplace is identified as an occupational safety and health hazard. Construction hazards lead to fatalities, severe damage, and economic detriment [6]. The construction industry significantly impacts a nation's economy, necessitating various risk assessment and mitigation measures to minimize the effects of hazards in construction.

Construction projects, including real estate and facilities, are distinctive. If some features are overlooked, it become vulnerable to dangers. Key components include team size, resource availability, appropriate supply storage, a skilled workforce, complex layout and structure, frequent team conferences, and ongoing project monitoring. If well managed, these aspects mitigate the project's effect [21, 22]. RM is crucial to project execution and oversight within the construction sector [7]. RM encompasses analyzing and mitigating different hazards associated with building initiatives, including monetary, socioeconomic, ecological, and construction-related concerns [4].

The erratic nature and randomness of the building industry's environment is undeniable. It is significantly affected by external factors, including technical, layout, logistical, tangible, functioning, ecological, socio-political, and unforeseen elements, which can derail undertakings and lead to irreversible deviations [8].

Risk Assessment (RA) methodologies, including polls and impact evaluations utilizing a Likert rating system and color coding, have been employed to identify dangers in construction [9]. The procedures employed assist project management in identifying hazards within the current building project. Traditional safety analyses at sites, while easily adaptable, encounter substantial challenges. Construction experiences significant alterations depending on the nature of the project and the accessible workforce. The RA techniques for particular operations do not account for adjacent endangered industries. RA, RM of high-risk zones in construction, and the implementation of innovative methods for risk mitigation are appropriate for short-term risk control. A user-friendly time and space strategy can facilitate managing risks at various construction phases to mitigate long-term concerns [10]. Proactive detection of hazards reduces their impact on the building. The spatial-based methodology in RA facilitates the strategic planning of structures in a deliberate and detailed manner. Geological

Information System (GIS) based RA in urban regions has been effectively conducted, considering seismically prone locations and seismic sensitivity curves [11]. The geographical methodology employed in Sikkim for multi-hazard RA yielded precise outcomes through both quantitative and qualitative analyses.

- Research evaluation indicates that geographical, temporal, and GIS-based technology is highly beneficial for building strategy and RA; moreover, there needs to be more research focused on examining and promoting their uses in building management. The primary aims of the planned study are outlined below.
- To determine significant risk domains in several categories of building projects documented in the literature,
- To examine diverse building initiatives and ascertain significant risk factors impacting them
- To select a highway convey for case study analysis, detect significant risk regions, and implement an RA methodology for roads and
- To propose a broader framework for RA and prevention applicable to diverse construction initiatives derived from the methodology invented for highways.

BACKGROUND

This section highlights the hazards associated with various building initiatives and their effects on development.

Risks Associated with Construction Projects

Construction endeavors are complex and can present several internal and external risks. To successfully reduce these hazards, it is essential to comply with a stringent set of norms, laws, and rules during the building phase [12]. It is unequivocally possible to eradicate risks, as unforeseen aspects will unavoidably arise during a project. Comprehending the many kinds of hazards and their corresponding management solutions is among the most productive methods of handling risks [13]. Proactively identifying and categorizing dangers before initiating a project facilitates the enhancement of risk control and the mitigation of possible losses. Building initiatives encountered several categories of hazards. This section delineated these threats into six primary categories.

- Technical hazards: Technical dangers include any elements that obstruct the creation of the specific product required by the client. This includes ambiguity over resources and supply, inadequate site evaluation, or unfinished design. These hazards often emerge due to project size and need alterations, design deficiencies, or omissions [23].
- Environmental hazards include natural disasters, meteorological events, and seasonal effects [14]. The typical neglect of these hazards arises when persons are unfamiliar with their surroundings. Before initiating a project in an unfamiliar town, it is essential to familiarize oneself with the prevailing climate trends of that area. One can substantially enhance the probability of averting possible damage and disruptions by adequately planning for impending weather threats.
- Logistical hazards [15]: Before initiating a project, it is essential to identify and address specific logistical risks. The identified threats include the reach of transport infrastructures and the affordability of machinery, such as spare components, fuel, and manpower. The inability to address these logistical problems leads to considerable project delays and financial consequences.
- Management hazards [16]: The primary risk linked to managing employees is the unpredictable productivity of assets. Before initiating a project, it must confirm that the team has the requisite competence and that their separate tasks and responsibilities are well-defined. Neglecting to do this leads to severe financial losses.

- Socio-political hazards [17]: Ports and import restrictions and difficulties in equipment destruction are socio-political issues that emerge throughout a construction project. The project's location will dictate the applicable regulations and regulations it must adhere to. If it assumes that all assignments will conform to the exact requirements and rules, it will face a stark awakening.

- Financial Hazards [18]: Possible financial risks associated with a construction project encompass price increases, local taxes, and the fluctuations and instability of foreign exchange rates.

When engaging in an international project, it is essential to possess a thorough comprehension of foreign money exchange regulations. Before initiating a project, evaluating the substantial discrepancies in taxation among several countries is necessary. The financial situation will differ markedly based on whether you work in a tax-free city or an elevated tax rate.

Risk Control in the Construction Sector

Construction risks encompass a variety of categories, including safety concerns, chemical dangers, physical dangers, design dangers, economic dangers, social dangers, dangers to the environment, technical dangers, time dangers, and financial hazards. These risks impact the construction timeline and budget if not managed promptly. RM is essential in construction to properly evaluate and recognize hazards and mitigate adverse outcomes.

RM is essential for assessing the effects of risks on infrastructure construction projects, including crossings. RM is a systematic process for finding and handling dangers and addressing them immediately throughout a project. RM is essential in construction to mitigate the impacts of risks [19]. RA is necessary in construction as it impacts the cost of capital. Crucial construction tasks must be meticulously planned from inception, with distinct project team leaders designated to manage these risks. The expansion of any sector necessitates safety, dependability, and long-term viability in its operations; hence, recognizing and handling risks are essential in burgeoning industries such as construction.

Various scholars employed diverse methodologies to implement RM in construction. The dangers have been categorized into outside, within, and project-specific dangers. These are further classified into several sorts, including political, meteorological, financial, social, asset, quality, temporal, construction, cost, technology risks, and others [20]. Multiple Criterion Decision-Making (MCDM), including Simple Addition Weighting (SAW), Technique for Order of Preference by Similarity to Ideal SolutionS (TOPSIS), and Complexity Proportional Assessment (COPRAS), have facilitated RA by employing various options as attributes through decision-making techniques such as COPRAS and the TOPSIS-grey level the framework. A form of survey is an essential initial step in evaluating risks. It facilitates site visits and in-person talks with teammates, from project managers to supervisors. The Likert rating system enables the administration of surveys with questionnaires and the RA intensity. Integrating the Questionnaire and the Relative Importance Indicator (RII) is beneficial for decision-making in risk mitigation within construction [21]. The Analytic Hierarchy Procedure (AHP), RII, and survey questions facilitated the identification of schedule delays in Nuclear Power Project (NPP) projects. The strategy established a scoring matrix for the seriousness of hazards and their frequency of recurrence. The strategy proved helpful in mitigating delay concerns in the planning of NPP operations. The administration of an online survey and the RII approach facilitated the identification of the type and incidence of risk events in development. RM is a crucial tool that enables us to address numerous hazards, analyze them, and implement corrective measures to mitigate them in a specific project.

RISK ASSESSMENT

Numerous firms need comprehensive knowledge of innovation risks and must adequately incorporate them into the project management procedure. This results in failures and losses of money. The essay seeks to determine and assess critical risks, enhancing organizational knowledge and readiness to manage problems. Effective RM in creative endeavors necessitates the formulation and execution of approaches to mitigate adverse impacts and guarantee the successful completion of the project. The research seeks to elucidate methods and techniques for RM that provide tangible value for companies.

A method for RA connected with creative efforts is developed based on the findings of the literary source assessment.

Step 1: Establishing the Context and Parameters of the RA

- Identification of the research domain for the creative project.
- Establishment of the objectives and subjects of RA.
- Delineation of the project's scope and its essential components.

Step 2: Risk Recognition

- Compile a list of possible hazards that impact the innovative task.
- Identify sources of risks, including technical challenges, financial limitations, fluctuations in market circumstances, etc.
- Evaluation of pop-up ventures akin to the creative initiative to ascertain potential risk situations.

Step 3: Evaluation of Risks

- Evaluation of the likelihood of every risk occurring and its potential effect on the creative project.
- Apply quantitative and subjective methodologies for RA, including data evaluation, expert evaluations, scenario evaluation, etc.
- They prioritize risks based on their significance and effect on the creative project.

Step 4: Formulation of Risk Management Tactics

- Evaluation of various RM tactics, including avoidance, reduction, transfer, or acceptance of risk.
- Recognition of specific evaluations and methodologies for each risk to mitigate its impact or likelihood of happening.
- Formulation of action objectives for executing RM tactics and designated individuals accountable for their execution.

Step 5: Surveillance and RM

- Implementation of a risk tracking structure to identify modifications in the risk surroundings and facilitate timely responses.
- Regular evaluation of the efficacy of RM methods and needed modifications.
- Interact and collaborate with all participants to promote effective risk administration throughout the project.
- The methodology offers overarching direction for RA in creative endeavors. It is important to note that specific techniques and methods differ based on the circumstances and particulars of every job.
- Business RM indicators fluctuate based on the particular environment and attributes of the firm, as indicated by the analysis findings. The subsequent are overarching indications that might be employed to assess and appraise the efficacy of RM:

- Recognized risks: The quantity of hazards recognized and articulated within the RM framework. This indicator demonstrates the organization's comprehension of possible dangers and possibilities.

- RA: An evaluation of the probability of hazards materializing and their possible effects on the company. This indicator enables the establishment of priorities for RM and decision-making.

- Risk Adoption Status: Document and evaluate the degree of risk tolerance for every determined risk. This indicator reflects the company's perception of risks and readiness to embrace them.

- Executed RM protocols: Quantity and efficacy of executed RM processes and approaches. This indicator demonstrates the effectiveness of the implemented RM strategies and procedures.

A projection of trends in the RM parameters related to creative initiatives was generated based on the statistical examination of domestic firms. The trending line indicates that by 2035, the RM of innovation initiatives would revert to pre-quarantine success metrics of:

- Identified dangers.

- RA.

- Risk tolerance levels.

- Applied RM strategies.

Two positive and ideal situations were developed to illustrate the pattern line. The optimistic scenario presumes a context devoid of adverse external influences on the sector. The perfect scenario accounts for adverse external circumstances or obstacles that might impede the industry's progress. Thus, a matrix was developed to illustrate the resultant aspects affecting the execution of projects in crises. The constructed matrix for assessing indicators facilitates the evaluation of every indicator's efficacy and its integration into the defined variables. This approach assists in identifying both favorable and ideal circumstances for the sector's advancement throughout crises.

RISK MANAGEMENT PROCESS

The analysis delineates multiple methods for RM, underscoring that discrepancies typically reside in the granularity and allocation of tasks to specific stages and phases instead of in the overarching substance of the procedure. Although categorization differs, the fundamental elements of the risk strategy for management stay unchanged. The World Road Organization delineates an RM approach for extensive road projects, primarily encompassing risk recognition and risk appraisal as essential elements.

The research suggestion aims to investigate the integration of risks into making choices at various phases of significant construction projects, utilizing the East-West construction as a case scenario. This study seeks to elucidate how decision-makers in developing countries manage intricate construction endeavors in the face of diverse hazards by analyzing the interplay between aspects of the attributes of the RA. This research aims to enhance the knowledge of the impact of methods for RM on how decisions are made in significant construction projects, especially in developing nations. The research seeks to provide practical suggestions for optimizing procedures for RM and increasing the effectiveness of construction endeavors in analogous environments through empirical inquiry and evaluation. Figure 1 illustrates the sequential phases of RM employed in the present research.

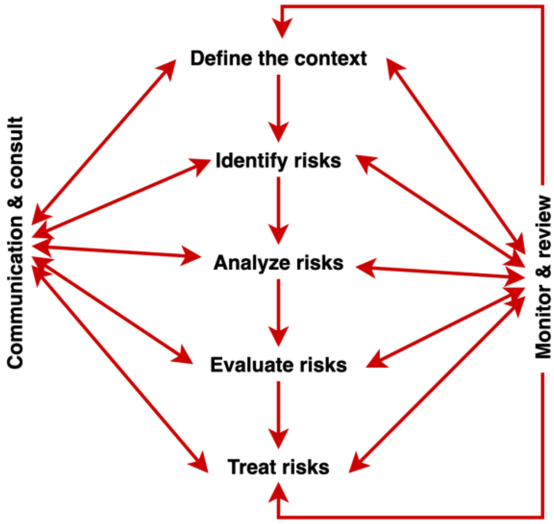

Figure 1. RM process

RM procedures differ in procedures and language across various sources and scholars. A cycle encompassing identifying risks, evaluation, control, and reports encapsulates a project's fundamental components of risk management.

The Project Managing Institute's (PMI) Guides to the Project Managing Body of Knowledge (PMBOK) delineates a more comprehensive procedure, which encompasses:

- RM Development: Defining the strategy, technique, and resources for overseeing risks during the project’s lifetime.
- Risk Recognition: Recognizing possible hazards that might impact the project's goals, both advantageous and detrimental.
- Qualitative RA: Evaluating the probability and consequences of recognized risks by subjective assessment or scales of ordinal value.
- Quantitative RA: A numerical assessment of the possible effects of hazards on the project's goals, frequently employing methodologies such as Monte Carlo simulations.
- Risk Response Development: Formulating methods to successfully address recognized hazards, encompassing mitigation, prevention, movement, or tolerance.
- Risk Tracking and Controlling: Ongoing surveillance of identified risks and evaluation of their current state during the project lifespan, with the implementation of remedies and assessment of the efficacy of risk-managing measures.

The research emphasizes analogous fundamental components in the RM procedure, encompassing risk detection, measurement, reaction, and control. Although multiple sources depict the risk-handling procedure differently, the core concepts remain unchanged. These encompass risk identification, impact assessment, strategy development for response, and ongoing tracking and oversight of risks during the work's lifespan. The purpose is to mitigate the adverse effects of hazards on project goals while enhancing prospects for success.

DECISION MAKING

It is widely believed that governmental strategy decisions significantly influence company efficiency levels. Strategic choices in building projects are frequently linked to project phases. The notion of strategic decisions must be explicitly delineated to examine its possible influence on project advancement. The strategic choice-making in big socio-economic construction initiatives poses significant challenges for administrations. This is attributable to substantial risks linked to project scale, financial resources, technical implementation, and the intricacy of managerial procedures inherent to such projects. Decision-making process shown in Figure 2.

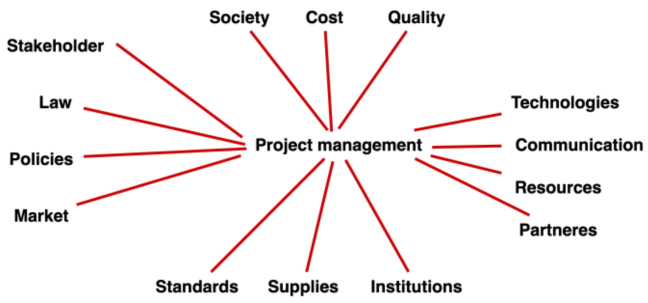

Figure 2. Decision-making process

In this setting, the growth of socio-economic development initiatives throughout the third century has been marked by substantial improvements in architecture and facilities, resulting in financial and social progress. These mega-projects have encountered significant problems, primarily arising from deficiencies in the way decisions are made.

The National Instrument Fund for Development recognized the ineffectiveness of decision-making procedures as a primary cause of issues in building infrastructure. These challenges have significantly affected investment expenses, workmanship, and building schedules. In response to these issues, the government implemented several legal and institutional reforms in 2002 to enhance the tactical oversight of socio-economic construction projects. Over the last decade, debates have highlighted the necessity of including two fundamental concepts in the decision-making procedure for large-scale building projects:

- Compliance with Regulations and the Organizational Framework: The initial method emphasizes the need to adhere to legal standards and delineate roles by following regulations about the company, planning, and timelines. This guarantees that judgments are logical and consistent with the government's objectives. It depends on well-defined organizational frameworks and the capabilities of executive entities to ensure the constitutionality and validity of actions.

- Comprehensive Analysis and Stakeholders Engagement: The second strategy is meticulously and systematically assessing a choice's beneficial and detrimental effects. This technique evaluates many situations and involves pertinent players and stakeholders in dialogues. By determining the merits and drawbacks of many alternatives, decision-makers guarantee clarity and logic in their decision-making processes.

Under the legislation, the decision-making procedure for highway construction consists of several phases:

Recognition: This preliminary phase entails recognizing and conceiving highway initiatives and delineating their scope and goals.

Expenditure Decision-Making: After identifying projects, judgments are taken concerning resource distribution and investment.

Implementation Stage: The concluding step involves tendering, building, and administration of the roadway projects, assuring compliance with set rules and schedules.

The decision-making method, especially concerning construction projects, is governed by the values of the social and economic project administration maturity paradigm. In the first evaluation phase, many approaches are typically utilized:

Evaluation of the ecological impact of plans and programs entails assessing the prospective environmental effects of planned construction tasks and initiatives. It evaluates adherence to ecological standards and sustainability goals.

Partial Sustainable: This evaluation concentrates on the environmentally friendly dimensions of construction projects. It evaluates financial, social, and ecological variables based on future forecasts and analyses.

Economic Impact Study (EIS) about projects: Comprehensive analyses are performed to evaluate the distinct environmental effects of particular infrastructure initiatives. This encompasses examining land utilization, ecosystems, water quality, and the environment. Many analytical tools are employed for comprehensive analysis:

- Multi-criteria evaluation: This approach assesses infrastructure projects according to many criteria, including economic viability, ecological impacts, and social advantages. It enables thorough evaluations and informed choices by incorporating several viewpoints.
- Value evaluation enhances project results by pinpointing opportunities to increase value and minimize expenses. It entails assessing several methods or strategies to attain objectives effectively.
- Cost-benefit research: This study evaluates the costs and advantages linked to infrastructure initiatives. It measures project advantages in financial terms and evaluates financial viability and prospective investment returns.
- Tariff research: Tariff research assesses prospective tariffs or tolls related to infrastructure construction. It evaluates traffic density and income production to establish suitable pricing approaches to generate long-term financing.

Using these methodologies and analytical tools, decision-makers can methodically assess construction projects and their ecological and long-term impacts and arrive at informed choices consistent with managing project standards and national growth objectives. Decision-making the architecture of the highway projects shown in Figure 3.

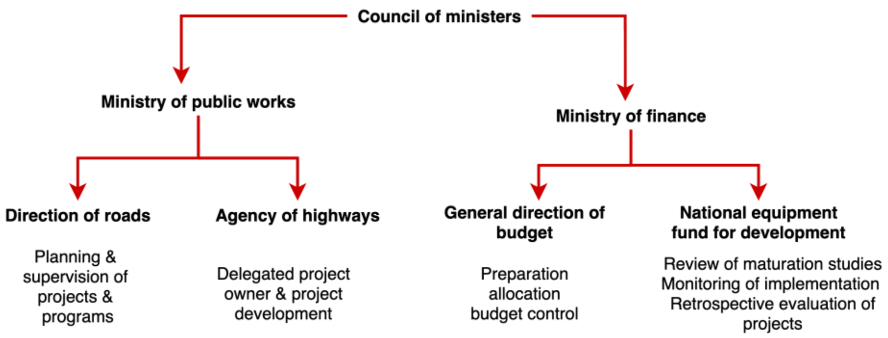

Figure 3. Decision-making the architecture of the highway projects

The authorities have enacted various legal tools to furnish substantial legislative backing for the management plan for mega-construction enterprises. These legislative frameworks seek to improve decisions among diverse businesses and government agencies building infrastructure. The federal government aims to enhance managerial efficiency, enforce adherence to guidelines and requirements, and foster transparency and responsibility in the construction industry by implementing these rules and legislation.

These legal tools are essential for furnishing the requisite legal framework for the oversight plan for mega-construction enterprises. They facilitate the establishment of a conducive atmosphere for effective project execution, encouraging healthy development and enhancing the enduring success of infrastructure improvements.

CONCLUSION

The application of GIS in RA aids in alleviating the effects of hazards faced during building. This study examines the primary dangers associated with construction sites. A thorough review was conducted, subsequently leading to the creation of a survey. A careful examination of chosen sites was performed to identify the primary risk sources across various building projects. The primary issues identified were difficulty obtaining land and the prevalence of black cotton soil. GIS was employed in the study to get data on the purchase of land and soil properties.

Land areas comprising urban regions, farms, countryside, and other natural environments have been purchased. The data RA method has shown considerable relevance, notably for roadways. If this had been accomplished during the preparation phase, it saved much time and effort. This study introduces a comprehensive methodology for assessing and mitigating risks in diverse building endeavors based on the structure established for roadways. Future research suggests employing Artificial Intelligence (AI) techniques, including Neural Networks (NN), optimization methods, and purely logical frameworks, to improve RM accuracy.

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