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A unified risk management framework for cost and resource optimization in housing development projects

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Abstract

The increasing demand for affordable housing has highlighted the need for more efficient project management strategies, especially in the face of rising costs, resource constraints, and regulatory complexities. This paper proposes a unified risk management framework designed to optimize cost and resource allocation in housing development projects. The framework integrates various risk management techniques, including risk identification, assessment, and mitigation, with cost control methods and resource optimization strategies. It emphasizes a dynamic, data-driven approach to evaluating and managing risks throughout the lifecycle of housing projects, from planning and execution to monitoring and completion. By embedding risk management practices into all project phases, this framework enhances project efficiency, reduces the likelihood of cost overruns, and ensures timely delivery of housing projects. Real-world case studies demonstrate the framework's potential to improve housing development outcomes, though challenges such as data limitations, stakeholder alignment, and resistance to change must be addressed for successful implementation. The paper also identifies promising areas for future research, including the integration of AI and machine learning for predictive risk assessment, real-time monitoring systems, and further exploration of strategies for large-

scale housing developments. Overall, the unified risk management framework offers a holistic solution to the persistent issues of cost and resource optimization in housing development.
Keywords: Risk Management, Housing Development, Cost Optimization, Resource Allocation, Predictive Analytics, Project Management.

INTRODUCTION

Context and Importance of Housing Development Projects

Housing development plays a pivotal role in shaping the socio-economic fabric of communities, influencing economic growth, and providing shelter as a fundamental human need. Particularly, affordable housing is critical to addressing the growing issue of urbanization and the increasing population in cities worldwide (Onukwulu, Fiemotongha, Igwe, & Ewim, 2023). In many regions, the gap between housing demand and supply continues to widen, exacerbating issues such as overcrowding, rising rent prices, and slum development. The successful execution of large-scale housing development projects is essential in addressing these problems while ensuring that the housing provided is accessible, livable, and sustainable (Abisoye et al.; Gil-Ozoudeh, Iwuanyanwu, Okwandu, & Ike).

However, housing development projects, especially on a large scale, often face significant challenges that hinder their success. Resource constraints, such as limited land availability, financing, and skilled labor, can greatly affect the project's timeline and quality. Additionally, cost overruns and delays are common problems, with projects frequently exceeding budgets and timeframes, which impacts the affordability and availability of housing (Eyo-Udo et al., 2024; Onukwulu, Agho, Eyo-Udo, Sule, & Azubuike, 2024b). These inefficiencies not only strain financial resources but can also result in missed opportunities to provide housing for those most in need. The urgency of addressing these challenges has made effective project management and resource optimization paramount in housing development, especially in times of economic uncertainty and rising demand for affordable housing (Afolabi & Akinsooto, 2021; Igwe, Eyo-Udo, & Stephen, 2024b).

Given the global and regional housing challenges, the integration of a comprehensive and structured approach to managing risks—particularly those related to cost and resource optimization—becomes increasingly important. Without the proper strategies in place to manage risks and optimize the use of resources, housing projects are at risk of failing to meet their goals, which can lead to even larger social and economic problems (Paul, Ogugua, & Eyo-Udo, 2024b).

Overview of Risk Management in Housing Projects

Risk management in housing projects is essential for navigating the complexities and uncertainties that arise during their planning and execution. Housing development projects often involve a multitude of stakeholders, including developers, contractors, governmental agencies, and the communities who will inhabit the spaces. Each of these entities may introduce various risks into the project that, if not properly mitigated, could cause disruptions. These risks can be classified into different categories: financial risks, operational risks, regulatory risks, and environmental risks (Adewoyin, 2022; Akhigbe, 2025).

Financial risks are among the most critical in housing development, as they directly affect the project's budget and overall viability. Fluctuations in construction costs, financing issues, and changes in market demand can jeopardize the financial stability of the project. Operational risks, on the other hand, involve issues like construction delays, resource shortages, and poor project coordination, which can all lead to project delays or compromised quality (Olufemi-Phillips, Ofodile, Toromade, Igwe, & Adewale, 2024).

Regulatory risks are related to non-compliance with local and international building codes, zoning laws, and other regulations that govern the construction process. Failure to meet these legal requirements can result in project halts, fines, or even project abandonment.

Environmental risks involve issues such as unexpected site conditions, adverse weather, and ecological concerns that can disrupt the construction process and escalate costs (Basiru, Ejiofor, Onukwulu, & Attah, 2022; Daramola, Apeh, Basiru, Onukwulu, & Paul, 2025).

Given the multifaceted nature of these risks, a holistic and integrated approach to risk management is crucial. This approach should identify and assess potential risks at every stage of the project, from planning and design to construction and post-completion. By effectively addressing these risks through preventive and corrective measures, housing developers can reduce the likelihood of negative impacts on cost and resource allocation, ensuring a smoother project execution process (Oluokun, Akinsooto, Ogundipe, & Ikemba, 2025; Onukwulu, Fiemotongha, Igwe, & Ewin, 2024).

Objectives of the Paper

The primary objective of this paper is to develop a unified risk management framework that focuses on the critical aspects of cost control and resource optimization in housing development projects. This framework aims to identify and mitigate the various risks that can affect the success of large-scale housing initiatives. By integrating risk management techniques into each phase of a housing project, the framework seeks to improve decision-making, enhance resource utilization, and prevent cost overruns and delays that are commonly associated with such projects.

Additionally, the paper aims to explore how a unified risk management approach can lead to better stakeholder coordination and more effective implementation of housing policies. The integration of such a framework can provide valuable insights for developers, project managers, and policymakers, helping them to optimize resource allocation, improve project planning, and execute projects within their defined budgets and timelines. Ultimately, the unified framework should contribute to the creation of more efficient, cost-effective, and sustainable housing development projects that are capable of addressing the global housing crisis.

Furthermore, the paper will explore the potential applications of the proposed framework across different housing projects, from small-scale residential developments to large urban housing initiatives. The potential benefits of this approach will be discussed, along with recommendations for further research into the refinement and scaling of the model. By offering a practical solution to managing the inherent risks in housing projects, this paper aims to contribute to the body of knowledge on project management and provide a foundation for future studies in housing development and risk management.

LITERATURE REVIEW

Existing Risk Management Frameworks in Housing Projects

Risk management in housing projects is a widely studied area, with various frameworks proposed over the years to address the unique challenges faced during development. Traditional risk management techniques have often focused on identifying, assessing, and mitigating risks through structured processes such as risk registers, qualitative and quantitative risk analysis, and contingency planning (J. O. Basiru, C. L. Ejiofor, E. C. Onukwulu, & R. U. Attah, 2023c). These methods, while effective in certain contexts, tend to be linear and reactive, offering limited flexibility in the face of dynamic project conditions. The risk identification process usually begins at the project initiation phase and progresses through planning, execution, and delivery. However, such traditional frameworks have been criticized for their inability to adapt to the complexity and unpredictability of modern housing projects, particularly those involving large-scale developments or a high number of stakeholders (Abisoye & Akerele, 2022; Chisom Elizabeth Alozie, Olanrewaju Oluwaseun Ajayi, Joshua Idowu Akerele, Eunice Kamau, & Teemu Myllynen).

In response to the limitations of traditional methods, more contemporary frameworks have emerged that emphasize flexibility, continuous monitoring, and real-time risk assessment.

These modern approaches incorporate new tools and technologies, including risk simulation models, advanced software for risk tracking, and integrated communication platforms for real-time decision-making (Oluokun, Akinsooto, Ogundipe, & Ikemba, 2024d). The incorporation of these advanced methodologies has allowed housing developers to better anticipate risks such as market fluctuations, labor shortages, and regulatory changes, with a more proactive approach.

Furthermore, these frameworks have increasingly incorporated the principles of lean management, systems thinking, and the integration of stakeholder perspectives into risk management processes. This shift has been aimed at addressing the limitations of traditional frameworks, which often overlooked the holistic nature of risk in housing projects (Chisom Elizabeth Alozie, Olarewaju Oluwaseun Ajayi, Joshua Idowu Akerele, Eunice Kamau, & Teemu Myllynen; Paul, Ogugua, & Eyo-Udo, 2024a).

Despite these advancements, existing frameworks still struggle with fully integrating various types of risks—financial, operational, environmental, and social—into a cohesive, dynamic model that adapts to the full range of challenges faced in housing development. The evolving complexity of housing projects requires more comprehensive frameworks that can account for both internal and external factors and facilitate real-time decision-making to optimize outcomes (Egbuhuzor, Ajayi, Akhigbe, & Agbede, 2024).

Cost and Resource Optimization in Housing Projects

The literature on cost and resource optimization in housing projects is extensive, with numerous studies exploring various strategies to minimize costs, reduce waste, and enhance resource allocation. One of the key challenges in housing development is balancing the desire for affordable housing with the escalating costs of land, materials, labor, and financing. Effective cost management is essential to ensuring that projects remain within budget, meet quality standards, and are completed on time (Egbuhuzor et al., 2025).

Resource optimization in housing projects typically focuses on improving the efficiency of resource usage across various stages of development. This includes strategies for better managing construction materials, reducing material wastage, improving labor productivity, and utilizing machinery and equipment effectively. Previous research has demonstrated the potential benefits of adopting lean construction techniques to streamline processes and reduce inefficiencies. Lean principles, which originated in manufacturing, emphasize minimizing waste—whether it is time, materials, or labor—by focusing on value creation and eliminating non-value-adding activities (ADENIYI & ADELUGBA, 2024; Egbuhuzor, Ajayi, Akhigbe, & Agbede, 2022).

Another important focus in the literature has been the role of technology in optimizing resource use. The advent of digital tools such as Building Information Modeling (BIM), advanced project management software, and automated scheduling tools has allowed developers to model and track the allocation of resources in real-time, leading to better planning and decision-making. These tools help project managers to optimize construction timelines, minimize costs, and avoid delays caused by resource shortages or misallocation. BIM, for example, enables precise calculations of material requirements, reducing excess procurement and the risk of errors during construction (Ajayi, Akhigbe, Egbuhuzor, & Agbede, 2022; Onukwulu, Fiemotongha, Igwe, & Ewim, 2022).

Moreover, studies have shown that effective cost management involves both short-term cost reduction strategies and long-term investment in sustainable practices. Sustainable building practices, such as energy-efficient designs and the use of environmentally friendly materials, may initially increase project costs but have the potential to yield long-term savings in terms of reduced energy consumption and maintenance costs. Therefore, a comprehensive cost and resource optimization strategy in housing projects should consider both the immediate

financial implications and the long-term economic benefits (Ajayi, Agbede, Akhigbe, & Egbuhuzor, 2023; Fiemotongha, Igwe, Ewim, & Onukwulu, 2023b).

Gaps in Existing Literature and Research

While the literature on risk management and cost optimization in housing projects is rich, there are several significant gaps that need to be addressed. One of the key shortcomings is the lack of integration between cost control and resource management. Although both cost and resource optimization are critical for the success of housing development, existing frameworks often treat them as separate entities. This siloed approach can lead to inefficiencies, as the allocation of resources may not be aligned with the project's financial constraints, and vice versa. There is a growing recognition in the literature that a more integrated approach is necessary, one that considers cost, resource use, and risk management as interconnected elements in a unified framework (Okeke, Alabi, Igwe, Ofodile, & Ewim, 2024a, 2024b).

Additionally, many of the existing frameworks remain static and rely on historical data, which can quickly become outdated or fail to account for dynamic market conditions, regulatory changes, or unforeseen disruptions. The need for more dynamic, data-driven approaches to risk management and resource optimization is becoming increasingly evident. Real-time data analytics, machine learning algorithms, and predictive modeling techniques are emerging as promising tools to address these challenges. However, their application in housing projects has been limited, and further research is needed to explore how these advanced technologies can be integrated into existing frameworks (Ajayi et al., 2023).

Furthermore, while there is an emphasis on cost and resource optimization, there is a lack of attention given to the human factors in housing projects, such as the skills and capabilities of the project team, the role of collaboration among stakeholders, and the importance of stakeholder engagement. These human elements are often critical in ensuring the successful execution of housing projects but are frequently overlooked in the existing literature on cost and resource optimization (Fiemotongha, Igwe, Ewim, & Onukwulu, 2023a).

Finally, the existing research on risk management in housing development has largely focused on large-scale projects in developed countries, with limited attention given to the challenges faced in developing regions. Housing projects in emerging economies often face different sets of risks, such as political instability, informal markets, and inadequate infrastructure. More research is needed to develop frameworks that are tailored to the specific risks and conditions in these contexts, ensuring that housing projects are both sustainable and adaptable to local conditions (Odio et al., 2021).

These gaps indicate that there is a need for more holistic, data-driven, and context-sensitive approaches to risk management and resource optimization in housing development. Bridging these gaps will not only improve project success rates but also ensure that affordable housing projects meet the growing demand for shelter across diverse regions and socio-economic contexts (Oluokun, Akinsooto, Ogundipe, & Ikemba, 2024c; Paul, Abbey, Onukwulu, Agho, & Louis, 2021).

METHODOLOGY FOR DEVELOPING THE UNIFIED FRAMEWORK

Approach to Risk Identification and Assessment

The first step in developing a unified risk management framework for housing development projects is the identification and assessment of potential risks. Risk identification is typically conducted through a combination of qualitative and quantitative methods. The qualitative approach includes brainstorming sessions, expert interviews, and workshops with stakeholders such as project managers, contractors, and architects. This approach helps to uncover risks that may not be immediately apparent from data alone, such as social, political, and regulatory risks. Experts can offer insights into the operational challenges that might not have been fully anticipated during the planning phase, such as labor strikes, material

shortages, or unexpected regulatory changes (Achumie, Oyegbade, Igwe, Ofodile, & Azubuike, 2022; Kokogho, Odio, Ogunsola, & Nwaozomudoh, 2024a).

On the quantitative side, historical data from previous housing projects serves as a valuable source for risk assessment. For instance, financial records and past project outcomes provide concrete information on cost overruns, delays, and resource misallocations. Statistical analysis of these data points, including regression models or Monte Carlo simulations, can help project managers estimate the probability and potential impact of similar risks in future projects. This method allows for the calculation of risk exposure, which is essential for developing strategies that effectively mitigate or control these risks. The combination of both qualitative and quantitative approaches provides a holistic view of potential risks, ensuring that the framework is comprehensive and adaptable to various project conditions (Adeniyi & Adeeko, 2024; Oyekunle, Adeniyi, & Adeeko, 2024).

Framework Development Process

The process of developing the unified risk management framework for housing development projects involves several key steps. Initially, it is crucial to categorize and define the types of risks that typically affect housing projects (Onukwulu, Agho, Eyo-Udo, Sule, & Azubuike, 2024a). These risks may be classified into several categories, including financial, operational, environmental, regulatory, and social risks. Financial risks include issues such as cost overruns, funding delays, and fluctuating market conditions, while operational risks may involve delays in construction, labor shortages, or supply chain disruptions. Environmental risks might include adverse weather conditions or environmental regulations, and regulatory risks could involve changes in zoning laws, permits, or safety standards. Social risks refer to the potential impacts of public perception, community opposition, or stakeholder disengagement (Igwe, Eyo-Udo, & Stephen, 2024a).

Once the risk categories have been established, the next step is to integrate cost control techniques and resource optimization tools into the framework. Cost control techniques such as Earned Value Management (EVM) and budgeting techniques, alongside resource optimization tools like resource leveling and critical path method analysis, help ensure that risks are quantified and managed effectively. The framework also incorporates stakeholder analysis to understand how different parties—ranging from project developers and contractors to local communities and regulatory bodies—may influence the project. This multi-faceted approach ensures that risk management is not limited to financial and operational concerns but is inclusive of social and environmental considerations, which are essential for the long-term success of housing projects (Eyieyien, Idemudia, Paul, & Ijomah, 2024b; Sule, Eyo-Udo, Onukwulu, Agho, & Azubuike, 2024).

Data Sources and Tools Used

A critical component of developing the unified risk management framework is the collection and analysis of relevant data. The data sources used for framework development primarily include historical project data, financial records, resource consumption patterns, and real-time project performance metrics. Historical data from previous housing projects is particularly valuable, as it provides insight into common risk factors, project timelines, cost estimations, and outcomes. Financial records, such as budget reports and cost breakdowns, offer detailed information on how risks, such as unforeseen expenses or funding issues, have impacted past projects (Agbede, Akhigbe, Ajayi, & Egbuhuzor; Olufemi-Phillips, Igwe, Ofodile, & Louis, 2024).

In addition to historical data, real-time project data collected from ongoing housing developments can be used to refine risk assessments. This data includes real-time progress reports, labor hours, material usage rates, and any operational bottlenecks encountered during construction. The integration of this data into the framework allows for continuous monitoring and real-time updates, ensuring that risks are mitigated as they arise rather than being

addressed reactively (Abisoye & Akerele; J. O. Basiru, C. L. Ejiofor, E. C. Onukwulu, & R. U. Attah, 2023b).

To process and analyze this data, a range of analytical tools and software are employed. Project management software such as Microsoft Project or Primavera P6 is used for scheduling and resource allocation, while data analytics platforms like R, Python, or specialized risk management software (e.g., RiskWatch or Risk+), which use advanced statistical methods and machine learning algorithms, enable more precise forecasting of risks and their impacts on cost and resources. These tools facilitate the identification of patterns, correlations, and trends that would be difficult to detect manually, thus providing more accurate risk assessments and optimization recommendations. By leveraging a combination of data sources and analytical tools, the framework is able to offer a dynamic, data-driven approach to risk management in housing projects (J. O. Basiru, C. L. Ejiofor, E. C. Onukwulu, & R. U. Attah, 2023a; Otokiti, Igwe, Ewim, Ibeh, & Sikhakhane-Nwokediegwu, 2022).

IMPLEMENTATION OF THE UNIFIED RISK MANAGEMENT FRAMEWORK

Application to Housing Projects

The unified risk management framework can be applied to various phases of housing development projects, from the initial planning stages to project execution and monitoring. During the planning phase, the framework is instrumental in identifying potential risks that may affect the project's scope, schedule, and budget. At this stage, the risk identification process, as outlined in the framework, helps project managers identify both internal and external risks, such as financial instability, regulatory changes, or environmental factors. The development of a risk register based on these identified risks ensures that the project team can allocate appropriate resources for mitigation measures (Afolabi & Akinsooto, 2023; Kokogho, Odio, Ogunsola, & Nwaozomudoh, 2024b).

In the execution phase, the framework's integration with cost control techniques and resource optimization strategies becomes crucial. Tools such as earned value management (EVM) can be used to track project performance in terms of time and cost. This enables real-time assessment of project deviations and ensures that risks related to cost overruns and delays are immediately addressed. Furthermore, the inclusion of resource optimization techniques, such as resource leveling, ensures that resources—whether human, financial, or material—are efficiently distributed across the project. This helps avoid bottlenecks and ensures that the project progresses according to the timeline and budget (Ajayi, Agbede, Akhigbe, & Egbuhuzor, 2024; Daramola, Apeh, Basiru, Onukwulu, & Paul, 2024; Umoga et al., 2024).

In the monitoring phase, the framework's reliance on real-time data integration and continuous risk assessment allows for ongoing risk evaluation. Project managers can use advanced analytics to track any emerging risks or project deviations. By doing so, corrective actions can be implemented promptly to avoid any escalation. The dynamic nature of the framework ensures that risks are continuously assessed, providing an adaptive approach to project management (J. O. Basiru, C. L. Ejiofor, E. C. Onukwulu, & R. Attah, 2023).

The application of the unified risk management framework can be illustrated through case studies of housing development projects, both successful and those where the framework could have improved outcomes. A key example is the development of affordable housing projects in urban areas, where large-scale developments often face significant risks, such as budget overruns and delays due to resource mismanagement or unforeseen environmental challenges (Oluokun, Akinsooto, Ogundipe, & Ikemba, 2024a, 2024b).

For instance, the construction of affordable housing in major cities like New York or London often deals with cost and time-related risks, particularly because of the high demand for labor, building materials, and the complexity of urban construction. In a project such as this, the unified risk management framework would allow stakeholders to identify early-stage financial risks and resource allocation issues through historical data and predictive analytics. By

implementing risk control strategies such as resource optimization and predictive scheduling, the project could have avoided several delays or cost overruns, ensuring it stays on track and within budget (Agho, Eyo-Udo, Onukwulu, Sule, & Azubuike, 2024; Eyieyien, Idemudia, Paul, & Ijomah, 2024a).

A notable real-world application of a similar approach is seen in the Singapore Housing Development Board (HDB), where project management frameworks are integrated with risk management practices to minimize construction delays and budget issues. By utilizing advanced data analytics and stakeholder collaboration, HDB has been able to deliver large-scale public housing projects on time and within budget. This case exemplifies how a unified risk management framework can be beneficial in achieving cost and resource optimization goals (Adewoyin, 2021; Ajiga, Hamza, Eweje, Kokogho, & Odio).

Challenges and Barriers to Implementation

Despite the clear advantages of the unified risk management framework, several challenges and barriers can hinder its successful implementation in real-world housing projects. One of the primary challenges is resistance to change from stakeholders who are accustomed to traditional risk management methods. The integration of new technologies and methodologies requires training and adaptation, which can face pushback from senior management, contractors, or local regulatory bodies who may be reluctant to adopt a new system (Durojaiye, Ewim, & Igwe, 2024; Otokiti, Igwe, Ewim, & Ibeh, 2021).

Additionally, the successful implementation of the framework depends on the availability and quality of data. Housing development projects often face challenges in gathering accurate and comprehensive data, especially in resource-constrained environments. Insufficient or inaccurate data can undermine the framework's predictive analytics capabilities and lead to suboptimal risk assessments (J. O. Basiru, L. Ejiofor, C. Onukwulu, & R. U. Attah, 2023; EZEANOCHIE, AFOLABI, & AKINSOOTO, 2021).

Another barrier to implementation is the difficulty in aligning stakeholders' interests and ensuring clear communication across various project teams. Housing projects often involve multiple parties, including government agencies, private developers, contractors, architects, and the local community. Coordination between these stakeholders can be challenging, particularly when risk management strategies differ across parties. Without proper alignment, it becomes difficult to ensure that the framework is consistently applied across all stages of the project. Finally, the complexity of integrating advanced risk management tools with existing project management software can also pose a technical barrier. For instance, if the tools require significant customization or data from disparate sources, project managers may face difficulties in synchronizing these systems effectively. This may increase the overall implementation time and cost (Ajiga, Hamza, Eweje, Kokogho, & Odio; Ezeanochie, Afolabi, & Akinsooto, 2024).

CONCLUSION AND FUTURE DIRECTIONS

This paper has outlined the critical importance of developing a unified risk management framework for housing development projects, particularly in addressing the challenges of cost and resource optimization. The framework, as presented, offers a comprehensive approach to identifying, assessing, and mitigating the diverse risks inherent in housing projects, such as financial, operational, and regulatory risks. By integrating these risk management techniques with cost control measures and resource optimization strategies, the framework ensures that projects can be executed efficiently, on time, and within budget.

A key takeaway is that risk management is not a standalone practice but must be embedded throughout all stages of housing development, from planning and execution to monitoring and closure. The framework's dynamic, data-driven nature allows for real-time risk evaluation and provides project managers with the tools needed to make informed decisions, ensuring that risks do not negatively impact project outcomes. Furthermore, the integration of predictive

analytics and resource optimization techniques significantly improves the likelihood of achieving cost-effective and timely delivery of housing projects.

Additionally, the application of the unified framework in case studies highlights its potential to enhance the execution of large-scale housing initiatives. However, successful implementation hinges on overcoming challenges such as stakeholder resistance, data limitations, and coordination difficulties. These insights demonstrate that while the framework holds considerable promise, its adoption requires careful planning, effective communication, and robust data infrastructure.

Given the evolving landscape of housing development and risk management, several areas remain open for further exploration. One promising direction for future research is the integration of Artificial Intelligence (AI) and machine learning algorithms into the risk assessment process. These technologies could significantly enhance the predictive capabilities of risk management frameworks, enabling more accurate identification of potential risks and more effective mitigation strategies. AI-driven models could continuously analyze data from past projects, monitor real-time conditions, and offer insights into emerging risks.

Another potential area for future research is the development of real-time monitoring systems that integrate with the unified risk management framework. Such systems could leverage Internet of Things (IoT) sensors and digital project management tools to provide continuous, real-time data on project performance, resource usage, and environmental factors. This would allow for quicker identification and response to issues, minimizing the chances of project delays or cost overruns. Lastly, further exploration of risk mitigation strategies in large-scale housing developments is essential. Research could focus on identifying best practices for managing risks related to stakeholder coordination, environmental factors, and the impact of regulatory changes. Developing new strategies to tackle these complex challenges could help scale housing projects more effectively while minimizing adverse effects on cost and resource use.

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