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Research paper

Bibliometric Insights into Stakeholder Complexity, Uncertainty, and Sustainability in Projects

Saloua CHRAYAH[1], Hassane EL MACHHOUR[2]

[1] *Doctoral Researcher, Laboratory of Studies and Research in Management of Organizations and Territories (ERMOT), USMBA Fez, Morocco*

[2] *Lecturer and Researcher, Laboratory of Studies and Research in Management of Organizations and Territories (ERMOT), USMBA Fez, Morocco*

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ABSTRACT

Modern projects are increasingly influenced by the demands of various stakeholders for transparency, accountability, and adherence to sustainable objectives. These expectations pose significant challenges for project managers, who must manage conflicts and ever-changing requirements while ensuring project success.

In general, project environments are characterized by increasing complexity and uncertainty, resulting from globalization, technological advancements, and shifting societal expectations. Stakeholder management, however, is a double-edged sword: it is both a factor of project complexity and a critical success factor. The extent to which stakeholder management contributes to the complexity and uncertainty of project environments remains unexpected.

This study aims to solve this issue by addressing the following question: To what extent does stakeholder management contribute to the complexity and uncertainty inherent in project environments? A bibliometric analysis was conducted on 623 peer-reviewed articles in the Scopus database on stakeholder management, complexity, and sustainability. Advanced bibliometric tools, such as VOSviewer, were used to identify key knowledge areas and research trends.

The results demonstrate that stakeholder diversity and conflicting motivations are major sources of project complexity. However, effective stakeholder engagement strategies can mitigate these challenges, creating opportunities for innovation and sustainable project outcomes. Despite this, the study highlights the lack of integrated frameworks for balancing environmental, social, and economic dimensions in complex projects, highlighting the need for further interrelated research.

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

INTRODUCTION

In an increasingly interconnected and complex world, projects have become powerful tools for achieving strategic objectives across all industries and sectors. However, modern projects' nature introduces complexity and uncertainty, requiring project managers to address various technical, human, and organizational challenges (Baccarini, 1996; Geraldi & Söderlund, 2018). Such challenges are magnified in environments characterized by globalization, rapid technological advances, and shifting societal expectations.

One major source of complexity is stakeholder management. Stakeholders, defined as "any group or individual who can affect or be affected by the achievement of the project's objectives" (Freeman, 1984), bring diverse interests, expectations, and levels of influence to projects. While a potential asset, this diversity often leads to conflicting priorities, misaligned objectives, and unpredictable interactions that can disrupt project timelines and outcomes (Mitchell et al., 1997; Aaltonen & Kujala, 2016). Further, projects are inherently transient and need constant adaptation to changing stakeholders' needs and external environmental factors, compounding the uncertainty project teams face.

The duality of stakeholder management – at once a factor in project success and a source of complexity and uncertainty – raises a key question: To what extent does stakeholder management contribute to the complexity and uncertainty inherent in project environments?

This article aims to answer this question using a bibliometric analysis of the existing literature on stakeholder management and project complexity. Using techniques such as co-citation and co-occurrence analysis, this study explores the evolution of research themes, key knowledge areas, and emerging trends in the field. By providing a structured overview of the literature, this study seeks to improve our understanding of the role of stakeholder management in project environments and its implications for researchers and practitioners.

The study is organized as follows: the first section presents a literature review, highlighting key concepts and theoretical frameworks related to stakeholder management, complexity, and uncertainty. Next, the methodology details the bibliometric approach, including data collection and analysis techniques. The results are then presented, focusing on the main areas of knowledge, the evolution of research themes, and the new frontiers of research. Finally, the discussion explores the practical and theoretical implications of the findings, followed by the conclusion, which summarizes the contributions and suggests directions for future research.

1. Stakeholder Management and Uncertainty & Complexity in Project Management: Literature Review

Stakeholder management is one of the most crucial aspects of project management, adding considerably to the complexity and uncertainty of a project. This literature review explores the different dimensions of stakeholder dynamics, using existing research to demonstrate how these dynamics impact project outcomes.

1.2 The Nature of Project Stakeholders

Stakeholders can be defined as "any group or individual who can affect or be affected by the achievement of a project's objectives" (Freeman, 1984). This extensive definition highlights the need to identify direct stakeholders and those who may indirectly impact the project (PMI, 2000). On many projects, stakeholders may include owners, contractors, designers, government agencies, and community groups, all of whom have potential conflicts of interest (Mok et al., 2018). This diversity of stakeholders complicates the management process since each group has its own expectations and concerns regarding the project.

A good knowledge of the different roles of stakeholders in a project is crucial for effective project management. Every stakeholder group has its interests, which may sometimes conflict with one another (Freeman, 1984). For example, owners often focus on achieving a return on investment (ROI) and ensuring the project achieves its objectives within budget constraints (Mok et al.,2018). For their part, contractors are usually concerned with profitability and meeting deadlines while maintaining quality standards (Newcombe, 2003). At the same time, government agencies might be worried about regulatory compliance and environmental issues, leading to the complexity of managing stakeholder expectations (Eskerod et al.,2015).

Olander (2007) pointed out the importance of distinguishing between stakeholders and influencers. He noted that even if influential people have no direct interest in the project, they can significantly impact its activities. This distinction is vital, as it highlights the complexity of stakeholder influence, which can result in varying degrees of uncertainty in project outcomes. The complexity of stakeholder relationships is further aggravated by the diversity of their origins and interests (Mok et al., 2018). For illustration, community groups may defend local interests such as environmental protection or social justice, while entrepreneurs may focus on profitability and efficiency.

Stakeholder interactions can also result in high levels of complexity. Dao et al. (2016) affirm that stakeholder complexity comes from motivations and relationships between the different groups implicated in a project. Oman

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

et al. (2016) also underline that managing these interrelationships is crucial to managing the complexity inherent in projects. Stakeholder interactions can manifest as collaboration, when stakeholders work together to achieve common goals, as conflict often arises when stakeholders' interests clash, and as information sharing, which is important for effective decision-making (Chinowsky et al., 2008).
In addition, understanding stakeholders' concerns is essential to effective management. Stakeholders' concerns are questions or interests regarding project implementation and outcomes. These concerns may vary according to each stakeholder's point of view. For example, economic concerns relate to profitability and meeting deadlines, environmental concerns focus on sustainable development practices, social concerns relate to safety and health effects, and functional concerns relate to user comfort and building durability (Hojem et al.,2014; Shi et al., 2016).

2.2 Frameworks related to project stakeholders' complexity and uncertainty

The need to manage stakeholder complexity results from the variety of their interests and motivations, which may significantly influence project outcomes. Dao et al. (2016) affirm that the complexity of a project is a key factor that can lead to project failure if stakeholders are not managed efficiently. This points to the importance of strong stakeholder management in reducing the risks associated with project complexity. Oman et al. (2016) similarly argue that the ability to manage stakeholders' relationships directly relates to project complexity and point out that the dynamics between different stakeholder groups can make decision-making and project execution more difficult.
That complexity necessitates the development of metrics and methodologies adapted to manage the different types of stakeholders involved, particularly in civil construction projects (Marques et al., 2018; Ahola et al., 2021). Literature defines a project as unique and transitory, using new processes (Turner & Muller, 2003). This definition conforms to the Project Management Institute's assertion that projects have a defined beginning and end and are distinct from other products or services (PMI,2000). Nevertheless, Mayor (2001) suggests that, as organizations become increasingly involved in multiple projects, the uniqueness of each project may become less apparent, leading to the perception of similarity between projects. This can create difficulties in stakeholder management, as project teams may underestimate the specificity of each project's stakeholder landscape.
Azim et al. (2010) distinguish between complex projects with clear, established objectives and complex projects with ill-defined or evolving objectives. Furthermore, Williams (1999) classifies complexity into two categories: "uncertainty" concerning the clarity of goals, and « structural complexity » concerning the underlying framework needed to achieve these objectives. Making the distinction between descriptive complexity -an objective measure of a project's intrinsic qualities- and perceived complexity- a subjective interpretation based on individual experiences- highlights how different stakeholders may perceive a project's complexity differently (Azim et al., 2010; Williams, 1999). It is essential to understand these complexity-generating factors to assess their impact throughout the project lifecycle (Azim et al., 2010). As Uribe et al. (2018) point out, the complexity inherent in stakeholder relationships significantly affects project success. In such a context, it is essential to recognize that interactions between stakeholders can create additional layers of uncertainty that complicate the decision-making process.

2.3 Framework Overview

To manage complexity and uncertainty, several frameworks have addressed this point:

- SHAMPU Framework :

The first is an approach called SHAMPU (Shape, Harness, and Manage Project Uncertainty), originally developed by Chapman and Ward (2003), which offers a structured framework for managing stakeholders' uncertainty throughout the project lifecycle. Through this framework, project managers can identify potential uncertainties and understand how these uncertainties change over time. Also, PM can systematically assess stakeholders' influence on a different project, minimize ambiguity, and improve decision-making.
The SHAMPU framework consists of several key steps to manage stakeholder uncertainty effectively in a project. These steps are: « defining the project context, focusing on key uncertainties, identifying issues related to stakeholder influence, structuring this issue for analysis, clarifying stakeholder ownership, estimating variability in stakeholder response, assessing impacts on project outcomes, developing communication plans to involve stakeholders, and managing implementation strategies throughout project execution (Chapman & Ward, 2003). The role of each step is important in managing stakeholder uncertainty because it provides a structured approach to analyze its potential impact on project performance.
This structured approach (Chapman & Ward, 2003) is instrumental in managing complex stakeholder environments where different interests must be balanced. By clearly setting out the project context from the outset,

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

managers can pinpoint the key stakeholders and gain insight into their concerns. This proactive engagement helps develop more useful communication strategies later in the process.

- VUCA framework :

The second is the VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) framework, a crucial tool for project managers, enabling them to address the various challenges associated with stakeholder dynamics in today's project environments. As organizations increasingly rely on projects to implement strategic initiatives, they face environments characterized by rapid change and unpredictability (Fridgeirsson et al., 2021). This phenomenon, known as « projectification », requires a solid understanding of VUCA elements to effectively manage the complexities and uncertainties inherent in stakeholder relationships.
Volatility refers to the speed and magnitude of change in a project's environment. Fridgeirsson et al. (2021) argue that higher change rates challenge traditional risk assessment approaches, forcing project managers to adopt more dynamic responses. This volatility can lead to shifts in stakeholder priorities and expectations, complicating management processes. For example, stakeholders may rapidly modify their requirements in response to external market conditions or internal organizational changes, creating an unstable basis for project planning and execution.
Uncertainty is often linked to the unpredictability of stakeholder behavior and external factors influencing project outcomes. Bennett and Lemoine (2014) describe uncertainty as a lack of predictability concerning future events that may significantly impact the project's success. This uncertainty is reinforced by the diverse motivations of stakeholders, which can lead to conflicting interests that complicate decision-making processes (Dao et al., 2016). Understanding these motivations is essential for anticipating potential conflicts and developing proactive management strategies (Eskerod et al., 2015).
Complexity arises from the complex relationships between stakeholders and the multidimensional nature of the projects themselves. Fridgeirsson et al. (2021) point out that project risks can be related to various uncertainties concerning scope, results, performance, technologies, stakeholders, interdependencies, and organizational issues. The distinction between complex projects with clear evolving objectives highlights project managers' challenges in navigating stakeholder dynamics (Azim et al., 2010). Williams (1999) classifies complexity into two categories: "uncertainty" relating to the clarity of objectives and "structural complexity" relating to the underlying framework needed to achieve those objectives.
Ambiguity refers to the lack of clarity regarding the role and responsibilities of stakeholders within a project. Millar (2007) points out that governance structures significantly influence how stakeholder relationships are managed throughout a project's lifecycle. Clear governance frameworks are essential for coordinating stakeholder interests and defining roles, reducing ambiguity, and improving overall project effectiveness.

- Stakeholder Landscape framework :

The third is the Stakeholder Landscape framework, which offers an in-depth approach to managing the complexities and uncertainties arising from the diversity of project stakeholders. This framework emphasizes the importance of considering stakeholders not simply as individual entities, but as interconnected actors whose relationships and interests significantly shape project dynamics (Atkinson, Crawford & Ward, 2006). As construction projects become increasingly complex, interactions between stakeholders are often a source of uncertainty, not least because of divergent objectives, risk perceptions, and levels of commitment (Chapman & Ward, 2003; Xia et al., 2018).
A key aspect of the project stakeholder landscape framework is the systematic mapping and analysis of all project stakeholders' roles, interests, and levels of influence. Atkinson et al. argue that visualizing the stakeholder landscape enables project managers to identify critical stakeholders and understand patterns of influence that may affect project outcomes (Atkinson, Crawford & Ward, 2006). This visual approach enables managers to design strategies that address potential conflicts and align interests, thus fostering a collaborative environment supporting project goals (Yang et al., 2009b; Mok, Shen & Yank, 2015).
In addition, the framework provides a structured methodology for assessing the uncertainties associated with stakeholder interactions by classifying stakeholders according to their influence, expectations, and potential contributions to the project. Atkinson et al. This categorization enables project teams to anticipate the challenges of conflicts of interest (Atkinson, Crawford & Ward, 2006). This framework feature is handy in high-stakes environments such as construction projects, where managing diverse and often transient stakeholder relationships is crucial to mitigating disruption (Mok, Shen & Yang, 2015; Xia et al., 2018).
In the same way, the framework encourages a dynamic approach to stakeholder management, promoting continuous adjustments to engagement strategies as the project progresses. This adaptability is vital in construction projects, where stakeholder interests may change in response to project evolution, regulatory requirements, or external environmental factors (Shen, Brandon & Baldwin, 2009; Read et al., 2017). By continuously focusing on the stakeholder landscape, project managers can ensure that engagement strategies remain aligned with current

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

project needs, improving resilience in the face of unexpected changes (Atkinson, Crawford & Ward, 2006; Yang et al., 2009b).
Due to its comprehensive and adaptable design, the stakeholder landscape framework equips project teams with an effective tool for navigating stakeholder complexities. The framework enhances understanding of the stakeholder environment and facilitates strategic alignment that promotes collaboration and reduces project risk, thereby increasing the likelihood of project success (Atkinson, Crawford & Ward, 2006; Mok, Shen & Yang, 2015).

1.4 Strategies for Stakeholder Management and Practical Implications (managing complexity uncertainty in stakeholder management concept)

Improving the strategies used for stakeholder management is crucial to reducing the project's complexity level. According to Newcombe (2003), trust between those involved in the project is essential, and it is recommended that trust be developed through effective communication. In this case, communication addresses the issue of transparency, which improves working relationships and minimizes the risk of conflict and divergence of objectives between stakeholders. Furthermore, understanding stakeholders' objectives enables disagreements to be anticipated and constructive management approaches to be implemented (Eskerod et al., 2015). This proactive strategy aims to address the uncertainties that arise from multiple stakeholders, enabling project managers to tackle potential problems before they even occur.
Furthermore, Millar (2007) adds that, among many other factors, a project's governance structures influence how stakeholders interact and manage their engagements. In multi-owner projects, where different organizations exercise joint control over crucial project components, it becomes necessary to put in place clear governance structures that will facilitate the harmonization of stakeholder interests. These infrastructures help clarify the boundaries between activities while providing conflict resolution methods to improve simplicity and reduce uncertainty. Such governance structures ensure that all stakeholders understand their roles and the processes involved, which can facilitate smoother project execution.
In the same way, informal stakeholder networks can also be considered marginally relevant to improving communication and cooperation. Chinowsky et al (2008) further recommend that to network effectively, these informal networks should be recognized to find the liaison person likely to be present among stakeholders who exchange and share information and resources as part of the collaboration. Project managers improve stakeholder engagement through these informal networks and encourage further cooperation.
Effective stakeholder management adds value to the project, as it is a continuous process that doesn't stop when launched. As stakeholder engagement is a process of elimination, it also enables plans to be modified if new factors or problems emerge. As Maylor and Turner (2O17) point out, managers also must deal with the complexity of stakeholder management, which encompasses both the planning and reactive aspects of the process. This balance is crucial because if there are rigid management approaches, these will not be able to cope with evolving requirements due to changing stakeholders or external factors.

2. Research method

This study used bibliometric analysis to obtain a comprehensive understanding of stakeholder management and project complexity, and the uncertainty research landscape. This approach identifies important themes, trends, and influential contributions in the field by systematically examining scientific publications. The approach combines data extraction, cleaning, and visualization using advanced bibliometric tools, ensuring a robust and structured analysis.

2.1 Bibliometric Method for Knowledge Exploration

Bibliometrics is a robust method for analyzing research field structure and evolution through bibliographic data. It enables researchers to discern trends, connections, and significant contributions objectively and systematically (Chen et al., 2010). In contrast to manual reviews, subjective influence may be limited; bibliometric techniques offer a systematic, data-driven process that can be both reproducible and comprehensive (Cobo et al., 2011).
Co-citation analysis is one of the analytic techniques in bibliometric analysis. In this way, the method detects the link between publications according to their co-citation frequency, allowing the detection of meaningful research clusters and intellectual structures in the field (Chen et al., 2010). A complementary method is keyword co-occurrence analysis, which identifies common themes and emerging topics throughout the literature, providing insights into research avenues (Su & Lee, 2010).
These analyses are often done using tools such as Citespace and Vosviewer. CiteSpace is superior in visualizing citation networks and analyzing the dynamic growth of research domains. Vosviewer can effectively visualize

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

large-scale bibliometric networks and analyze the space between authors, institutions, or concepts (Van Eck & Waltman, 2014). Such tools have proven invaluable for researchers exploring their field's diversity and evolution (Cobo et al., 2011).
In project management, bibliometric methods have been used to examine the role of stakeholder management in project success. For example, Li et al. (2017) highlighted the usefulness of these techniques for analyzing how collaboration between stakeholders influences the success of green building projects. Similarly, Mok et al. (2015) used bibliometric approaches to trace the challenges and opportunities associated with managing diverse stakeholders in complex project environments.

2.2 Data collection

2.2.1 The database

This study employed the Scopus database as the primary source to identify the literature pertinent to the research field. Scopus is one of the largest and most comprehensive bibliographic databases, including many high-quality scientific publications across various disciplines (Chadegani et al., 2013). Scopus is well known for its high coverage of peer-reviewed journal articles, conference proceedings, and book chapters (Mongeon & Paul-Hus, 2016), which makes it a prevalent database in bibliometric analyses.

Scopus contains rich bibliographic records with a high level of metadata: author names, article titles, abstracts, keywords, and references, which are essential for performing advanced bibliometric analyses. This database is well regarded in bibliometric research due to its comprehensive nature, such as its integrated data visualization and export options compatible with Vosviewer and Citespace (Van Eck & Waltman, 2014).

For this study, we selected peer-reviewed articles and reviews for analysis, as these documents typically exhibit high academic quality and credibility. This approach is consistent with previous bibliometric studies in the field, such as those by Mok et al. (2015) and Derakhshan, Turner, and Mancini (2019). By concentrating on these high-impact sources, the analysis ensures a comprehensive and dependable understanding of the relationship between stakeholder management, complexity, and uncertainty in project contexts.

2.2.2 The Searching Terms

The keywords for this study were crafted to capture pertinent literature focusing on stakeholder management within project environments defined by complexity and uncertainty. The keywords stakeholders, project, management, complexity, and uncertainty were utilized to identify studies exploring these concepts' relationships to achieve this goal. The search terms were carefully chosen to reflect the intersection of stakeholder management, project complexity, and uncertainty. The search query was formulated as: "stakeholders" AND project AND management AND (complexity OR uncertainty).

This combination of terms was selected to ensure the inclusion of relevant studies that address stakeholder-related challenges in projects noted for their complexity and uncertainty.

Using Scopus as the search database, the initial query returned 2614 articles without filters. The Scopus subject area filter "Business, Management, and Accounting" was applied to refine the results and concentrate on pertinent disciplines, which reduced the dataset to 623 articles. This filtering process is consistent with best practices in bibliometric research, as it improves the relevance and quality of the extracted dataset (Chadegani et al., 2013).

2.2.3 Bibliographic Records

This study collected bibliographic records from Scopus, emulating the methodologies of prior bibliometric research conducted by Mok et al. (2015) and Derakhshan et al. (2019). The extracted records contained essential details such as author names, article titles, abstracts, keywords, publication details (journal name, volume, and issue), DOI references, and the full list of cited references.

2.3 Data analysis

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

2.3.1 Document co-citation analysis

Documents' co-citation analysis was performed to examine the patterns of frequently co-cited articles within the dataset. This technique identifies articles with similar research interests based on their co-citation frequency in other publications (Chen et al., 2010). A co-citation network was developed, with nodes representing the articles and links denoting the co-citation relationships. The clustering of these nodes highlighted significant knowledge domains associated with stakeholder management, complexity, and uncertainty in projects (Li et al., 2017).

The dataset used in this analysis is summarized in the table below:

Table 1: The summary of the dataset used in the study
(Source: Author)

Step	Articles Retrieved	Articles Retained
Initial Dataset	2614	-
After Filtering (Business, Management, and Accounting)	-	623

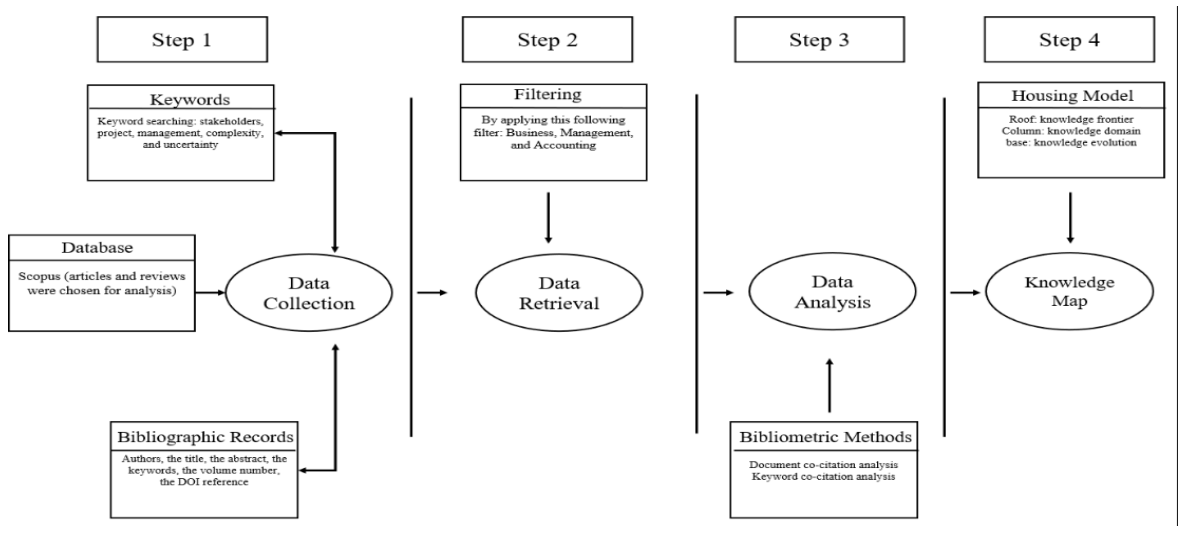
This co-citation analysis facilitated the identification of thematic clusters and significant research areas within the field, offering insights into the developing knowledge landscape of stakeholder management in project contexts.

2.3.2 Keyword Co-Occurrence Analysis

Keyword co-occurrence analysis determined the frequency and relationships between key terms within the dataset. This approach identifies keywords that frequently appear across various articles, aiding in uncovering crucial research focuses and thematic structure within the field (Chen et al., 2012).

This study examined the keywords stakeholders, project, management, complexity, and uncertainty as they embody essential concepts in investigating stakeholder management within complex and uncertain project environments. The frequent co-occurrence of these terms underscores their significance as foundational elements in the literature selected for this analysis (Li et al., 2017). This approach offers a basis for more in-depth bibliometric analysis, providing a complete understanding of the research field and its key areas of interest.

Figure 2: research framework of this study
(Source: Author)

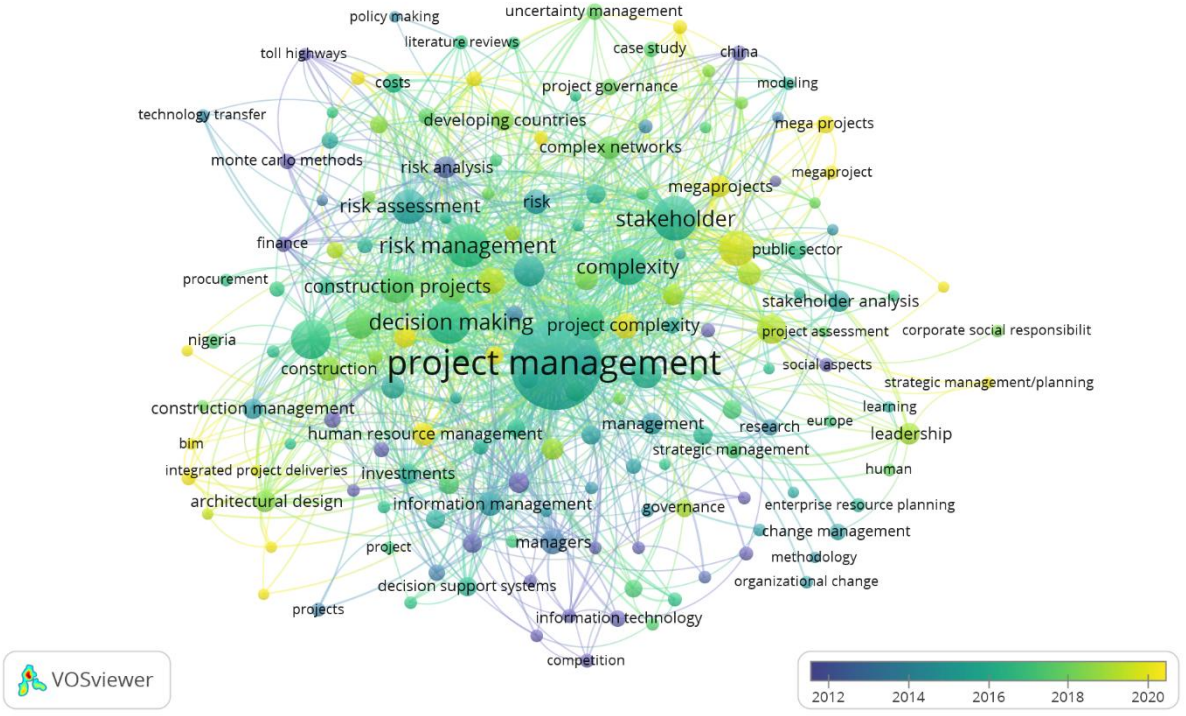


*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

3. RESULTS

To provide an overall understanding of the research landscape, this section presents the results of a bibliometric analysis. It highlights the main areas of knowledge, their evolution over time, and the limits of research in this field.

Figure 3: Keyword Co-Occurrence Network: Identifying Core Themes in Literature
(Source: VOSviewer)



3.1 Results of data collection

The dataset analyzed in this study consists of publications on stakeholder management and project complexity retrieved from Scopus. 2614 publications were retrieved, demonstrating the growing academic interest in the interaction between stakeholder engagement and project outcomes. This is consistent with the findings of Söderlund and Müller (2008), who highlighted the growing number of publications dealing with the multidimensional challenges of project management. The generation of keyword co-occurrence networks using VOSviewer software revealed significant clusters of topics consistent with the methodology used by van Eck and Waltman (2010).

3.2 Knowledge domain

The central concept identified in the keyword network was ‘project management’, highlighting its central role as a framework for addressing stakeholder challenges and complexity. This result confirms Turner’s (1999) assertion that project management is an essential discipline for integrating stakeholders and organizational needs.
The analysis highlighted three groups of dominant themes:
Cluster 1: Stakeholder management and engagement: This group contains keywords such as ‘stakeholder analysis, stakeholder complexity, and stakeholder engagement’ reflecting a focus on understanding and managing different stakeholder groups, such as the work of Mitchell et al. (1997), who introduced a salience model to prioritize stakeholders.
Cluster 2: Risk and uncertainty management: keywords such as ‘risk assessment, uncertainty management, and ‘decision making’ emphasize the importance of mitigating the risks and uncertainties inherent in complex projects. This is consistent

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

with the work of Hillson (2002), who argues that risk management is a key element of decision-making in uncertain environments.
Cluster 3: Sustainability and Governance: the importance of keywords such as 'sustainability', 'governance', and 'leadership' reflects the growing concern about the long-term impacts of projects and the need for robust governance structures, such as those highlighted by Elkington (1997) in his triple bottom model.
These groups reveal the interconnection between stakeholder management and project management's wider objectives and support Bourne and Walker's (2005) conclusions about stakeholders' central role in project success.

3.3 Knowledge evolution

The temporal distribution of keywords shows the evolution of the search axis over time:
- 2010 – 2015: Early research focused on fundamental concepts such as 'stakeholder analysis' and 'risk management' and highlighted the need for structured frameworks to manage stakeholder diversity. This is consistent with the early work of Cleland (1986), who emphasized the fundamental role of stakeholders in project contexts.
- 2016 – 2020: During this period, there is a shift towards sustainability, complexity, and governance, reflecting the increasing importance of aligning stakeholder engagement with long-term project outcomes and societal goals. This trend is consistent with the view of Geraldi et al. (2011), who identified complexity as a growing problem in project management.
- 2021 – Present: Recent research emphasizes the integration of new methodologies such as 'decision support systems' and 'complex networks' to deal with stakeholder-induced uncertainty in large projects. This is in line with the findings of Flyvbjerg (2014), who advocates the use of advanced tools to address the unique challenges of large projects.

As noted by Söderlund (2011), this development reflects the maturation of a field of knowledge that increasingly focuses on the practical impact of stakeholder engagement.

3.4 Knowledge frontier

The keyword network highlights several emerging areas of interest that represent the knowledge frontier in stakeholder and project management research:
- Integrating stakeholder diversity into decision models: The network is increasingly interested in developing advanced decision tools to address the complexity created by diverse stakeholder groups. This is consistent with the work of Mitchell et al. (1997), who proposed a framework for managing stakeholder materiality in complex environments.
- Sustainability-focused stakeholder engagement: The link between 'sustainable development' and 'stakeholder management' suggests that there is an increasing focus on balancing economic, social, and environmental dimensions in project outcomes. This result supports Elkington's (1997) arguments in favor of a three-pronged approach.
- Leadership and governance in complex projects: as Müller and Turner (2007) note, the presence of 'leadership' and 'governance' as emerging themes highlights the key role of strategic management in coordinating the interests of different stakeholders.

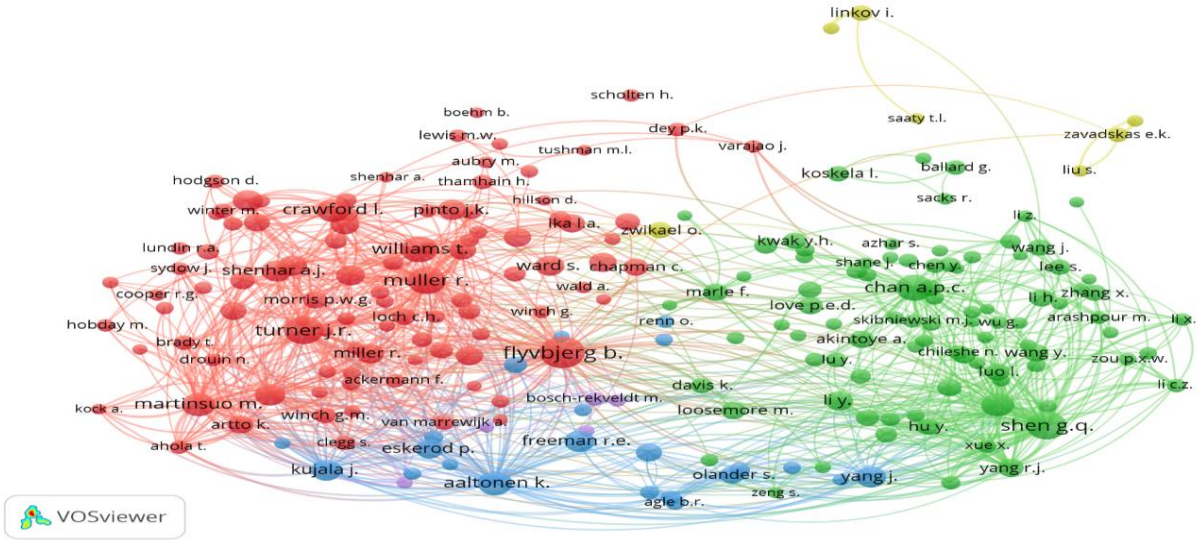
As Ward and Chapman (2003) note, these emerging areas open new avenues of research, particularly concerning the development of frameworks that take account of the complexity of stakeholder-led projects while ensuring sustainable outcomes.

Figure 4: Co-Authorship Network Analysis of Key Authors in Stakeholder Management Research

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

(Source: VOSviewer)

3.5 Results of data collection



This co-citation network graph visually illustrates the relationship between authors who are frequently cited together in the research areas of stakeholder and project management. The nodes represent the authors, while the links indicate the strength of their co-citation relationships. Larger nodes indicate more highly cited authors, and stronger (thicker) links indicate stronger co-citation relationships. This approach corresponds to that described by Small (1973), who first introduced co-citation analysis as a measure of intellectual connections.

The graph contains three main groups (indicated by color):

- Red cluster: main author focusing on project management and stakeholder theory.
- Green cluster: related to construction management and complex projects.
- Blue cluster: focusing on governance and decision-making frameworks.

3.6 Knowledge domain

The red cluster is directed by renowned authors such as Müller, Turner, and Flyvbjerg, who highlight fundamental work on project complexity, stakeholder management, and risk governance. These authors are widely cited in their research on the interaction between project governance and stakeholder engagement. For illustration:

- Flyvbjerg (2003) is well known for his work on the challenges of managing large projects and their inherent complexity.
- Turner (1999) laid the foundations for integrating stakeholder perspectives into project success criteria.

The green cluster emphasizes research in the field of construction and engineering, led by authors such as Chan and Shen, who focus on construction project management and sustainable stakeholder engagement (Chan et al., 2004). This group demonstrates the application of stakeholder management theory in the field of high technology.
The blue cluster, represented by authors such as Freeman and Eskerod, reflects the theoretical emphasis on stakeholder importance and collaboration. Freeman's (1984) seminal work on stakeholder theory underpins this group, emphasizing the strategic role of stakeholders in achieving project objectives.

3.7 Knowledge evolution

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

The graph illustrates the development of the research area over the years:

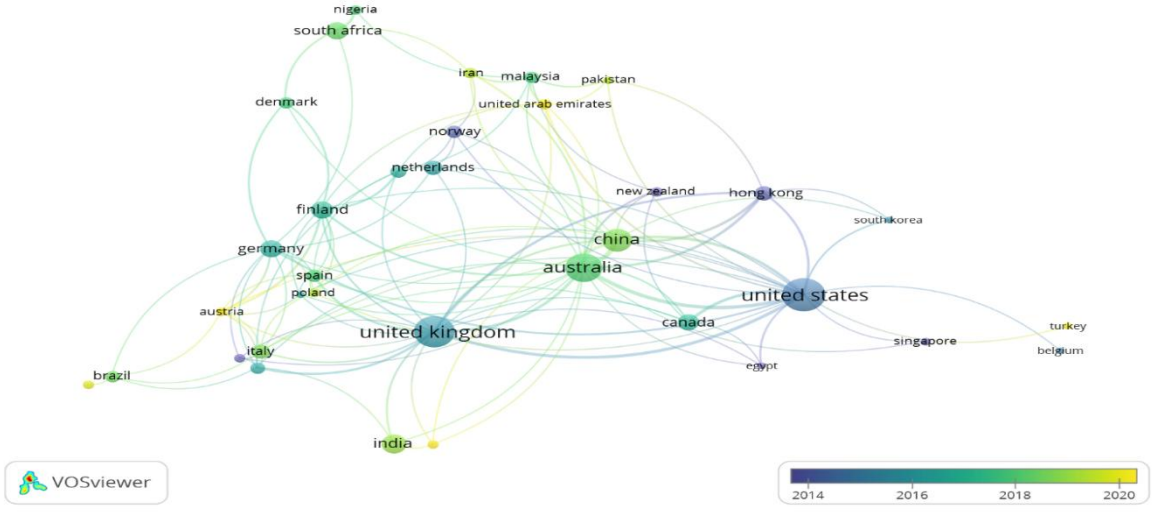
- Early research (1980-2000): Predominated by the work of Freeman (1984) and Turner (1999), research focused on stakeholder theory and its integration into project management frameworks. These seminal studies formed the theoretical basis for subsequent work.
- 2001-2015: During this period, there was a shift towards considering complexity and uncertainty in project management, as noted by Flyvbjerg (2003) and Müller et al. (2010). His work has highlighted the challenges of managing different stakeholders in large projects and complex environments.
- 2016-2022: More recent work (e.g., Shen and Chan) has emphasized the need for sustainability and innovative governance mechanisms when engaging stakeholders. This reflects a trend to align project management practices with long-term social and environmental objectives.

3.8 Knowledge frontier

The figure reflects emerging thoughts and areas for further research that follow:

- Governance of stakeholders within megaprojects: The presence of Flyvbjerg and Turner in the red group shows that they are still interested in enhancing the governance framework of megaprojects.
- Eco-friendly construction projects: The green group emphasizes the need for ecological preservation research as a part of construction activity. People like Shen and Chan are setting paths for the incorporation of social and environmental issues into project development and execution.
- Multi-stakeholder decision-making strategies: the relationship in blue, particularly Freeman and Eskerod, suggests the scope for the creation of cooperative initiatives that highlight stakeholders and the need for shared value creation among them.

Figure 5: Geographical Collaboration Network in Research on Stakeholder Management
(Source: VOSviewer)



3.8 Results of data collection

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

The graph shows that countries such as the United States, the United Kingdom, China, and Australia dominate scientific collaboration in this field, as they have the largest centers. The edges indicate that these countries have established strong bilateral collaborations, as evidenced by the closer links, particularly between the US and the UK, China and Australia, USA and China.
Smaller centers such as Malaysia, the United Arab Emirates, and Turkey indicate new contributors to the field whose participation has increased over time (indicated by the yellow-green tint).

4. Discussion

The results of this study offer valuable insights into the evolving landscape of research into stakeholder management and project complexity, and uncertainty. By examining the intellectual structure of the field, key themes and influential frameworks have been identified, highlighting the dual role of stakeholders as enablers and sources of complexity and uncertainty. In this section, we interpret the findings in the context of existing theories and practices, explore their implications for project management, and identify areas for further research.

4.1 Theoretical confrontation and practical implications

- **Mitigating complexity in construction projects through stakeholder collaboration and strategic management**

The construction sector is inherently complex and subject to technical, human, and organizational factors that project managers must expertly manage. As Winch (2010) noted, construction projects often involve different stakeholders with different objectives, creating an uncertain environment that increases the project's complexity. Furthermore, Loosemore et al (2003) stated that the ever-changing nature of construction projects further complicates the decision-making process, requiring adaptive strategies to effectively manage uncertainty.
Collaboration emerges as a key strategy for mitigating these complexities. Clear communication and coordination between stakeholders are critical to project success, as highlighted by Walker (2015), who links collaborative practices to improve project outcomes. As highlighted by Cheng et al (2005), human resource management plays a key role in facilitating effective teamwork, while optimized information management ensures that critical data is accessible and usable by all project teams.
In addition, the integration of tools such as Building Information Modeling (BIM) has revolutionized construction project management. Azhar (2011) has pointed out that BIM improves project transparency and efficiency, enables better coordination between stakeholders, and reduces inefficiencies. In summary, these factors are consistent with those reported by Chan et al (2004), who identified key success factors and showed that strong collaboration and value for resources are essential to navigate the multi-stakeholder environment of construction projects.
These findings highlight the importance of a holistic and collaborative approach to construction project management to manage complexity and achieve positive outcomes.

- **Balancing opportunities and challenges in stakeholder management: addressing complexity, sustainability, and societal impact**

The integration of stakeholder theory into project management demonstrates the dual nature of stakeholder engagement, which can enhance, as well as complicate, project outcomes. In this regard, Freeman (1984) has observed that engaging a diverse range of stakeholders can facilitate the acquisition of diverse expertise and perspectives, thereby stimulating innovation and enhancing the congruence between project goals and stakeholders' expectations. However, Mitchell et al. (1997) have also highlighted the challenges associated with managing multiple stakeholders, particularly the balancing act of conflicting interests and priorities, which can present a significant challenge for project managers.

Managing complex approaches such as change management and agile project management offers flexibility and adaptability (Rigby et al., 2016). Kotter (1996) contends that efficacious change management is pivotal in ensuring a seamless transition in the face of evolving stakeholder dynamics, while Rigby et al. (2016) emphasize that agile methodologies can adapt iteratively to address shifting requirements, particularly in dynamic environments. In addition, contemporary projects must consider broader societal issues, including environmental impacts, sustainability, and social aspects. Integration of these perspectives, as advocated by Elkington (1997), aligns initiatives with the triple bottom line, thereby ensuring that benefits are delivered to the environmental, social, and economic domains. Nevertheless, as Epstein and Buhovac (2014) have demonstrated, the integration of these dimensions invariably engenders an increase in uncertainty.

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

They argue that integrating sustainability necessitates the implementation of robust planning and decision-making processes to effectively manage the associated complexity.

The findings indicate that stakeholder involvement enriches project outcomes; however, sophisticated management strategies are also necessary to effectively manage the associated complexity and uncertainty (Epstein & Buhovac, 2014).

- **Advanced tools and analytical methods for effective decision-making in multi-stakeholder projects**

The management of projects with multiple stakeholders necessitates the establishment of intricate structures and the deployment of sophisticated tools to facilitate effective collaboration and decision-making processes. Knowledge management systems, such as those developed by Ajmal et (2010), enhance the capacity of project teams to process large-scale data and optimize communication between different teams. Similarly, decision support systems such as that used by Power et al (2002) focus on structured methods for analyzing complex data, improving coordination, and facilitating informed decision-making in demanding project environments (Power et al, 2002).

The utilization of methodologies such as decision theory, problem solving, and optimization has been demonstrated to be highly effective in addressing uncertainty. Fuzzy logic, as pioneered in 1965 by Zadeh, offers a particularly pertinent methodology for dealing with fuzzy and incomplete information. Dubois & Prade (1998) further emphasize the efficacy of mathematical models based on fuzzy principles for enhancing decision-making processes, underscoring how such models can take uncertainty into account in a more flexible manner. These methods are of particular significance in development projects and supply-chain management, where operational complexity necessitates the utilization of sophisticated analytical tools. Christopher (2000) emphasizes that advanced analytical techniques can facilitate risk management and enhance supply chain coordination. Furthermore, Beamon's (1998) study emphasizes that optimization models play a pivotal role in enhancing supply chain efficiency and reducing uncertainty, thereby fostering smooth operations in complex multi-stakeholder environments.

- **Agile practices, information systems, and risk management framework: enhancing decision-making and project value**

In rapidly changing settings, agile project management was found to be a helpful strategy in developing new products due to its components that facilitate the review and modification of processes. As cited in the publication of Highsmith (2009), agile principles/ methods are at times vague and changing. Likewise, Conforto et al (2016) note that agile methods are applicable in fast-changing business circumstances that require regular consultations from clients and regular revisions to meet the set goals.
The use of information systems in the agile processes also makes work easier and speeds up the decision-making process. According to Lee et al. (2015), the application of sophisticated information systems enables one to make accurate decisions regarding the allocation of resources based on information obtained from the system. This is especially useful in industrial and RD settings that involve numerous complicated activities that have to be integrated, coordinated, and insight as pointed out by Barczak et al. (2009).
Another major role is risk management in achieving project success. An established project risk management approach, collated in the science of management, offers appropriate mechanisms for risk factor recognition, measurement, and control. Hillson and Simon (2020) argue that there is a gap in scholarship in terms of aligning specific risk management practices objectives with organizational broader strategies in enhancing resilience and sustainability. Ward and Chapman (2003) also highlight the incorporation of qualitative and quantitative analysis in risk management frameworks to handle all the uncertainties involved.

More so, it is important to link the project targets with the higher-level and long-term plans and the developmental goals to be able to make sense and to be sustainable. According to Shenhar and Dvir (2007), project deliverables and their relation to higher goals and needs must not be overlooked for value to be created over time. Turner (2016) also insists that one should not only focus on projects that address requirements on the spot but also work on those that will benefit societies and institutions.

The research in this area provides evidence that there are synergistic advantages of agile methods, modern information technologies, and orderly risk management systems. Taken together, these solutions help organizations to cope with complicated situations, support creativity, and achieve responsible and durable results.

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

- **Uncertainty management and sensemaking: strategies for resilience and flexibility in complex project lifecycles**

The project lifecycle contains different degrees of uncertainty, requiring robust strategies to manage ambiguity and risk at each stage. Atkinson et al (2006) and Perminova et al. (2008) point out that uncertainty is a fundamental aspect of projects, which necessitates appropriate strategies for dealing with constantly changing challenges. Against this background, sensemaking plays a key role in helping teams to interpret and cope with ambiguity, as argued by Weick (1995) and Colville et al. (2013), who assert that effective sensemaking enables project teams to apprehend complex scenarios and adjust their actions accordingly. In the same way, harnessing formal and informal networks can improve collaboration and facilitate the flow of critical information. Granovetter (1973) and Cross & Parker (2004) demonstrate how network interactions promote better decision-making, particularly in uncertain environments. Ward & Chapman (2003) and Hillson (2002) illustrate how these tools can help to identify and quantify potential risks, permitting proactive management and strategic adjustments as the project progresses. Finally, as Shenhar & Dvir (2007) and Flyvbjerg (2006) point out, incorporating these methods throughout the project lifecycle ensures resilience and flexibility, arguing that such integration is key to success in complex and unpredictable project environments. Taken together, these ideas provide insight into how to effectively manage uncertainty in project environments, opening the way to more resilient and adaptive management practices.

4.2 Theoretical insights, practical recommendations, and limitations in stakeholder management

These results have several theoretical implications. They reinforce, in line with the work of Aaltonen and Kujala (2016), the dual role of stakeholders as facilitators and sources of complexity. The results also build existing theories by providing specific guidelines for the integration of early-stage complexity assessment tools that support proactive management strategies (Williams et al., 2020). In addition, terms such as “sustainability” and “stakeholder engagement” often coincide, indicating an increasing integration of stakeholder management practices into wider societal objectives (Elkington, 1997).

In practice, this study has concrete implications for project management practitioners. Network analysis tools can also be used to identify critical relationships between stakeholders and improve collaboration (Aaltonen & Kujala, 2016). Using tools such as the complexity assessment tool at an early stage to identify potential barriers early on can improve management risk mitigation over the life of the project.

However, there are some limitations that must be acknowledged. The attention on Scopus may exclude relevant research studies that are in other databases. In addition, the concentration on publications done only in English may overlook localized insights. Future research could include this gap by incorporating a range of databases as well as considering the cultural aspects of stakeholder interactions.

CONCLUSION

In conclusion, research on stakeholder management in complex and uncertain project environments highlights its dual nature as a critical success factor and source of significant challenges. Stakeholder management is a cornerstone of project success because it improves collaboration, coordinates different interests, and promotes innovative solutions (Freeman, 1984; Mitchell et al., 1997). However, at the same time, it is a source of complexity and uncertainty due to the different motivations, expectations, and influences of stakeholders (Aaltonen & Kujala, 2016; Mok et al., 2015).
This research highlights the importance of taking advantage of advanced frameworks and tools to deal effectively with these complexities. Frameworks such as SHAAMPU, VUCA, and the Stakeholder Landscape Framework provide structured approaches to managing stakeholder-induced uncertainty (Chapman & Ward, 2003; Fridgeirsson et al., 2021; Atkinson, Crawford & Ward, 2006; Nyqvist, Peltokorpi & Seppänen, 2023). By combining these frameworks with decision support systems and advanced analytical methods, project managers can anticipate potential challenges, prioritize key risks, and improve the collaborative decision-making process (Power et al., 2002; Dubois & Prade, 1998).
Results also highlight the value of sustainability-focused stakeholder engagement that aligns project goals with broader social and environmental objectives (Elkington, 1997; Epstein & Buhovac, 2014). Incorporating frameworks that emphasize governance, adaptability, and ongoing engagement can improve resilience and flexibility throughout the project lifecycle (Millar, 2007; Perminova et al., 2008). Furthermore, combining soft skills such as communication and negotiation with technical expertise highlights the need for a holistic approach to stakeholder management that goes beyond the traditional project management paradigm (Azim et al., 2010; De Carvalho & Rabechini Junior, 2015).
From a practical point of view, this study advocates the early adoption of complexity assessment tools and the establishment of robust governance structures. These measures can help to proactively mitigate risk and ensure effective management of stakeholder interactions (Williams, 1999; Remington & Pollack, 2007). In addition, the application of agile methodologies

*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma

and advanced information systems improves responsiveness to changing stakeholder needs, contributing to project success (Highsmith, 2009; Lee et al., 2015).

Despite its contributions, this study acknowledges some limitations, including its reliance on English-language publications on the Scopus database, which may limit the diversity of findings (Chadegani et al., 2013; Mongeon & Paul-Hus, 2016). Future research should broaden its scope to include cross-cultural studies and other data sources to better understand stakeholder dynamics in different contexts (Aaltonen & Kujala, 2016; Mok et al., 2015).

In summary, while stakeholder management remains inherently complex, its strategic application (supported by advanced tools and frameworks) offers transformative potential for achieving sustainable and impactful project outcomes. By implementing a dynamic and integrated approach, project managers can transform stakeholder diversity into a source of strength, fostering innovation and resilience in today's rapidly changing project environment (Turner, 1999; Shenhar & Dvir, 2007).

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*Corresponding author. Email: Saloua.chrayah@usmba.ac.ma