
Ex-Ante Evaluation and Implementation of Science, Technology and Innovation Projects

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Abstract

Monitoring and Evaluation Process is a crucial component of any project, involving progress tracking, outcome assessment, and understanding the project's impact on the target population. Ex-ante evaluation, one of the widely studied and utilized evaluation types, plays a significant role in the success of Science, Technology, and Innovation (STI) projects, which are fundamental for the socio-economic transformation of any country. This study aimed to investigate the relationship between the implementation of STI projects and early assessment of the projects prior to execution. A systematic review of published literature was conducted, selecting five articles with geographical diversity covering various STI settings, such as emerging technologies in production industries, research and development, and ICT projects in universities. The articles, published in English and having thematic relevance on the relationship between ex-ante evaluation and STI projects, employed methodologically sound research approaches. The period of publication was widened to include an article from 2009. All five articles had similar objectives of assessing the role of ex-ante evaluation in the adoption and implementation of STI-related projects and converged in their findings regarding the positive impact of ex-ante evaluation on project outcomes. However, some studies diverged in research problems, data collection, analysis methods, and research gaps. In conclusion, this paper presents a multifaceted exploration of ex-ante evaluation as a contemporary concept in project monitoring and evaluation, outlining several steps for evaluating STI projects prior to implementation. Further research is needed on the operationalization and conceptualization of ex-ante evaluation as an approach to monitoring and evaluation in the context of implementing complex and diverse STI projects.¹

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Introduction

In the field of project management, Monitoring and Evaluation (M&E) are indispensable processes that ensure projects meet their objectives and deliver the desired impact. M&E involves rigorous data collection and analysis to monitor progress, identify obstacles, and facilitate necessary adjustments throughout the project lifecycle. As highlighted by Micah & Luketero (2017), this systematic approach allows organizations to not only track advancements but also pinpoint areas requiring improvement, thereby enhancing overall effectiveness. Eckerson (2010) further supports this view by emphasizing that consistent evaluation keeps projects aligned with their strategic goals, providing a clear pathway for achieving targeted outcomes.

Within this broad context, ex-ante evaluation represents a specialized, proactive subset of evaluation practices. Conducted before project implementation, ex-ante evaluation focuses on the initial planning phases of projects, assessing their design and feasibility, particularly in sectors driven by innovation and complex dynamics, such as STI. According to Dziallas & Blind (2019), these early assessments are crucial for STI projects, which play significant roles in driving economic growth and technological advancement. By evaluating projects before they commence, stakeholders can identify potential issues and adjust strategies accordingly, thereby increasing the likelihood of success and efficient resource utilization.

Despite the critical importance of ex-ante evaluations in ensuring the effectiveness of STI projects, there is a notable gap in the literature concerning their systematic application and outcomes. This gap is particularly evident in the documentation of methodologies used for conducting these evaluations and the analysis of how their findings influence subsequent project decisions and success rates. This deficiency suggests a need for comprehensive research aimed at understanding the impact of ex-ante evaluations on project planning and implementation within the STI sector.

The current study aims to bridge this gap by conducting an extensive review of the existing literature on ex-ante evaluations of STI projects. This research will explore several key areas: the methodologies employed in these evaluations, the typical findings they generate, and the manner in which these findings are integrated into project planning and execution. Furthermore, the study will investigate the broader implications of these evaluations, such as their role in shaping project outcomes and their contribution to the field of project management.

By focusing into these aspects, the study seeks to provide a comprehensive overview of ex-ante evaluations in STI projects, highlighting best practices and identifying areas where further research is needed. This endeavor is not only academically significant but also of practical importance to policymakers, project managers, and other stakeholders involved in the planning and implementation of STI projects. Through a detailed synthesis of past research and the identification of existing gaps, this paper aims to contribute valuable insights into the effective use of ex-ante evaluations, ultimately enhancing the success rates of STI projects.

Objective of the Study

The objective of the study is to determine the role of ex-ante evaluation in implementation of STI projects.

Research Questions

The study seeks to address the following research questions:

What ex-ante evaluations have been carried out to contribute towards the success in the implementation of STI projects?

How does ex-ante evaluation contribute to the success in implementation of STI Projects?

What are the key areas of convergence and divergence among the reviewed studies on ex-ante evaluations in STI related projects?

What research gaps, conclusions and recommendations do the reviewed studies offer in regard to the ex-ante evaluation and implementation of STI projects?

Research Methodology

This study employed a scoping review method to identify and analyze published literature on ex-ante evaluations of STI projects. The research was guided by the main research question: "What ex-ante evaluations have been carried out to contribute towards the success in the implementation of STI projects?" Ex-ante evaluation is defined here as the critical assessment conducted in the early stages of a project, focusing on evaluating the quality of project planning before implementation.

Secondary data collection involved a systematic search of articles using specific inclusion and exclusion criteria. The databases used for this search included Google Scholar, ResearchGate, grey literature, and the Jomo Kenyatta Memorial Library at the University of Nairobi (Gustafson et al., 2023). Titles, abstracts, and full texts of articles were screened to ensure relevance and quality. The search yielded ten articles published in peer-reviewed journals, of which five met the criteria for inclusion in this study. Articles were selected based on several criteria: geographical diversity, ensuring a broad representation of STI settings such as emerging technologies in production industries, research and development, and ICT projects in universities; thematic relevance, focusing on the relationship between ex-ante evaluation and STI projects; language, with only articles published in English being considered; and publication date, with a general restriction to articles published within the last five years. However, an exception was made for one article published in 2009 due to the limited number of studies on the specific variables of interest.

The selected articles were analyzed thematically to identify common findings and patterns regarding the role of ex-ante evaluation in the success of STI projects. This thematic analysis allowed for a comprehensive understanding of how early-stage evaluations impact project outcomes. The five articles reviewed included studies from diverse geographical regions: one article focused on a local study in Kenya, another covered the East African region, specifically Rwanda, the third article examined a study from South Africa, specifically Zimbabwe, and the remaining two articles covered South America (Colombia) and Europe (Netherlands), respectively. The review process involved systematic screening and thematic analysis to ensure the selected articles were methodologically sound and relevant to the research question. This structured approach provided a robust foundation for understanding the impact of ex-ante evaluations on STI project success.

Literature Review

Theoretical Framework

For a comprehensive examination of ex-ante evaluations in STI projects, three theoretical frameworks prove particularly relevant: ToC, the Logic Model, and the Diffusion of Innovations Theory. Each theory offers distinct insights and methodologies that can significantly enhance the understanding and execution of these evaluations.

Theory of Change (ToC)

The ToC represents a sophisticated framework that elucidates the intricate pathways through which a desired transformation is anticipated to unfold within a specific setting. Its utility is particularly pronounced in the realm of planning and assessing multifaceted initiatives, where it plays a pivotal role in rendering explicit the foundational presumptions held by stakeholders regarding the mechanisms of change (Weiss, 1995). The methodology commences with a clear delineation of the ultimate objective and then systematically traces back to chart the requisite preconditions, linking them to the planned activities and the anticipated outcomes.

In the domain of STI projects, the application of ToC during ex-ante evaluations proves to be a strategic move. It allows for a meticulous mapping of the routes through which novel technologies or ideas are expected to contribute to broader societal benefits, including economic expansion, enhancements in public health, and advancements in environmental conservation. This methodical approach is instrumental in pinpointing the critical resources and strategic actions necessary to realize the project's ambitions. Moreover, it ensures that all stakeholders possess a unified comprehension of the project's goals and the pathways to achieve them, fostering a cohesive and collaborative environment (Anderson, 2005).

Beyond its role in initial planning, ToC promotes a keen focus on quantifiable markers of achievement, thereby establishing a robust framework for continuous monitoring and recursive feedback mechanisms. This emphasis on measurement and adaptation is vital for navigating unforeseen obstacles and capitalizing on emerging opportunities. Consequently, ToC not only enhances the efficacy of STI project planning and execution but also cultivates a dynamic and adaptive approach that is responsive to the ever-evolving internal and external landscapes of the project. This adaptability is a cornerstone of successful STI initiatives, enabling them to remain aligned with their objectives while being agile enough to adjust course as needed.

Logic Model

The Logic Model stands as a structured instrument employed in the realms of program planning, administration, and appraisal. It offers a visual depiction of the interconnections between a program's resources, its activities, the outputs it generates, and both its short-term and long-term outcomes, thereby providing a succinct overview of how program initiatives are designed to culminate in the achievement of desired results (McLaughlin & Jordan, 1999). Within the context of ex-ante evaluations for STI projects, the Logic Model functions as a foundational plan, enabling a comprehensive grasp and documentation of the sequential flow of activities and their envisioned impacts.

This model distinguishes itself by its ability to elucidate each constituent element of a project, starting from inputs such as financial backing and human capital, proceeding through processes and activities like research and development, and culminating in outputs like patents or prototypes, and ultimately in outcomes that might encompass marketable products or novel standards in practice. By diagramming these elements, the Logic Model helps to guarantee that all facets of the project are harmonized with the project's overarching objectives and are logically interconnected to yield the intended effects (W.K. Kellogg Foundation, 2004).

In the dynamic environment of STI, where projects frequently operate at the forefront of technological and innovative advancements, the Logic Model serves as a vital tool for stakeholders. It aids in maintaining a clear focus on the sequential steps' indispensable for success, thereby augmenting strategic planning and communication both within project teams and with external collaborators. Additionally, the Logic Model facilitates the identification of

performance metrics at each stage of the project, which are critical for ongoing evaluation and reporting purposes.

In essence, the Logic Model furnishes a roadmap that not only charts the course from inputs to outcomes but also ensures that each phase of the project is aligned with its broader goals. Its application in STI projects not only enhances transparency and accountability but also fosters an environment conducive to achieving innovative and impactful results. By clarifying the logical sequence of activities and their expected impacts, the Logic Model plays a pivotal role in the successful planning, execution, and evaluation of STI initiatives.

Diffusion of Innovations Theory

Diffusion of Innovations Theory, developed by Everett Rogers, explores how new ideas, practices, or products gain momentum and spread through specific populations or social systems (Rogers, 2003). The theory identifies several factors that influence the adoption of innovations, including the characteristics of the innovation itself, communication channels, time, and the social system. This theory is particularly pertinent to ex-ante evaluations of STI projects as it provides insights into the factors that affect the uptake and implementation of new technologies or ideas.

Applying the Diffusion of Innovations Theory in ex-ante evaluations helps project planners and evaluators understand not just the development of an innovation, but also the broader context of its implementation and adoption. The theory encourages a focus on the usability and adaptability of the innovation, the readiness of the target market or community to adopt it, and the strategies needed to facilitate widespread adoption. Moreover, the theory underscores the importance of effective communication strategies in promoting innovation uptake, highlighting the role of opinion leaders and change agents in influencing others within a system.

By integrating the Diffusion of Innovations Theory into the planning and evaluation of STI projects, project teams can gain a deeper understanding of how innovations can be effectively introduced into, and adopted by, targeted settings. This, in turn, helps ensure that these innovations achieve their maximum impact and reach their full potential.

The Diffusion of Innovations Theory complements the other two frameworks – the ToC and the Logic Model – in providing a robust theoretical foundation for the ex-ante evaluation of STI projects. While ToC focuses on outlining the causal pathways and underlying assumptions, and the Logic Model offers a systematic tool for planning and evaluation, the Diffusion of Innovations Theory brings an important perspective on the factors that influence the adoption and implementation of innovative solutions.

By using these three theories in combination, project planners and evaluators can enhance the planning, implementation, and evaluation processes of STI initiatives. This holistic approach ensures that not only are innovative solutions developed, but that they also achieve broad and sustainable impacts within the targeted settings. The integration of these frameworks provides a comprehensive lens through which to assess the viability, feasibility, and potential for success of STI projects, ultimately contributing to their long-term impact and success.

Empirical Review

The systematic literature review identified five studies that met the inclusion and exclusion criteria. All the studies used different methods to arrive at their research findings, but they all had the common objective of assessing the role of ex-ante evaluation in the adoption and implementation of STI projects.

The study by Enciso, Charry, Castillo and Burkat (2021) probed into the ex-ante evaluation of economic impacts linked to adopting improved forages in the Colombian Orinoquía region. Utilizing two models – the cost-benefit analysis (discounted free cash flow model) and the Monte Carlo simulation analysis at the micro or farm level – the study aimed to assess the feasibility of implementing the Agrosavia Caporal technology compared to traditional methods. Financial results from the simulation highlighted in Table 1 showcased the superior performance of the Agrosavia Caporal technology over the reference technology, with higher Net Present Value (NPV) and Internal Rate of Return (IRR) values.

Table 1: Profitability Indicators in the Simulation Model

Decision criterion	Indicator	<i>Brachiaria brizantha</i> 26,124 cv. Agrosavia caporal	<i>Brachiaria decumbens</i> (reference technology)
NPV (US\$)	Mean ^a	328	182
	SD ^b	95	134
	IC (95%) ^c	(30)-622	(223)-509
IRR (%)	Mean	21%	18%
Payback period (years)	Mean	5	5

^aMean value of the NPV obtained in the simulation (5,000 iterations).
^bSD: Standard deviation of the NPV with respect to the mean value.
^cIC: Minimum and maximum values with a 95% confidence interval.

Source: (Enciso et al., 2012)

The Economic Surplus Model, detailed in Table 2, demonstrated positive NPV, IRR, and Benefit-Cost Ratio (B/C) values at both regional and national level.

Table 2: Economic Stimulus Model Results (Values in Thousands USD)

Level	Scenario	Change CS	Change PS	Change TS	NPV	IRR (%)	B/C
Regional	B	1,184	1,979	3,165	903	19	8
	O	2,540	4,246	6,786	1,573	20	18
	P	444	742	1,186	-36	11	3
National	B	7,115	11,893	19,008	5,087	26	50.3
	O	15,261	25,508	40,768	11,342	30	108
	P	1,905	3,184	5,089	1,085	19	13.5

CS: Consumer Surplus, PS: Producer Surplus, TS: Total Surplus.

Source: (Enciso et al., 2012)

In the Basic Scenario, both the regional and national levels had a total benefit of USD 3,165,000 and USD 19,008,000 representing IRR of 19% and 26% respectively. Optimistic Scenario both the regional and national levels had a total benefit of USD 6,786,000 and USD 40,768,000 representing IRR of 20% and 30% respectively, while Pessimistic Scenarios, both the regional and national levels had a total benefit of USD 1,186,000 and USD 5,089,000 representing IRR of 11% and 19% respectively.

Furthermore, Figure 1 illustrates the Adoption Curves of the Economic Stimulus Model, showcasing the adoption and diffusion process characterized by Early Adoption, Exponential Growth, and Transition Phase stages.

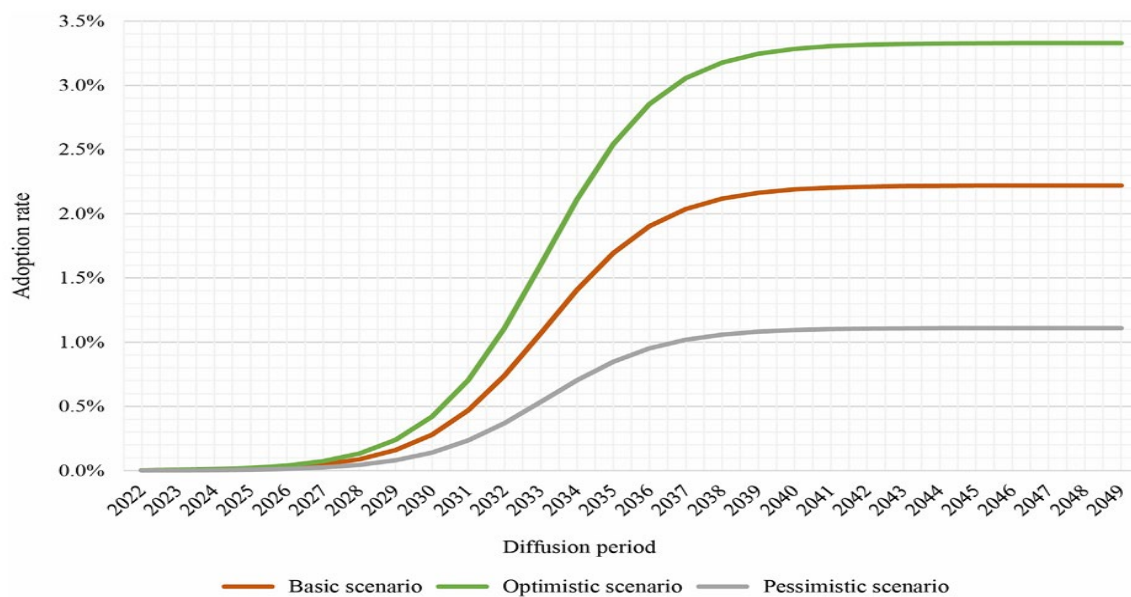


Figure 1: Adoption Curves of the Economic Stimulus Model.

Source: (Enciso et al., 2012).

The sensitivity analysis results, presented in the above graph, indicated an 80% probability of success with adoption rates of 2.8% and 2.2% at the regional and national levels respectively.

Overall, the study found that the investment and operational costs of the Agrosavia Caporal technology were higher than those of traditional technology. However, the new technology produced better productive outcomes and was found to be more resistant to drought, diseases, humidity, and local pests. The study recommended conducting ex-ante evaluations before deciding on R&D investments to utilize their results for strategic decision-making processes and allocation of scarce resources.

The study by Santiago-Herrera, Igos, Alegre, Martel-Martin and Barros (2024) focused on the ex-ante life cycle assessment gearbox production using Additive Manufacturing (AM) as compared to casting. The study aimed to compare AM with conventional manufacturing methods in terms of environmental sustainability. The study found that AM technology achieved a reduction of 94% in climate change impacts and recommended further investigation into the quality and warranty standards of the component. The study had a conceptual gap because the study partially brought out the concept of investment in ex-ante evaluations before application of new technologies although this study itself was conducted while omitting the explanation of most concepts and variables.

The study by Waema and Mwamburi (2009) focused on the ex-ante evaluation of Information and Communication Technology (ICT) projects in public and private Kenyan universities. The study found that external stakeholders, such as the Ministry of Education, played a significant role in the ex-ante evaluation process, but their bureaucratic nature affected the progress of evaluations. The study recommended the formal monitoring and evaluation of ICT projects through ex-ante and ex-post evaluations.

The study by Dube et al. (2024) investigated the ex-ante evaluation of incorporating indigenous knowledge systems-based climate services in anticipatory action (AA) in Zimbabwe. The study found that 83% of households combined IKS and scientific methods for climate forecasting and recommended the formal adoption of IKS in climate forecasting.

The study by McCampbell, Adewopo, Klerkx and Leeuwis (2023) focused on the use of the ex-ante approach to assess the readiness of Rwandan smallholder farmers to use digital tools for agronomic advice. A survey was carried out in order to collect data from small scale banana farmers from Eight (8) Districts namely; Gisagara, Rubavu, Gatsibo, Burera, Rulindo, Karongi, Muhanga and Kayonza. These Districts are within Four (4) provinces in Rwanda namely; Northern, Southern, Eastern, and Western which are largely covering all agro-ecological zones producing bananas. The sampling strategy involved selection of districts in consultation with agricultural extension officers. The selection criteria were based on diversity in production zones and production topologies. Stratified sampling was conducted followed by purposive sampling based on distance district office and the village and incident severity. The demographic variables that were used were based age, gender, level of education, household position and district of origin. The distribution of focal villages is as shown in Figure 2 below.

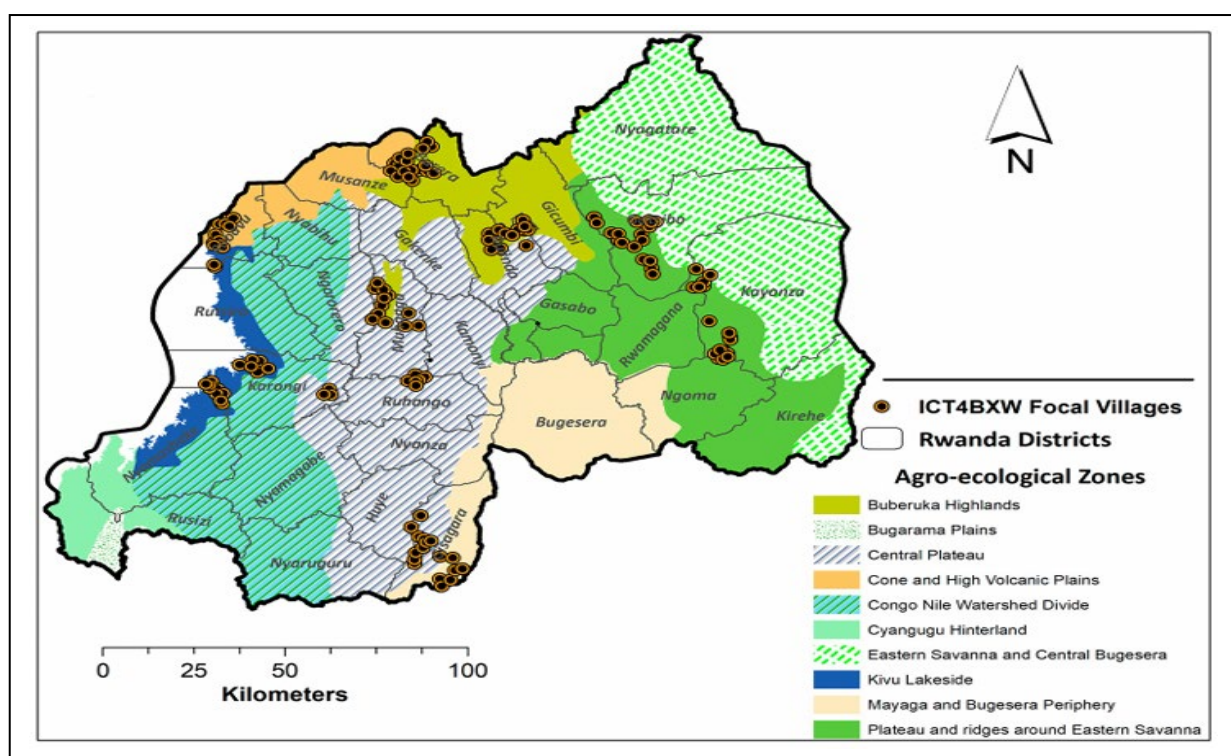


Figure 2: Distribution of Focal Villages

Source: (McCampbell et al., 2023)

The study found that 85% of households were limited in terms of physical opportunity, physical capability, and psychological capability. However, the study recommended the adoption of the ex-ante approach to explore user readiness before developing a new digital extension intervention.

In summary, the review of literature highlights the importance of ex-ante evaluation in the implementation of STI projects. The studies reviewed demonstrate that ex-ante evaluation has a positive impact on project outcomes, including improved productivity, resistance to external factors, and environmental sustainability. However, there is a need for further research on the operationalization and conceptualization of ex-ante evaluation as an approach to monitoring and evaluation in the context of implementing complex and diverse STI projects.

Findings

The studies reviewed demonstrate that ex-ante evaluation is very crucial in project management, however, the studies revealed several gaps and limitations that need to be addressed in future research. One of the gaps identified in the studies is the knowledge gap. For instance, the study by Waema and Mwamburi (2009) had a knowledge gap because few studies have focused on the STI variable. This gap highlights the need for more research on the relationship between ex-ante evaluation and STI projects.

Another gap identified in the studies is the conceptual gap. For example, the study by Dube et al. (2024) partially brought out the concept of investment in ex-ante evaluations before application of new technologies although this study itself was conducted while omitting the explanation of most concepts and variables. This gap highlights the need for further research on the conceptualization of ex-ante evaluation as an approach to monitoring and evaluation in the context of implementing complex and diverse STI projects.

The studies also reveal a theoretical gap. For instance, the study by McCampbell et al. (2023) was not grounded on any theory or Model. This gap highlights the need for future research to ground ex-ante evaluation in a theoretical framework that can guide its application in STI projects.

The studies also reveal a methodological gap. For example, the study by Enciso et al. (2021) had a methodological gap during the study from lack of ethical statements to presence of conflicting information. This gap highlights the need for future research to adopt rigorous and ethical research methods that can enhance the reliability and validity of the findings.

The studies also reveal an evidence gap where it cannot be generalized that the results from the studies will have a positive impact in most of the developing countries. This gap highlights the need for future research to consider the contextual factors that may influence the success of ex-ante evaluation in different settings.

The findings of this systematic literature review have several implications for research and practice. Firstly, the studies reviewed demonstrate the importance of ex-ante evaluation in STI projects, which can enhance their success and sustainability. Secondly, the studies reveal several gaps and limitations that need to be addressed in future research to enhance the reliability and validity of the findings. Thirdly, the studies highlight the need for future research to adopt rigorous and ethical research methods that can enhance the reliability and validity of the findings. Fourthly, the studies highlight the need for future research to consider the contextual factors that may influence the success of ex-ante evaluation in different settings.

The limitations of this systematic literature review include the focus on English language articles, which may have excluded relevant studies published in other languages. Additionally, the review included only five studies, which may limit the generalizability of the findings. Finally, the review did not assess the quality of the studies included, which may have influenced the findings.

Table 3 shows a summary of convergence analysis pertaining to the studies.

Table 3: Convergence Analysis Table

Convergence Themes	Guiding Questions
The research problem being investigated	Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) carried out research on ex-ante evaluation of incorporating indigenous knowledge systems-based climate services in AA in Zimbabwe that was similar to study by McCampbell, Adewopo, Klerkx and Leeuwis (2023) on ex-ante user readiness assessment using the case of Rwandan banana farmers on their readiness to use phone-based digital tools for agronomic advice.
The purpose, objectives, questions, hypotheses	All the studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024), McCampbell, Adewopo, Klerkx and Leeuwis (2023) and Enciso, Charry, Castillo and Burkart (2021) have similar objectives of assessing the role of ex-ante evaluation in adoption of emerging technologies.
The design of the study	Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) have similar research designs based on the scope where surveys have been used. Additionally, Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and Waema and Mwamburi (2009) used longitudinal design while causation design was used by Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Charry, Castillo and Burkart (2021).
Target population and sample size	Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) used similar target populations of households.
Sampling procedures/ methods	Stratified sampling was utilized by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) while Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) have used simulations to pick samples.
How data was collected	Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) have utilized interviews and desk top reviews to collect data. Additionally, Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and Adewopo, Klerkx and Leeuwis (2023) have utilized surveys to collect data while Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) utilized Monte Carlo simulations to generate data.

How data was analyzed	Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) used descriptive statistics methods to analyze data while Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) utilized sensitivity analysis.
Findings/ results of the study	All the studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024), McCampbell, Adewopo, Klerkx and Leeuwis (2023) and Enciso, Charry, Castillo and Burkart (2021) had similar findings where application of new technologies have positive results and ex-ante evaluation for project viability has been recommended.
The gaps	Knowledge Gap. Waema and Mwamburi (2009) research had a knowledge gap because few studies have focused on the STI variable. Conceptual Gap. Studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) had conceptual gaps as the studies partially brought out the concept of investment in ex-ante evaluations before application of new technologies although this study itself was conducted while omitting the explanation of most concepts and variables. Theoretical Gap. The studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) were not grounded on any theory or Model hence presented theoretical gap. Methodological Gap. The studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) presented methodological gaps during the study from lack of ethical statements to presence of conflicting information. Evidence Gap. All the studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024), McCampbell, Adewopo, Klerkx and Leeuwis (2023) and Enciso, Charry, Castillo and Burkart (2021) had evidence gaps since it cannot be generalized that the results will have a positive impact in most of the developing countries.

The divergence of the studies is summarized in Table 4.

Table 4: Divergence Analysis Table

Divergence Themes	Guiding Questions
The research problem being investigated	All the studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) did not have similar research problems.
The purpose, objectives, questions, hypotheses	There was no divergence in purposes and objectives of study.
The design of the study	The study by Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) is the only one that utilized case study design.
Target population and sample size	The studies by Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) targeted populations that were different from the target populations and sample sizes by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009) and Martel-Martín and Barros (2024), McCampbell, Adewopo, Klerkx and Leeuwis (2023).
Sampling procedures/methods	Waema and Mwamburi (2009) did not have similar sampling procedure because the choice and sampling were done based on willingness of institution to participate in the study.
How data was collected	There was no divergence in data collection methods.
How data was analyzed	Study by Waema and Mwamburi (2009) was the only one that utilized case analysis method. On the other hand, Enciso, Charry, Castillo and Burkart (2021) used cost benefit analysis and quantitative risk analysis.
Findings/ results of the study	There was no divergence in findings of study.
The gaps	Contextual Gap. Limited studies have been carried out in locally and that is why Waema and Mwamburi (2009) study was published in 2009 was considered. Conceptual Gap. McCampbell, Adewopo, Klerkx and Leeuwis (2023) did not have a conceptual gap. Theoretical Gap. Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021)

	studies were grounded on Models hence did not present theoretical gaps. Methodological Gap. The study by McCampbell, Adewopo, Klerkx and Leeuwis (2023) was the only one that did not present a methodological gap. Empirical/Evidence Gap. There is no divergence in all the studies.
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Discussion

The current study conducted a systematic review of the literature to investigate the relationship between the implementation of STI projects and early assessment of the projects prior to execution. The review selected five articles that focused on ex-ante evaluation, a critical assessment conducted before project implementation to evaluate the quality of project planning. The articles, which covered various STI settings and employed methodologically sound research approaches, all found that ex-ante evaluation had a positive impact on project outcomes.

However, the study also identified several gaps and limitations in the existing literature. These gaps include knowledge gaps, conceptual gaps, theoretical gaps, and methodological gaps. The knowledge gap refers to the need for more research on the relationship between ex-ante evaluation and STI projects. The conceptual gap refers to the need for further research on the conceptualization of ex-ante evaluation as an approach to monitoring and evaluation in the context of implementing complex and diverse STI projects. The theoretical gap refers to the need for future research to ground ex-ante evaluation in a theoretical framework that can guide its application in STI projects. The methodological gap refers to the need for future research to use a consistent and rigorous methodological approach in studying the relationship between ex-ante evaluation and STI projects.

Overall, the findings of this study suggest that ex-ante evaluation has a positive impact on project outcomes in STI projects. However, there is a need for further research to address the gaps and limitations identified in the study. This will help develop a more comprehensive understanding of the relationship between ex-ante evaluation and STI projects, leading to the development of best practices and strategies for successful implementation.

Based on the findings of this systematic literature review, several recommendations can be made for future research. Firstly, future research should focus on addressing the gaps and limitations identified in the studies reviewed. For instance, future research should aim to address the knowledge gap by focusing on the relationship between ex-ante evaluation and STI projects. Secondly, future research should aim to address the conceptual gap by further exploring the conceptualization of ex-ante evaluation as an approach to monitoring and evaluation in the context of implementing complex and diverse STI projects. Thirdly, future research should aim to address the theoretical gap by grounding the study of ex-ante evaluation in a theoretical framework that can guide its application in STI projects. Fourthly, future research should aim to address the methodological gap by adopting rigorous and ethical research methods that can enhance the reliability and validity of the findings. Finally, future research should aim to address the evidence gap by considering the contextual factors that may influence the success of ex-ante evaluation in different settings.

A summary of the critique of the journal articles is presented in Table 5.

Table 5: Critiquing Journal Articles

Theme	Guiding Questions
The research problem being investigated	The study by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) presented a research problem was compelling because there is lack of accuracy in climate forecasting as of usage of Indigenous Knowledge Systems (Tanyanyiwa, 2018). The study by Waema and Mwamburi (2009) had a justifiable research problem since management of benefits that are anticipated after implementation of a new technology are to be managed prudently through support and execution other ICT evaluations, similar to what other businesses do (Gow & Morss, 1988). The research that was carried out by Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) was unique since few studies have been carried using Life Cycle Assessment (LCA) methodology (Paris et al., 2016) including the use of titanium matrix powder (Genna & Rubino, 2020). In the research by McCampbell, Adewopo, Klerkx and Leeuwis (2023), it was revealed that the use of technology had been widely utilized in African agricultural extension services especially online services coupled with ex-post evaluation of its usability. However, there is little ex-ante assessment has been carried out to determine ability to adopt the services and its sustainability (Daum et al., 2021). The study by Enciso, Charry, Castillo and Burkart (2021) would eventually aid in estimation of the potential yields from carrying out R&D activities of this improved forage variety (Piesse & Thirtie, 2010).
The purpose, objectives, questions, hypotheses	All the studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024), McCampbell, Adewopo, Klerkx and Leeuwis (2023) and Enciso, Charry, Castillo and Burkart (2021) had relevant purposes and objectives that were in the context of the overall research problem which is relevance of ex-ante evaluation prior to implementation of STI related projects (Williams, Samset and Sunnevaag, 2009).
The design of the study	All the Five studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009), Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024), McCampbell,

	Adewopo, Klerkx and Leeuwis (2023) and Enciso, Charry, Castillo and Burkart (2021) utilized appropriate designs. Studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) utilized Survey design (Fink, A., & Kosecoff, J., 1985) because of the uniqueness in gathering information that was not available from other sources and use survey data to complement existing data from secondary source. Case study was used by Waema and Mwamburi (2009) to find solutions to implementation of ICT problems in Kenyan Universities based on past problem-solving experiences (Feagin, Orum and Sjoberg, 2016). The studies Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) utilized causal design in order to assess impacts of various processes and specific changes on existing norms (Axelrod, 1997).
Target population and Sample Size	The research by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), McCampbell, Adewopo, Klerkx and Leeuwis (2023) and Enciso, Charry, Castillo and Burkart (2021) targeted populations which were households (Dwyer, W. O., et al., 1993) that was appropriate for the studies because of the need to involve local population as stakeholders in project. The study by Waema and Mwamburi (2009) considered target population from both private and public local Kenyan universities thus the objective of the study was met. In addition, the study by Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) provided results for adoption of an eco-design that supports decision making for further development of new technology by Heijungs and Kleijn (2001).
Sampling Procedures/ Methods	Stratified sampling that was utilized by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) was appropriate (Neyman, 1992) while use of simulations to pick samples in the study by Santiago-Herrera, Igos, Alegre, Martel-Martín) and Enciso, Charry, Castillo and Burkart (2021) was justified (Gasparini, 2018).
How data was collected	Studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024), Waema and Mwamburi (2009) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) utilized interviews (Alshenqeeti, H. , 2014) and desk top reviews to collect data which were appropriate. Additionally, Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023)

	utilized surveys (Alam, I., Khusro, S., Rauf, A., & Zaman, Q. , 2014) to collect data while Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) utilized Monte Carlo simulations to generate data(Gasparini, 2018).
How data was analyzed	The data analysis techniques were appropriate because good results were yielded. The studies by Dube, Huhn, Guimarães Nobre, Moyo and Enenkel (2024) and McCampbell, Adewopo, Klerkx and Leeuwis (2023) used descriptive statistics methods by Thompson (2009) to analyze data while Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) and Enciso, Charry, Castillo and Burkart (2021) utilized sensitivity analysis (Christopher Frey and Patil, 2002). McCampbell, Adewopo, Klerkx and Leeuwis (2023) utilized case analysis that generated reliable results by Houghton et al., (2015)
Findings/ results of the study	The study by Santiago-Herrera, Igos, Alegre, Martel-Martín and Barros (2024) presented the results from the comparative analysis of the Additive and Conventional technologies that are based on the research objectives. The study by Enciso, Charry, Castillo and Burkart (2021) led to better results where the product was found to be resistant to drought, diseases, humidity, local pests like spittlebug and more palatable in accordance with the study objectives.
The gaps/ How they are to be addressed	These shortcomings to be addressed through studies on ex-ante evaluation before investment in STI projects, consideration of ethical issues, proper depiction of all the results and conclusive studies to cover large areas for better representation.

Conclusion and Recommendations

The research question for this study was to investigate the relationship between the implementation of STI projects and early assessment of the projects prior to execution. The study aimed to explore how ex-ante evaluation can be used to assess the viability of STI projects before their implementation. The study employed a systematic literature review approach, which involved identifying and analyzing relevant articles published in peer-reviewed journals. The search was conducted in databases such as Scopus, Web of Science, and Google Scholar. The inclusion and exclusion criteria were established, and a total of five articles were selected for the review.

The review revealed that ex-ante evaluation is an essential tool for assessing the viability of STI projects before their implementation. The findings show that ex-ante evaluation can help identify potential risks and challenges in the early stages of project development, which can be

addressed before project implementation. The review also revealed that ex-ante evaluation can help enhance the success and sustainability of STI projects. However, the review also revealed several gaps and limitations in the existing literature. For instance, the review identified a knowledge gap, a conceptual gap, a theoretical gap, a methodological gap, and an evidence gap. These gaps highlight the need for further research to address the limitations identified in the existing literature.

The study has achieved its aim of exploring the role of ex-ante evaluation in assessing the viability of STI projects before their implementation. The most important findings of the study are that ex-ante evaluation can help identify potential risks and challenges in the early stages of project development, which can be addressed before project implementation. The study also revealed that ex-ante evaluation can help enhance the success and sustainability of STI projects.

The limitations of the study include the focus on English language articles, which may have excluded relevant studies published in other languages. Additionally, the review included only five studies, which may limit the generalizability of the findings. Finally, the review did not assess the quality of the studies included, which may have influenced the findings.

The study has satisfied its aims by providing insights into the role of ex-ante evaluation in assessing the viability of STI projects before their implementation. The study has also identified several gaps and limitations in the existing literature, which opens new research possibilities.

The study has practical implications for real-world situations as follows:

The results of this study suggest that the implementation of ex-ante evaluation in STI projects can help improve their success and sustainability. Therefore, it is recommended that STI projects incorporate ex-ante evaluation as part of their project management process.

The findings of this study also highlight the need for further research on the conceptualization of ex-ante evaluation as an approach to monitoring and evaluation in the context of implementing complex and diverse STI projects. This can help enhance the reliability and validity of the findings and improve the overall success of STI projects.

The methodological gap identified in this study highlights the need for future research to adopt rigorous and ethical research methods that can enhance the reliability and validity of the findings. This can help improve the overall success of STI projects.

The evidence gap identified in this study highlights the need for future research to consider the contextual factors that may influence the success of ex-ante evaluation in different settings. This can help enhance the generalizability of the findings and improve the overall success of STI projects.

The limitations of this study, such as the focus on English language articles, the use of only five studies, and the lack of quality assessment, should be considered when interpreting the findings of this study. Future research should aim to address these limitations to enhance the reliability and validity of the findings.

The findings of this study can be used to inform decision-making in the implementation of STI projects, which can enhance their success and sustainability. This can have practical implications for real-world situations, such as in the implementation of STI projects in developing countries.

The findings of this study can also be used to inform policy-making in the implementation of STI projects, which can enhance their success and sustainability. This can have practical implications for real-world situations, such as in the development of STI policies and strategies.

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