



LIFECYCLE IMPACT ASSESSMENT OF AN ENGINEERING PROJECT MANAGEMENT PROCESS – A SLCA APPROACH

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ABSTRACT

Engineering projects are designed to solve societal problems, foster community development, and enhance quality of life. However, these projects often have unintended consequences that affect human life and ecosystems. The management process of these projects significantly influences their social, environmental, and economic impacts. This paper presents a framework for evaluating the lifecycle impacts of engineering project management processes on various stakeholders, including workers, clients, communities, and society at large. The model adopts the UNEP/SETAC guidelines for Social Lifecycle Impact Assessment (SLCA). By identifying potential impacts during the lifecycle stages, project managers can reinforce positive outcomes and mitigate negative effects. Incorporating SLCA in project management is expected to improve overall project value, particularly from a social sustainability perspective.

Keywords: Social sustainability, lifecycle assessment, community impact assessment, social impacts, engineering project management, sustainable development, impact assessment.

DOI:10.5281/zenodo.14580780

Manuscript ID # 220

1. INTRODUCTION

Project Management in Engineering

Project management involves the application of knowledge, skills, tools, and techniques to project activities to meet specific requirements [1]. According to the Project Management Institute, the project lifecycle encompasses several stages: initiation, planning, execution, monitoring, controlling, and closure [2]. These stages provide a structured approach to managing projects efficiently and effectively.

Engineering projects, which range from large-scale infrastructure like bridges and highways to advanced systems like spacecraft, require meticulous planning and execution. Such projects rely heavily on structured management frameworks to ensure timely delivery, cost control, and adherence to quality standards [30]. The process framework, plays a critical role in organizing and controlling activities to achieve desired outcomes while addressing risks and uncertainties inherent in engineering tasks.

Project management processes can have both positive and negative impacts on stakeholders, including the project team, community members, and investors. The severity of these impacts varies across stakeholder groups. For instance, while economic benefits may be realized through job creation and enhanced infrastructure, adverse social and environmental consequences may also arise. Social impacts, in particular, have garnered increased attention as society becomes more mindful of the implications of engineering activities on human well-being [29].

Social impacts refer to changes experienced by individuals and communities as a result of project activities, such as constructing new facilities or infrastructure. For example, building an airport may generate economic opportunities and enhance connectivity but could also lead to increased noise pollution, displacement of local communities, and traffic congestion [31]. To evaluate such impacts comprehensively, Social Lifecycle Assessment (SLCA) has emerged as a critical methodology. SLCA focuses on analyzing how products, projects, and activities affect human well-being throughout their lifecycle [6]. While its importance continues to grow, SLCA methodologies are still evolving, with challenges in standardization, data availability, and practical application [7, 8].

SLCA typically follows a structured approach consisting of four key stages:

- **Goal and Scope Definition:** Establishing the purpose of the assessment, identifying the target audience, and defining the boundaries of the study.
- **Lifecycle Inventory:** Collecting data on social aspects related to each stage of the product or project lifecycle.
- **Lifecycle Impact Assessment:** Evaluating the social implications based on indicators such as labor rights, community health, and equity.
- **Lifecycle Interpretation:** Analyzing and interpreting results to support decision-making and identify areas for improvement.

These stages, enable a systematic evaluation of social consequences, facilitating informed decision-making by project stakeholders [9]. SLCA's application promotes transparency and accountability, helping stakeholders balance social benefits and risks effectively.

Despite its potential, SLCA faces several challenges. Standardization remains a significant barrier, as different projects and regions may require tailored approaches. Additionally, data collection can be resource-intensive, particularly when dealing with qualitative aspects such as social equity or cultural impact. However, advances in digital tools and international collaboration present opportunities to enhance SLCA's reliability and applicability. By integrating SLCA into engineering project management, organizations can better address the social dimensions of sustainability. This approach not only aligns with global sustainability goals but also builds trust among stakeholders by demonstrating a commitment to ethical and responsible practices.

2. Goal and Scope Definition

Project management involves the application of knowledge, skills, tools, and techniques to project activities to meet specific requirements [1]. According to the Project Management Institute, the project lifecycle encompasses initiation, planning, execution, monitoring, controlling, and closure [2]. Engineering projects, ranging from large-scale infrastructure like bridges and roads to complex systems like spacecraft, rely heavily on structured management approaches for realization [3]. The process framework, illustrated in Figure 1, is fundamental in organizing and controlling activities to achieve desired outcomes.

However, these processes have both positive and negative impacts on stakeholders, varying in severity across groups. Social impacts, in particular, have garnered attention in recent years, as society increasingly evaluates the implications of human activities on wellbeing [4].

Assessing Social Impacts

Social impacts stem from changes introduced by projects, such as constructing new facilities or infrastructure [5]. For example, building an airport might create employment opportunities while simultaneously increasing noise pollution and traffic. Social Lifecycle Assessment (SLCA) has emerged as a critical tool for analyzing how products, projects, and activities affect human wellbeing [6]. Despite its growing importance, SLCA methodologies are still evolving, with challenges in standardization and practical application [7, 8].

SLCA is typically implemented in four stages: goal and scope definition, lifecycle inventory, lifecycle impact assessment, and lifecycle interpretation (Figures 2 and 3). These stages provide a structured approach for evaluating social consequences, facilitating informed decision-making by project stakeholders [9].

Objectives and Scope of the Study

A. Objectives

The primary goal of this study is to provide awareness of the social consequences of engineering project management processes. It aims to enable stakeholders, including policymakers and project managers, to make informed decisions throughout the project lifecycle. Specifically, the study seeks to identify social sustainability hotspots to support the development of sustainable project management strategies [10].

B. Scope of the Study

This SLCA study focuses on developing a generic model for assessing the social impacts of project management processes. A case study on an infant food production plant project demonstrates the application of the model. The scope includes defining the system's function, boundaries, and key metrics for assessing social impacts, such as net change in human wellness per person (NCIHWPP) [11].

C. Function and Functional Unit

The function of the project management process is defined as achieving the project's purpose and deliverables within the scheduled timeframe. The functional unit, NCIHWPP, reflects the impact of the project on human wellbeing, encompassing physical, emotional, and economic dimensions [12, 13].

D. System Boundaries

This study evaluates the impacts of project management stages on the wellbeing of project team members and the immediate community. While broader societal implications are recognized, the analysis focuses on direct and localized effects to maintain specificity [14].

Lifecycle Inventory (LCI)

Lifecycle inventory involves collecting and quantifying data related to the project's social impacts. This study employs site-specific data from a research and development organization in Lagos State, Nigeria, supplemented by UNEP/SETAC guidelines [15].

A. Data Collection

Data was collected using quantitative, semi-quantitative, and qualitative methods, including surveys, interviews, and public records. The inventory captures metrics such as employment generation, training opportunities, and community infrastructure development [16].

B. Data Aggregation

Lifecycle inventory results are summarized in Tables 1 and 2, which present impact criteria for workers and local communities. Metrics include health and safety, income changes, and access to resources [17].

Social Lifecycle Impact Assessment (SLCIA)

SLCIA evaluates the social impacts identified during the inventory phase. Following UNEP/SETAC guidelines, this study considers two key stakeholder categories: workers and local communities [18].

A. Impact Categories and Classification

The impact categories include health and safety, employment quality, community engagement, and equity [19]. These categories were mapped to subcategories such as access to healthcare, training opportunities, and local business stimulation. Classification aligns with the principles outlined in SLCA literature [20].

B. Characterization and Weighting

Characterization involves quantifying the significance of each impact using normalized scores. Weighting prioritizes impacts based on stakeholder feedback and societal importance. For instance, health and safety received the highest weighting due to its critical role in project sustainability [21].

5. Case Study: Infant Food Production Plant

Social Impacts

1. Employment The infant food production project in Nigeria has significantly boosted local employment opportunities. Specifically:

- Direct Employment: The plant directly employed 50 individuals. These positions included various roles ranging from production line workers, quality control personnel, logistics coordinators, to administrative staff. This direct employment not only provided stable income to these individuals but also contributed to the overall economic growth of the region.
- Indirect Employment: An additional 100 indirect jobs were created. These roles encompassed supply chain roles such as local farmers supplying raw materials, transportation services, and other support services. The multiplier effect of these jobs significantly enhanced the local economy by increasing disposable income and promoting local businesses [23].

2. Community Development The project led to several infrastructure improvements that benefited surrounding communities:

- Road Access: Improved road infrastructure ensured easier and faster transportation of raw materials to the plant and finished products to the market. This development reduced travel time, lowered transportation costs, and opened up new economic opportunities for local businesses.
- Power Supply: To support the plant's operations, enhancements in the local power supply were necessary. These improvements not only ensured consistent production but also provided more reliable electricity to nearby communities, enhancing the quality of life for residents and enabling the growth of other businesses [24].

3. Training and Knowledge Transfer The project emphasized capacity building through:

Workshops and Seminars: These were conducted to transfer knowledge and skills to local entrepreneurs and potential business owners. Topics covered included modern agricultural practices, business management, food safety standards, and production techniques. These educational initiatives aimed to empower locals with the necessary skills to start and manage their own businesses successfully [25].

Technology Dissemination: By introducing advanced production technologies and practices, the project helped modernize local food production methods. This dissemination of technology had a long-lasting impact on the agricultural sector, promoting sustainability and efficiency.

Conclusion

This case study highlights the utility of Social Life Cycle Assessment (SLCA) in managing engineering projects. Key takeaways include:

Identifying Social Sustainability Hotspots: SLCA helped in pinpointing areas where social sustainability could be improved, allowing for targeted interventions that maximized positive social impacts.

Enhancing Project Value: By focusing on social impacts, the project not only achieved its primary goal of producing nutritious baby food but also created additional value through community development and economic upliftment.

Stakeholder Wellbeing: The project underscored the importance of considering stakeholder wellbeing in project planning and implementation. Ensuring the welfare of employees, suppliers, and the local community

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