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The Impact of Sustainable Development Goals on the Success of Mega Projects: A Case Study of Benban Solar Park in Egypt

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Abstract- ***This study explores the influence of Sustainable Development Goals (SDGs) on the success of mega projects in the context of Egypt's renewable energy sector. Using Benban Solar Park—one of the largest solar installations worldwide—as a case study, the paper investigates how alignment with three specific SDG dimensions (Quality Education, Decent Work and Economic Growth, and Industry, Innovation and Infrastructure) impacts project sustainability and stakeholder satisfaction. The research employs a quantitative approach, utilizing structured surveys and secondary data, with results analyzed through Structural Equation Modeling (SEM). Findings reveal a strong positive correlation between SDG alignment and key project success indicators, emphasizing the strategic value of integrating sustainability goals into large-scale infrastructure development. The paper concludes with recommendations for policymakers and project planners to institutionalize SDG frameworks in national development agendas.***

Index Terms- ***Sustainable Development Goals; Mega Projects; Renewable Energy; Project Success; Sustainability; Egypt; Benban Solar Park***

I. INTRODUCTION

The global pursuit of sustainability has become increasingly urgent in response to escalating challenges such as climate change, resource depletion, and socio-economic disparities. As the world transitions towards greener economies, the role of Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, has gained prominence in shaping development agendas. The SDGs provide a unified framework of 17 goals aimed at fostering inclusive economic growth, environmental protection, and social equity by the year 2030.

Mega projects, especially in the field of renewable energy, play a pivotal role in achieving these goals. These large-scale initiatives often involve significant investments and have far-reaching impacts on economies, communities, and ecosystems. However, the successful implementation of mega projects depends not only on engineering and financial execution, but also on strategic alignment with broader developmental and sustainability objectives.

Egypt, as a developing nation with ambitious energy and infrastructure goals, has embraced the SDGs in its national development strategy. A key illustration of this commitment is the Benban Solar Park in Aswan, a $2 billion project that represents one of the largest solar energy installations in the world. It serves as a real-world example of how alignment with SDG principles can contribute to project success—measured not only in megawatts, but also in job creation, technological advancement, and environmental impact.

This paper examines the role of SDGs in shaping the success of mega projects by focusing on three dimensions: Quality Education (SDG 4), Decent Work and Economic Growth (SDG 8), and Industry, Innovation, and Infrastructure (SDG 9). Through a detailed case study of Benban Solar Park and quantitative analysis using Structural Equation Modeling (SEM), the study evaluates the extent to which these dimensions influence sustainability and stakeholder satisfaction.

The findings aim to fill an empirical gap in literature by offering evidence-based insights into how SDG alignment contributes to the strategic success of mega infrastructure projects. The paper also provides practical recommendations for policymakers, development agencies, and project managers seeking to embed sustainable development principles into national planning and project design

II. LITERATURE REVIEW

The intersection of sustainable development goals and mega project success has become a focal point in recent academic discourse. Numerous studies have examined how SDG integration enhances project outcomes, particularly in sectors such as energy, infrastructure, and urban planning.

Juarez, Metaxas, and Olmos (2023) analyzed the branding of Madrid as a sustainable city through mega infrastructure projects. Their study found that projects aligned with sustainability standards can enhance a city's global image while simultaneously delivering long-term socio-economic benefits. This underscores the broader applicability of SDG principles beyond environmental considerations alone.

Izam et al. (2022) conducted a comprehensive review of solar photovoltaic technologies and their contribution to sustainable development. The study highlighted the challenges of cost and access but emphasized that solar energy can substantially drive progress toward SDGs, particularly in emerging economies.

Sankaran et al. (2022) focused on energy justice issues in renewable energy megaprojects, stressing the need for equitable stakeholder engagement and social inclusivity. The authors advocated for a justice-based framework to project planning, reinforcing the idea that sustainable development is inseparable from social equity and community empowerment.

Li et al. (2021) investigated the risk factors influencing mega infrastructure projects from a sustainable development perspective. Their findings emphasized the importance of communication, transparency, and public engagement, noting that risk management strategies aligned with SDGs improve project viability.

Krzymowski (2020) studied the integration of SDGs in the Arab region, using the UAE as a case example. He concluded that while progress was evident, sustainable development efforts must be institutionalized across sectors and linked to national vision frameworks to ensure long-term impact.

While these studies provide valuable insights, most adopt either a macro-level policy perspective or focus on specific technologies or regions. Few studies have quantitatively measured the effect of SDG alignment on project performance outcomes. This research aims to address this gap by using the Benban Solar Park in Egypt as a case study and applying structural equation modeling to quantify the impact of SDGs on measurable indicators of project success.

The unique contribution of this paper lies in its focus on three SDG dimensions—Quality Education, Decent Work and Economic Growth, and Industry, Innovation and Infrastructure—as mediators of project sustainability and stakeholder satisfaction. By integrating theoretical insights with empirical data, the study offers a nuanced understanding of how sustainability frameworks can be operationalized in mega project management.

III. RESEARCH METHODOLOGY

This study adopts a quantitative research approach to examine the relationship between Sustainable Development Goals (SDGs) and the success of mega projects, using the Benban Solar Park in Egypt as a case study. The methodology is designed to evaluate how alignment with selected SDG dimensions—Quality Education (SDG 4), Decent Work and Economic Growth (SDG 8), and Industry, Innovation and Infrastructure (SDG 9)—impacts project sustainability and stakeholder satisfaction.

3.1 Research Design

A descriptive-correlational research design was employed to identify and quantify relationships between the independent variables (SDG dimensions) and dependent variables (project success indicators).

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The research is grounded in a positive paradigm, utilizing statistical modeling to validate hypotheses through empirical evidence.

3.2 Data Collection

Data was collected from both primary and secondary sources:

Primary Data: A structured questionnaire based on a 5-point Likert scale was distributed to professionals and engineers at the Ministry of Electricity and Renewable Energy in Egypt, many of whom were directly or indirectly involved in the Benban project.

Secondary Data: Reports from Egypt's Central Agency for Public Mobilization and Statistics (CAPMAS), outcomes from COP27, and internal project documentation were used to supplement and validate primary findings.

3.3 Sampling

The study used a convenience sampling technique due to accessibility constraints. The sample included 120 respondents, representing project managers, engineers, and policy specialists. This sample size was considered adequate for the use of Structural Equation Modeling (SEM), which requires a minimum sample of 100 for stable estimates.

3.4 Research Instrument

The survey instrument was divided into three sections:

Demographic Information

Perceptions of SDG Integration (Independent Variables)

Indicators of Project Success (Dependent Variables)

Reliability testing using Cronbach's Alpha yielded values above 0.80 for all scales, indicating high internal consistency.

3.5 Data Analysis Tools

SPSS (Statistical Package for the Social Sciences) was used for descriptive analysis, reliability testing, and initial correlation assessments.

SmartPLS (Partial Least Squares Structural Equation Modeling) was used for hypothesis testing and model evaluation. SEM was selected due to its capacity to test complex relationships among latent variables and its robustness in smaller samples.

3.6 Conceptual Framework

The conceptual framework is structured around the hypothesis that each of the three selected SDG dimensions exerts a direct and significant positive impact on two key constructs:

Sustainability of the project

Stakeholder satisfaction

These relationships are tested through a reflective measurement model within the SEM process

IV. CASE STUDY: BENBAN SOLAR PARK, EGYPT

Background

The Benban Solar Park, located in Aswan Governorate, is one of the largest photovoltaic power stations in the world, with a planned capacity of 1.65 GW. Commissioned as part of Egypt's Vision 2030 strategy, the project represents a flagship initiative in the country's transition towards renewable energy. Benban was developed through a combination of public and private investments, supported by international financial institutions and development banks, making it a model for public-private partnerships (PPPs) in the renewable energy sector.

Strategic Relevance

The project aligns closely with Egypt's national development priorities and the UN Sustainable Development Goals (SDGs). Specifically:

SDG 4 (Quality Education): Training programs were established in collaboration with the Industrial Modernization Center and Aswan University to upskill over 1,500 local technicians. These efforts enhanced local capacity for operation and maintenance, improving efficiency by an estimated 30% compared with other projects in the region.

SDG 8 (Decent Work and Economic Growth): The park generated more than 10,000 direct and indirect jobs during construction and continues to provide long-term employment opportunities for the local community, thereby contributing to poverty reduction and regional economic growth.

SDG 9 (Industry, Innovation, and Infrastructure): Benban introduced advanced photovoltaic technology and innovative financing models to Egypt's renewable energy market. Its robust infrastructure has made it a benchmark for scaling similar projects across the MENA region.

Technical and Financial Specifications

The project covers an area of 37 km² and consists of 32 individual plants operated by different investors under Egypt's Feed-in Tariff (FiT) program. The total investment exceeded USD 2 billion, with financing facilitated by international institutions such as the World Bank's International Finance Corporation (IFC). The project's modular structure has allowed for diversified investment, reducing financial risk while ensuring scalability.

Sustainability Outcomes

The Benban Solar Park contributes significantly to reducing Egypt's carbon footprint. Once fully operational, it is expected to displace approximately 2 million tons of CO_2 annually. Furthermore, the project provides clean and affordable energy to millions of households, strengthening Egypt's energy security and reducing dependency on fossil fuels.

Stakeholder Engagement

Community engagement was a cornerstone of Benban's implementation. Local stakeholders, including residents of Aswan, were involved in employment, training, and maintenance activities. Social development initiatives linked to the project included infrastructure improvements in nearby villages, healthcare access, and educational support. These initiatives enhanced public acceptance and ensured that the project delivered inclusive benefits beyond electricity generation.

Conclusion of the Case Study

The Benban Solar Park illustrates how aligning mega projects with SDGs can generate holistic value. By integrating education, employment, and innovation within its operational framework, Benban demonstrates that mega renewable energy projects can achieve environmental, economic, and social objectives simultaneously. As such, it provides a replicable model for other developing countries seeking to balance growth with sustainability.

V. RESULTS

Demographic Characteristics of Respondents

Out of 250 distributed questionnaires, 210 valid responses were collected. The respondents represented a diverse range of backgrounds within the Ministry of Electricity and Renewable Energy:

Age: Majority were between 30–45 years (56%).
Education: 68% held a bachelor's degree, while 22% held postgraduate qualifications.

Experience: More than 60% had over 10 years of professional experience.

Job roles: Included engineers, project managers, and administrative staff, ensuring a comprehensive perspective on mega project success factors.

This distribution indicates a representative sample of professionals directly engaged in renewable energy projects.

Descriptive Analysis of SDG Dimensions

The three SDG dimensions scored above the midpoint (3.0) on a five-point Likert scale, indicating generally positive perceptions among respondents:
Quality Education (SDG 4): Mean = 4.12, SD = 0.65
Decent Work and Economic Growth (SDG 8): Mean = 4.08, SD = 0.71
Industry, Innovation, and Infrastructure (SDG 9): Mean = 4.20, SD = 0.68
Dependent variables also scored highly:
Sustainability: Mean = 4.15, SD = 0.62
Stakeholder Satisfaction: Mean = 4.09, SD = 0.66

Measurement Model Evaluation (CFA)

Confirmatory Factor Analysis (CFA) was conducted to test construct validity and reliability:
Cronbach's Alpha: All constructs > 0.80, indicating strong internal consistency.
Composite Reliability (CR): Ranged between 0.82 and 0.91.
Average Variance Extracted (AVE): All constructs exceeded the 0.50 threshold, confirming convergent validity.
Fornell–Larcker Criterion: Demonstrated adequate discriminant validity among constructs.

Structural Model Evaluation (SEM)

Structural Equation Modeling (SEM) was applied to test the hypothesized relationships:

SDG 4 → Sustainability: $\beta = 0.31$, $p < 0.01$

SDG 4 → Stakeholder Satisfaction: $\beta = 0.28$, $p < 0.05$

SDG 8 → Sustainability: $\beta = 0.27$, $p < 0.05$

SDG 8 → Stakeholder Satisfaction: $\beta = 0.33$, $p < 0.01$

SDG 9 → Sustainability: $\beta = 0.35$, $p < 0.01$

SDG 9 → Stakeholder Satisfaction: $\beta = 0.30$, $p < 0.01$

All hypothesized paths were significant, confirming that the three SDG dimensions positively impact both sustainability and stakeholder satisfaction.

Model Fit and Predictive Power

R^2 for Sustainability: 0.62

R^2 for Stakeholder Satisfaction: 0.58

These values indicate that the model explains a substantial proportion of variance in both dependent variables.

Q^2 values from PLS-Predict confirmed predictive relevance (> 0.30).

Summary of Findings

The statistical results validate the study's hypotheses: Quality Education (SDG 4) enhances local capacity and innovation, positively affecting both sustainability and satisfaction.

Decent Work and Economic Growth (SDG 8) drives inclusive employment and social benefits, strengthening project acceptance.

Industry, Innovation, and Infrastructure (SDG 9) improves efficiency and scalability, ensuring long-term sustainability.

Together, these dimensions explain a significant portion of the success of renewable energy mega projects in Egypt

VI. DISCUSSION

The results of this study provide robust empirical evidence that the Sustainable Development Goals (SDGs) play a critical role in shaping the success of mega projects in Egypt. By focusing on three key dimensions—Quality Education (SDG 4), Decent Work and Economic Growth (SDG 8), and Industry, Innovation, and Infrastructure (SDG 9)—the findings confirm that the integration of SDGs positively influences both sustainability and stakeholder satisfaction.

1. Quality Education (SDG 4) and Project Sustainability

The analysis revealed a significant positive relationship between SDG 4 and both sustainability and stakeholder satisfaction. This supports the argument by Krzymowski (2020) that education is a catalyst for innovation and long-term project performance. In the Benban Solar Park, training programs improved workforce efficiency by 30%, which aligns with the statistical evidence that education-driven capacity building enhances sustainability. This finding underscores the importance of embedding training and knowledge-transfer programs within mega project frameworks, particularly in emerging economies where local expertise is often underdeveloped.

2. Decent Work and Economic Growth (SDG 8) and Social Acceptance

The study confirmed that decent work and economic opportunities significantly influence stakeholder satisfaction. This is consistent with Kumar and Majid (2020), who found that renewable energy projects in India succeeded largely because of the employment opportunities they created. Similarly, in the Egyptian context, the creation of over 10,000 jobs through Benban's development contributed not only to poverty reduction but also to building local trust and community acceptance. The results suggest that mega projects that neglect employment and economic inclusivity risk resistance from stakeholders and diminished long-term impact.

3. Industry, Innovation, and Infrastructure (SDG 9) as Drivers of Resilience

The results highlighted SDG 9 as the strongest predictor of sustainability. This finding echoes the work of Sibtain et al. (2021) and Vidadili et al. (2017), who emphasized that technological innovation and robust infrastructure are prerequisites for project resilience. In Egypt, the Benban project introduced advanced photovoltaic technology and

innovative financing models, enabling scalability and risk reduction. This validates the argument that infrastructure and innovation are not only technical necessities but also social and economic enablers of success.

4. Integration of SDGs in Mega Project Frameworks
Collectively, the results illustrate that the integration of SDGs into mega project planning and execution contributes to a triple bottom line: economic growth, social inclusion, and environmental protection. This finding advances the literature by providing empirical evidence from a developing country context, addressing a key research gap identified by Breuer et al. (2019) and Juarez et al. (2023). Importantly, the Egyptian case demonstrates that SDG-aligned projects can achieve international recognition while delivering local benefits, positioning Egypt as a regional leader in sustainable mega projects.

5. Practical Implications
For policymakers, the findings suggest that embedding SDGs in national strategies enhances both the performance and legitimacy of mega projects. For project managers, the study highlights the value of investing in training, fostering inclusive economic opportunities, and adopting innovative technologies. The combination of these factors not only improves technical outcomes but also ensures stakeholder buy-in, which is essential for long-term sustainability.

6. Contribution to Theory
The study contributes to project management and sustainable development literature by empirically testing the relationship between SDG dimensions and project success indicators. While previous studies often treated sustainability and stakeholder satisfaction separately, this research demonstrates their interconnectedness within an SDG framework. The use of SEM and CFA strengthens the reliability of these findings, offering a replicable methodological approach for future studies

CONCLUSION

This study examined the impact of the Sustainable Development Goals (SDGs) on the success of mega projects in Egypt, with a focus on the Benban Solar Park as a case study. By integrating survey data from the Ministry of Electricity with insights from national policy frameworks, the research demonstrated that SDGs 4 (Quality Education), 8 (Decent Work and Economic Growth), and 9 (Industry, Innovation, and Infrastructure) significantly and positively influence project success, measured through sustainability and stakeholder satisfaction.

The findings highlight that:
Quality Education (SDG 4) enhances local capacity, knowledge transfer, and innovation, strengthening long-term sustainability.

Decent Work and Economic Growth (SDG 8) contributes to stakeholder trust and project legitimacy through job creation and inclusive economic benefits.
Industry, Innovation, and Infrastructure (SDG 9) provides the technological and structural foundation necessary for resilience and scalability.

Together, these dimensions form a synergistic framework that supports both national development priorities and international sustainability commitments. This research contributes to bridging the gap in literature by providing empirical evidence from a developing country perspective, where the integration of SDGs into mega project design is still emerging.

RECOMMENDATIONS

For Policymakers:
Integrate SDG-based performance metrics into national mega project evaluation frameworks to ensure alignment with Egypt's Vision 2030.

Strengthen public-private partnerships that emphasize capacity building, technological innovation, and inclusive economic growth.

Expand incentives for renewable energy projects, particularly through international financing mechanisms and green bonds.

For Project Managers:
Prioritize workforce training programs in collaboration with universities and research centers to sustain innovation and technical expertise.

Incorporate stakeholder engagement strategies that address social, economic, and environmental concerns to enhance legitimacy and public acceptance.

Adopt advanced project management tools that integrate sustainability indicators alongside traditional measures of cost, time, and scope.

For International Development Agencies:
Provide targeted support for capacity development and technology transfer in developing countries undertaking mega renewable energy projects.

Facilitate knowledge-sharing platforms that allow replication of successful models, such as Benban, across similar contexts in Africa and the MENA region.

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