SUSTAINABLE INFRASTRUCTURE

Integrating Environmental, Social, Cultural and Economic Value into Sustainable Infrastructure Development in Saudi Arabia: An Integrated Framework Aligned with Saudi Vision 2030

Nadeem Akram

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Abstract

Background: Large-scale infrastructure development can generate substantial economic, social, cultural and environmental benefits, but conventional project-performance assessment frequently concentrates on cost, time, quality, scope and technical compliance. Such measures are necessary but may not fully capture the long-term value generated by infrastructure for communities, the environment, cultural identity and the wider economy.

Purpose: This study develops an Integrated Infrastructure Value Framework (IIVF) for assessing environmental, social, cultural, economic and technical/lifecycle value in major infrastructure projects in Saudi Arabia.

Methodology: The research adopts a conceptual framework-development methodology incorporating structured literature and policy review, comparative analysis of existing sustainability and infrastructure approaches, development of value dimensions and indicators, and application of the proposed framework to a conceptual cultural and environmental village. Existing international frameworks were examined to identify complementary approaches to environmental, social, economic, resilience and community sustainability. ISO 37101, for example, establishes a holistic management-system approach for sustainable development in communities, while the World Bank Environmental and Social Framework emphasizes environmental and social risk management, inclusion, climate change, biodiversity, community health and stakeholder engagement.

Findings: The study proposes five principal infrastructure-value dimensions: Environmental Value (EV), Social Value (SV), Cultural Value (CV), Economic Value (EC) and Technical/Lifecycle Value (TL). A preliminary indicator system and Integrated Infrastructure Value Score (IIVS) are developed to support structured decision-making. The framework is designed to operate across the infrastructure lifecycle from strategic planning through design, procurement, construction, operation and review.

Originality: The principal contribution is the explicit integration of cultural value with environmental, social, economic and technical/lifecycle value within a single infrastructure decision framework. The study proposes that cultural identity should be considered a measurable project-value dimension rather than treated solely as an architectural or heritage issue.

Implications: The framework provides a potential decision-support methodology for infrastructure clients, designers, contractors, planners, sustainability professionals and policymakers. It is particularly relevant to Saudi Arabia's transformation programme, where infrastructure development increasingly intersects with tourism, culture, environmental sustainability, community development and economic diversification.

Conclusion: Infrastructure should be evaluated not only by what it costs and whether it is delivered successfully, but also by the environmental, social, cultural, economic and technical value it creates throughout its lifecycle. The proposed IIVF provides a basis for future empirical validation through expert assessment and project-level case studies.

Keywords: sustainable infrastructure; Saudi Arabia; Saudi Vision 2030; environmental value; social value; cultural value; economic value; lifecycle value; infrastructure development; sustainability; cultural heritage; construction management

1 Introduction

Infrastructure is a fundamental component of economic development, social wellbeing and territorial connectivity. Roads, utilities, public buildings, tourism facilities, housing, energy.

systems, water infrastructure and cultural facilities shape how communities function and how economic activity develops.

Traditional construction management evaluates projects primarily through measures such as:

- cost;
- time;
- quality;
- scope;
- safety;
- productivity; and
- technical compliance.

These measures remain essential. However, an infrastructure asset has consequences that extend beyond the construction phase.

A project may be delivered within budget and programme but generate limited community benefit. Conversely, a project with a higher initial investment may produce substantial long-term value through reduced operating costs, environmental improvement, employment, tourism, education, cultural preservation and improved quality of life.

This creates a broader infrastructure-value question:

How should infrastructure projects be evaluated when their benefits and impacts extend beyond conventional project-delivery performance?

The issue is particularly relevant to Saudi Arabia because the Kingdom is undertaking major economic, urban, tourism, cultural and environmental transformation. The United Nations Sustainable Development Goals also explicitly connect infrastructure with sustainable industrialization, inclusive cities, responsible consumption, climate action and resilient development. [3].

This paper proposes an integrated framework that brings these dimensions together.

1.1 Saudi Arabian infrastructure context

Saudi Arabia is experiencing significant infrastructure development associated with economic diversification, tourism, culture, urbanization, transportation, energy, environmental initiatives and quality-of-life objectives.

The significance of this transformation is that infrastructure can serve multiple purposes simultaneously.

For example, a public development may provide physical infrastructure plus employment, tourism, cultural preservation, environmental improvement, community facilities and economic activity.

The conventional project-management triangle does not adequately capture all of these outcomes.

A broader infrastructure-value model is therefore appropriate.

1.2 Research problem

The research problem can be summarized as follows: existing project evaluation (cost + time + quality + scope + safety) may not fully capture environmental, social, cultural, economic and lifecycle value. This can produce fragmented decision-making. For example:

- environmental specialists may optimize ecological outcomes;
- engineers may optimize technical performance;
- project managers may optimize cost and programme;
- economists may assess financial returns;
- cultural specialists may protect heritage;
- communities may prioritize wellbeing and accessibility.

Without an integrated framework, these objectives can compete rather than reinforce one another.

1.3 Research gap

Existing sustainability approaches provide important foundations for environmental, social, economic and community sustainability.

ISO 37101, for example, provides a holistic management-system approach for sustainable development in communities and aims to support resilience, smartness and sustainable-development outcomes. [1].

The World Bank Environmental and Social Framework addresses environmental and social sustainability through standards covering areas such as labour, inclusion, climate change, biodiversity, community health and safety, and stakeholder engagement. [2].

International sustainable-development goals similarly connect infrastructure with economic growth, resilient infrastructure, sustainable cities, responsible consumption, climate action and partnerships. [3].

However, a research opportunity remains in developing an infrastructure-project framework that explicitly integrates:

1. environmental value;
2. social value;
3. cultural value;
4. economic value; and
5. technical/lifecycle value

These dimensions should be integrated within one practical project-level evaluation system. The proposed study addresses this gap.

1.4 Aim

The aim of this research is:

To develop an integrated framework for identifying, evaluating and improving environmental, social, cultural, economic and technical/lifecycle value throughout the lifecycle of major infrastructure projects in Saudi Arabia.

1.5 Research objectives

The research has eight objectives.

RO1. Review established approaches to sustainable infrastructure and community development.

RO2. Identify environmental, social, cultural, economic and technical indicators relevant to infrastructure.

RO3. Develop an Integrated Infrastructure Value Framework.

RO4. Develop a preliminary methodology for measuring infrastructure value.

RO5. Examine the role of cultural identity and heritage in sustainable infrastructure.

RO6. Demonstrate how infrastructure can generate social and economic value.

RO7. Apply the framework conceptually to a cultural and environmental development.

RO8. Establish a foundation for future empirical validation.

1.6 Research questions

RQ1. What dimensions of value should be incorporated into sustainable infrastructure evaluation?

RQ2. What environmental indicators can effectively measure infrastructure value?

RQ3. What social indicators can measure community benefit?

RQ4. How can cultural value be incorporated into infrastructure planning and development?

RQ5. How can economic value be measured across the infrastructure lifecycle?

RQ6. How can technical performance and lifecycle value be integrated with sustainability?

RQ7. Can an Integrated Infrastructure Value Score provide a useful decision-support mechanism?

RQ8. How can the framework support Saudi Arabia's sustainable-development objectives?

2 Dimensions of infrastructure value

2.1 Conceptual foundation

The research proposes that infrastructure value consists of five interconnected dimensions:

- **Environmental value:** Protection and enhancement of natural systems.
- **Social value:** Benefits to individuals, communities and society.
- **Cultural value:** Protection, enhancement and transmission of cultural identity and heritage.
- **Economic value:** Direct and indirect economic benefits.
- **Technical/lifecycle value:** Technical performance, resilience, durability and lifecycle efficiency.

The model is: environmental value + social value + cultural value + economic value + technical/ lifecycle value = integrated infrastructure value.

2.2 Environmental value

Environmental value should be evaluated across the entire project lifecycle.

2.2.1 *Energy*

Potential indicators include:

- energy consumption;
- energy intensity;
- renewable-energy contribution;
- passive-design performance;
- operational efficiency.

2.2.2 *Water*

Potential indicators include:

- potable-water consumption;
- water reuse;
- irrigation efficiency;
- wastewater management;
- water-loss reduction.

2.2.3 *Materials*

Indicators include:

- recycled content;
- local sourcing;
- material efficiency;
- construction waste;
- lifecycle environmental impact.

2.2.4 *Biodiversity*

Potential indicators include:

- habitat protection;
- native/adapted planting;
- ecological restoration;
- biodiversity enhancement.

2.2.5 *Carbon*

Potential indicators include:

- embodied carbon;
- operational carbon;
- transport emissions;

- lifecycle carbon.

2.2.6 Climate resilience

Infrastructure should be assessed for resilience against relevant climate and environmental risks.

2.3 Social value

Social value concerns the benefits created for people.

2.3.1 Employment

Potential measures:

- local employment;
- number of jobs;
- employment duration;
- indirect employment.

2.3.2 Skills

Measures may include:

- training hours;
- apprenticeships;
- professional-development programmes;
- vocational skills.

2.3.3 Accessibility

Projects should consider accessibility for different user groups.

2.3.4 Community facilities

Potential facilities include:

- education;
- recreation;
- public spaces;
- community centres;
- cultural facilities.

2.3.5 Wellbeing

Potential indicators include:

- access to green space;
- recreational opportunities;
- pedestrian environments;
- public safety;
- social interaction.

2.3.6 Community participation

Measures could include:

- number of engagement activities;
- participation rate;
- stakeholder feedback;
- issues resolved.

2.4 Cultural value

Cultural value represents one of the principal original dimensions of this framework. Cultural infrastructure value may include both tangible and intangible heritage.

2.4.1 Tangible cultural value

Examples:

- historic structures;
- traditional architectural elements;
- cultural landscapes;
- heritage materials;
- archaeological assets.

2.4.2 Intangible cultural value

Examples:

- traditional knowledge;
- crafts;
- food;
- oral history;
- music;
- storytelling;
- traditional practices.

2.4.3 Cultural education

Infrastructure can create opportunities for:

- museums;
- exhibitions;
- workshops;
- educational programmes;
- cultural interpretation.

2.4.4 Cultural identity

Design can support a sense of local identity while remaining compatible with contemporary engineering and safety requirements.

2.4.5 Cultural tourism

Appropriately designed cultural infrastructure can potentially contribute to responsible tourism and local economic activity.

2.5 Economic value

Economic value should be assessed beyond initial construction expenditure.

2.5.1 Local procurement

Measure eligible expenditure directed to local businesses.

2.5.2 Sme participation

Measure opportunities created for small and medium-sized enterprises.

2.5.3 Employment

Consider direct and indirect employment.

2.5.4 Tourism

Where relevant, evaluate potential:

- visitor expenditure;
- tourism employment;
- hospitality activity;
- local business activity.

2.5.5 Lifecycle economics

Include:

- capital cost;
- operating cost;
- maintenance;
- replacement;
- residual value.

Therefore:

Whole-life cost should be considered alongside initial capital cost.

2.6 Technical and lifecycle value

Technical performance remains essential. The framework therefore incorporates:

- **Safety:** protection of workers and users.
- **Quality:** compliance with specifications.
- **Durability:** expected service life.
- **Resilience:** ability to withstand disruption.
- **Maintainability:** ease and cost of maintenance.
- **Constructability:** ability to build efficiently and safely.
- **Operational performance:** actual performance after commissioning.

- **Digital management:** use of digital tools to monitor assets.

3 Integrated Infrastructure Value Framework

3.1 Integrated Infrastructure Value framework

The proposed framework is summarised in Table 1.

Table 1. Integrated Infrastructure Value Framework.

Dimension	Example indicators	Lifecycle stage
Environmental	Energy, water, carbon, biodiversity, waste	All stages
Social	Employment, accessibility, wellbeing, community participation	All stages
Cultural	Heritage, identity, education, traditions	Planning–operation
Economic	Local procurement, SMEs, tourism, lifecycle cost	All stages
Technical	Safety, quality, resilience, durability, maintenance	All stages

The framework is intentionally lifecycle-based.

3.2 Indicator architecture

A three-level hierarchy is proposed.

1. **Value dimension:** environmental, social, cultural, economic or technical.
2. **Value category:** for example, environmental → energy.
3. **Measurable indicator:** for example, energy → annual energy consumption per square metre.

This hierarchical structure improves traceability.

3.3 Proposed indicator register

The proposed indicators are listed in Table 2.

Table 2. Proposed indicator register.

Dimension	Code	Indicator
Environmental	EV01	Energy efficiency
	EV02	Renewable-energy contribution
	EV03	Water efficiency
	EV04	Water reuse
	EV05	Waste diversion
	EV06	Carbon performance
	EV07	Sustainable materials
	EV08	Biodiversity
	EV09	Climate resilience
Social	SV01	Local employment

Dimension	Code	Indicator
	SV02	Skills development
	SV03	Accessibility
	SV04	Community facilities
	SV05	Public wellbeing
	SV06	Community participation
	SV07	Inclusion
	SV08	Public safety
Cultural	CV01	Heritage protection
	CV02	Intangible heritage
	CV03	Cultural identity
	CV04	Traditional architecture
	CV05	Cultural education
	CV06	Cultural participation
	CV07	Cultural tourism
	CV08	Intergenerational knowledge
Economic	EC01	Local procurement
	EC02	SME participation
	EC03	Direct employment
	EC04	Indirect employment
	EC05	Tourism activity
	EC06	Operational revenue
	EC07	Lifecycle cost
	EC08	Investment potential
Technical/lifecycle	TL01	Quality
	TL02	Safety
	TL03	Durability
	TL04	Resilience
	TL05	Maintainability
	TL06	Constructability
	TL07	Operational efficiency
	TL08	Digital asset management

3.4 Scoring methodology

A preliminary 0–5 scale is proposed (Table 3).

Table 3. Preliminary scoring scale.

Score	Description
0	No demonstrated value
1	Very low
2	Low
3	Moderate
4	High
5	Exceptional

For each dimension:

$$D_j = \frac{\sum X_i}{n} \tag{1}$$

where D_j is the dimension score, X_i the individual indicator score and n the number of indicators.

3.5 Integrated Infrastructure Value score

An initial equal-weight model is proposed:

$$\text{IIVS} = \frac{\text{EV} + \text{SV} + \text{CV} + \text{EC} + \text{TL}}{5} \tag{2}$$

where:

- EV = Environmental Value;
- SV = Social Value;
- CV = Cultural Value;
- EC = Economic Value;
- TL = Technical/Lifecycle Value.

The resulting score would range from 0 to 5.

However, the equal-weight model is conceptual and not yet empirically validated.

3.6 Weighted model for future validation

A more sophisticated model could be:

$$\text{IIVS} = w_E\text{EV} + w_S\text{SV} + w_C\text{CV} + w_{EC}\text{EC} + w_T\text{TL} \tag{3}$$

where:

$$w_E + w_S + w_C + w_{EC} + w_T = 1 \tag{4}$$

The weights should be established through a scientifically justified expert methodology such as:

- Delphi;
- Analytic Hierarchy Process;
- Best-Worst Method;
- expert survey;

- stakeholder preference analysis.

This avoids arbitrarily deciding that every dimension has equal importance.

4 Proposed research methodology

4.1 Research methodology

The proposed research methodology consists of six phases.

1. **Phase 1 — Literature Review:** Review:

sustainable infrastructure;

social value;

cultural sustainability;

lifecycle assessment;

infrastructure governance;

community sustainability.

2. **Phase 2 — Policy Review:** Review relevant Saudi national policies and international sustainability objectives.
3. **Phase 3 — Indicator Development:** Identify and classify potential indicators.
4. **Phase 4 — Expert Validation:** Experts assess:

relevance;

measurability;

importance;

applicability.

5. **Phase 5 — Framework Development:** Develop the validated IIVF and scoring methodology.
6. **Phase 6 — Case Study:** Apply the framework to a selected infrastructure concept or project.

4.2 Proposed expert validation

A future empirical study should recruit experts from:

- civil engineering;
- construction management;
- architecture;
- sustainability;
- environmental engineering;
- urban planning;
- economics;
- cultural heritage;
- tourism;
- project management.

Experts could score each indicator on:

1. importance;
2. relevance;

3. measurability;
4. feasibility;
5. Saudi applicability.

A five-point Likert scale could be used.

4.3 Delphi validation

A Delphi process could proceed as follows:

Round 1. Experts independently evaluate indicators.

Analysis. Indicators with weak relevance are identified.

Round 2. Experts receive anonymized group results.

Reassessment. Experts reconsider their scores.

Round 3. Consensus is assessed.

The final indicator set could then be used to establish the validated framework.

5 Conceptual case study

5.1 Conceptual case study: cultural and environmental village

To demonstrate the framework, this research proposes a conceptual development referred to as the Cultural and Environmental Village: a conceptual development proposed by the author for demonstrating the application of the Integrated Infrastructure Value Framework. It is not an existing completed project.

5.2 Case-study vision

The concept combines culture, environment, community, education, tourism, local economy and sustainable infrastructure.

The objective is to demonstrate how a physical development can create multiple forms of value simultaneously.

5.3 Environmental components of the case study

Potential components include:

- solar-energy generation;
- energy-efficient buildings;
- passive cooling;
- efficient lighting;
- water-saving fixtures;
- greywater reuse;
- efficient irrigation;
- drought-tolerant landscaping;
- waste segregation;
- recycling;

- sustainable materials;
- biodiversity areas;
- shaded public spaces.

All features would require engineering feasibility assessment before implementation.

5.4 Social components

Potential components include:

- public gathering areas;
- educational facilities;
- family areas;
- accessible pathways;
- vocational training;
- employment opportunities;
- community workshops;
- recreational facilities;
- youth activities;
- cultural programmes.

5.5 Cultural components

Potential components include:

- cultural interpretation;
- traditional architecture;
- craft workshops;
- exhibitions;
- cultural education;
- traditional food;
- oral-history programmes;
- heritage demonstrations;
- cultural events;
- intergenerational learning.

The actual cultural content should be developed with qualified Saudi cultural and heritage specialists.

5.6 Economic components

Potential economic activities include:

- local restaurants;
- crafts;
- SMEs;
- tourism;
- hospitality;
- events;

- training;
- local procurement;
- cultural enterprises.

The economic case would need actual market research before any financial claims are made.

5.7 Case-study application of IIVF

The conceptual village can be evaluated using the five dimensions (Table 4).

Table 4. Case-study application of the IIVF.

Dimension	Potential value
Environmental	Water efficiency, renewable energy, biodiversity
Social	Employment, education, recreation
Cultural	Heritage, identity, crafts
Economic	Tourism, SMEs, local procurement
Technical	Resilience, safety, durability

The case demonstrates that one infrastructure development can potentially create multiple value streams.

5.8 Illustrative scoring example

The following scores are illustrative and are not empirical research data; they simply demonstrate how the proposed scoring methodology could work (Table 5).

Table 5. Illustrative scoring example (hypothetical values).

Dimension	Illustrative score
Environmental	4.2
Social	4.1
Cultural	4.7
Economic	3.8
Technical/Lifecycle	4.0

Using equal weights:

$$\text{IIVS} = \frac{4.2 + 4.1 + 4.7 + 3.8 + 4.0}{5} = 4.16 \quad (5)$$

The illustrative overall score would therefore be 4.16 out of 5. This value is an example only and is not a research finding.

6 Implementation

6.1 Lifecycle application

The framework should be embedded throughout the project lifecycle.

Planning. Identify desired values.

Design. Translate values into measurable requirements.

Procurement. Include relevant sustainability and social-value requirements.

Construction. Monitor performance.

Commissioning. Verify asset performance.

Operation. Measure actual outcomes.

Review. Compare planned and actual value.

6.2 Procurement implications

The framework could potentially be incorporated into procurement evaluation. Instead of the lowest compliant price, a client could consider technical + financial + environmental + social + cultural + lifecycle value.

This does not imply that sustainability criteria should override safety, technical requirements or procurement law.

Instead, they could become additional measurable evaluation criteria where permitted.

6.3 Contractor responsibilities

Contractors could contribute through:

- sustainable construction methods;
- waste reduction;
- local employment;
- training;
- local procurement;
- safety;
- environmental protection;
- quality;
- digital reporting.

Performance could be incorporated into monthly project reporting.

6.4 Project-control integration

The IIVF could be integrated with conventional project controls. A project dashboard could include the KPIs in Table 6.

Table 6. Proposed integrated project dashboard.

KPI	Traditional/integrated
Cost	Traditional
Schedule	Traditional
Quality	Traditional
Safety	Traditional
Carbon	Integrated
Water	Integrated
Waste	Integrated
Local employment	Integrated
Training	Integrated
Cultural participation	Integrated
Local procurement	Integrated
Community satisfaction	Integrated

This creates a broader project-performance dashboard.

6.5 Governance

Successful implementation requires clear responsibility.

- **Client:** defines strategic value.
- **Designer:** embeds value into design.
- **Contractor:** implements requirements.
- **Consultant:** measures and verifies.
- **Community:** provides stakeholder feedback.
- **Government:** provides policy/regulatory context.
- **Independent assessor:** may validate performance.

6.6 Risk management

The framework itself has risks.

1. **Greenwashing.** Projects could claim sustainability without measurable evidence. Mitigation: measurable indicators and independent verification.
2. **Cultural Misrepresentation.** Cultural elements could be included superficially. Mitigation: qualified cultural specialists and stakeholder engagement.
3. **Excessive Cost.** Sustainability measures could increase initial expenditure. Mitigation: whole-life cost analysis.
4. **Measurement Difficulty.** Social and cultural benefits can be difficult to quantify. Mitigation: mixed quantitative and qualitative indicators.
5. **Conflicting Objectives.** Environmental, economic and technical objectives may conflict. Mitigation: multi-criteria decision analysis.

7 Discussion

The proposed framework expands infrastructure evaluation from a narrow project-delivery perspective to a lifecycle-value perspective.

This does not mean that conventional project controls become less important. Rather, traditional performance remains the foundation, and the proposed model adds environmental, social, cultural and economic value to that foundation.

ISO 37101 supports a holistic approach to sustainable development at community level, including environmental, economic and social performance and resilience. [1].

The World Bank's Environmental and Social Framework similarly demonstrates the importance of considering environmental and social risks and opportunities throughout project cycles. [2].

The proposed framework extends these principles by making cultural value an explicit infrastructure-value dimension.

7.1 Cultural value as an infrastructure outcome

One of the principal arguments of this paper is that culture should not be regarded solely as an architectural decoration.

Infrastructure can influence:

- identity;
- heritage;
- education;
- tourism;
- community cohesion;
- intergenerational knowledge.

Therefore:

Cultural value can be treated as a legitimate infrastructure outcome when it is defined, measured and evaluated appropriately.

This is particularly relevant to infrastructure projects incorporating cultural destinations, heritage areas, tourism facilities and community developments.

7.2 Environmental-social-cultural-economic interdependence

The five dimensions should not be treated as independent silos. For example, water-efficient landscaping can provide environmental value + social wellbeing + aesthetic value + potential tourism value. Similarly, traditional architecture can potentially provide cultural value + tourism value + educational value + local employment. This demonstrates why an integrated framework is useful.

7.3 The value-creation chain

The proposed conceptual chain is: infrastructure investment → physical asset → services → environmental, social, cultural and economic outcomes → long-term community value. This moves the research focus from outputs to outcomes.

7.4 Theoretical contribution

The study proposes three theoretical contributions.

Contribution 1. Integration of cultural value into sustainable infrastructure evaluation.

Contribution 2. A lifecycle-based infrastructure-value architecture.

Contribution 3. A preliminary quantitative framework for integrating different value dimensions.

7.5 Practical contribution

The framework could potentially help:

- government agencies;
- infrastructure owners;
- developers;
- project managers;
- consultants;
- contractors;
- sustainability teams;
- planners;
- cultural organizations.

It could provide a common evaluation language.

7.6 Alignment with international sustainability objectives

The framework has clear conceptual relationships with several UN Sustainable Development Goals.

- **SDG 8:** Decent work and economic growth.
- **SDG 9:** Industry, innovation and infrastructure.
- **SDG 11:** Sustainable cities and communities.
- **SDG 12:** Responsible consumption and production.
- **SDG 13:** Climate action.
- **SDG 15:** Life on land.
- **SDG 17:** Partnerships.

The UN specifically identifies SDG 9 as promoting resilient infrastructure and SDG 11 as seeking inclusive, safe, resilient and sustainable cities and human settlements. [3].

7.7 Alignment with community sustainability standards

ISO 37101 provides a useful reference point because it establishes requirements for a community sustainability management system and addresses sustainability, resilience, smartness and performance assessment. [1].

ISO 37104 provides practical guidance for implementing ISO 37101 principles in cities and other settlements [4].

The proposed IIVF can therefore be positioned as a project-level value-assessment framework, rather than a replacement for ISO 37101.

7.8 Alignment with environmental and social risk management

The World Bank Environmental and Social Framework emphasizes environmental and social risk management, labour, inclusion, climate change, biodiversity, community health and safety and stakeholder engagement. [2].

The proposed framework similarly emphasizes environment, people and community, but adds culture, economic value and technical/lifecycle performance.

8 Limitations

Several limitations must be recognized.

1. The framework is conceptual and requires empirical validation.
2. Some indicators may not be applicable to every infrastructure type.
3. Cultural value involves contextual and qualitative judgement.
4. Equal weighting has not been scientifically established.
5. Economic and social outcomes can be affected by external factors.
6. Project-specific data may be confidential.
7. The conceptual village is not evidence of actual project performance.

9 Future research

9.1 Future research programme

The next stage of research should include:

1. Expert Delphi validation.
2. Statistical testing of indicator importance.
3. Determination of dimension weights.
4. Application to completed Saudi infrastructure projects.
5. Comparison between conventional project evaluation and IIVF evaluation.
6. Development of a digital IIVF dashboard.
7. Development of a Saudi Infrastructure Value Index.

9.2 Proposed future statistical model

After collecting survey data, the research could test:

$$\mathrm{IIV} = f(\mathrm{EV},\ \mathrm{SV},\ \mathrm{CV},\ \mathrm{EC},\ \mathrm{TL}) \tag{6}$$

where infrastructure value is predicted by the five dimensions. Statistical methods could include:

- descriptive statistics;
- reliability analysis;
- correlation;
- exploratory factor analysis;
- confirmatory factor analysis;
- regression;

- structural equation modelling.

The appropriate method would depend on sample size and data characteristics.

10 Research ethics

If human participants are used in future expert surveys:

- informed consent should be obtained;
- participation should be voluntary;
- personal information should be protected;
- data should be securely stored;
- institutional ethical requirements should be followed.

11 Conclusion

Major infrastructure projects have the potential to create value extending far beyond the physical asset.

Traditional project-performance measures remain essential, but a comprehensive evaluation should also consider environmental protection, social wellbeing, cultural identity, economic development and lifecycle technical performance.

This study proposes the Integrated Infrastructure Value Framework (IIVF), consisting of five dimensions: environmental value, social value, cultural value, economic value and technical/lifecycle value.

The framework provides a structured methodology for identifying indicators, setting objectives, evaluating alternatives and monitoring outcomes throughout the infrastructure lifecycle.

The proposed framework is compatible in principle with the holistic sustainability approach reflected in ISO 37101, environmental/social risk-management principles such as those of the World Bank, and relevant UN Sustainable Development Goals. [1].

The principal research contribution is the explicit treatment of cultural value as a measurable component of infrastructure value, alongside environmental, social, economic and technical dimensions.

The conceptual cultural and environmental village demonstrates how these principles could be brought together in a single development concept incorporating cultural heritage, environmental sustainability, education, community facilities, tourism and economic opportunities.

However, the proposed scoring system and framework require empirical validation before they can be regarded as a validated measurement instrument.

Future research should therefore use expert Delphi analysis, statistical validation and real project case studies to determine the relevance, reliability and weighting of the proposed indicators.

Ultimately, sustainable infrastructure should be assessed not only by asking “Was the project delivered on time, within budget and to specification?” but also “What lasting environmental, social, cultural, economic and technical value did the project create for the people, community and environment?”

The Integrated Infrastructure Value Framework provides a proposed research pathway for answering that question.

Declarations

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References

[1] International Organization for Standardization. *ISO 37101:2016 Sustainable development in communities — Management system for sustainable development — Requirements with guidance for use*. Geneva: ISO; 2016.

[2] World Bank. *Environmental and social framework*. Washington (DC): World Bank.

[3] United Nations. *Sustainable Development Goals* [Internet]. New York: United Nations. Available from: https://sdgs.un.org/goals

[4] International Organization for Standardization. *ISO 37104:2019 Sustainable cities and communities — Transforming our cities — Guidance for practical local implementation of ISO 37101*. Geneva: ISO; 2019.

[5] International Organization for Standardization. *ISO 37101:2016/Amd 1:2024 Climate action changes*. Geneva: ISO; 2024.

[6] World Bank. *Infrastructure governance framework*. Washington (DC): World Bank.

[7] United Nations. *Goal 11: Sustainable cities and communities* [Internet]. New York: United Nations. Available from: https://sdgs.un.org/goals/goal11