SESSION: Navigating Uncertainty in Impact Assessment to Support Expedited Decision-Making

PAPER TITLE: BALANCING SPEED AND STEWARDSHIP: RED SEA GLOBAL'S JOURNEY

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Abstract

Saudi Arabia's Vision 2030 has catalyzed an unprecedented pace of development, particularly in the tourism and infrastructure sectors. Projects such as those under Red Sea Global are emblematic of this transformation, where environmental sustainability must be balanced with ambitious timelines and evolving design strategies. Red Sea Global (RSG) faced a familiar yet formidable challenge navigating uncertainty in environmental and social impact assessments (ESIA) while under pressure to accelerate project approvals to meet national development goals.

When dealing with uncertainty, RSG adopted a variety of approaches. From the outset, the organization adopted a proactive, integrated ESIA strategy rooted in precautionary principles, adaptive management, and early-phase stakeholder engagement. This approach ensures that environmental and social considerations are embedded into every phase of the project from planning right through to delivery.

Uncertainty within ESIAs came in many forms such as incomplete baseline datasets, shifting infrastructure corridors, design refinement, and evolving regulatory framework. RSG responded with a suite of technical tools, scenario modeling, geospatial overlays, and adaptive management informed by lessons learned across its portfolio for implementation in each new ESIA. These tools allowed uncertainties to be addressed in an efficient and effective manner.

The insights shared will be particularly relevant to regions undergoing rapid transformation, where balancing speed with sustainability is a critical imperative. To illustrate the RSG approach, a case study has been used to highlight how RSG applied a variety of methods to deliver projects that are not only fast-tracked, environmentally and socially resilient, but also allowed for informed decision making.

Introduction

Humans are generally not naturally comfortable with uncertainty, yet every major environmental decision occurs ‘within it’. The way we react and plan to approach it is fundamental for the subsequent decision-making process. This also applies to environmental assessments. However, when structured and explicitly managed, uncertainty becomes a decision enabler rather than a constraint. This paper draws on practical experience from large-scale coastal developments in Saudi Arabia, where uncertainty is managed under compressed delivery timelines.

Ambitious development schedules increasingly stress and squeeze design, impact assessment, and construction schedules, which can result in complex, inefficient and uncertain delivery programs.

This paper presents a pragmatic risk management approach, tested across fast-tracked projects, delivered by Red Sea Global (RSG) in the Red Sea region. The approach considers uncertainty as a bounded decision condition rather than a deficiency to be deferred. It integrates three pillars along the typical project life cycle of Screening, ESIA Phase and the Construction & Operations Phases:

a. early embedding of environmental and social (E&S) opportunities and constraints in concept design, including strategic nature based solutions (NbS) and basic environmental principles (Screening Phase)
b. evidence-based assessment using credible and appropriate secondary datasets and conservative assumptions where baseline data are constrained. If needed, using clear and transparent uncertainty statements and present project specific NbS; (ESIA Phase), and
~~c.~~ adaptive management using pre-agreed thresholds, triggers, and escalation pathways (Construction & Operations Phaes)

We also show how checklists, trigger tables, and decision pathways allow teams to proceed under schedule pressure while maintaining regulatory credibility.

Socio-economic considerations are addressed where relevant through practical, proportionate measures aligned to delivery realities.

A case study example involving a subsea cable installation within a semi-enclosed lagoon has been selected to demonstrate how this approach enabled informed and defensible decision-making under schedule pressure, masterplan design evolution, and maintained regulatory credibility while preserving programme certainty.

Expedited Approvals

Major coastal developments under Saudi Arabia’s Vision 2030 are increasingly delivered under compressed and overlapping design, ESIA, and construction programmes. Early contractor mobilisation, ambitious national milestones, and investor expectations often require approvals before full design freeze or completion of multi-season environmental baselines. In high-sensitivity Red Sea environments, early decisions relating to shoreline modification, marine access, and construction methods carry inherent ecological risk. Traditional linear ESIA sequencing struggles in such contexts, increasing the risk of design freeze. This paper argues that robust decision-making remains achievable if uncertainty is explicitly acknowledged and actively managed. Large parts of the Red Sea coastline remain relatively pristine, magnifying the consequences of early choices on reefs, turtle beaches, and seagrass habitats. Managing uncertainty therefore becomes a condition for moving forward any development rather than a task to defer.

We have identified five dominant forms of uncertainty that recur across fast-tracked projects:

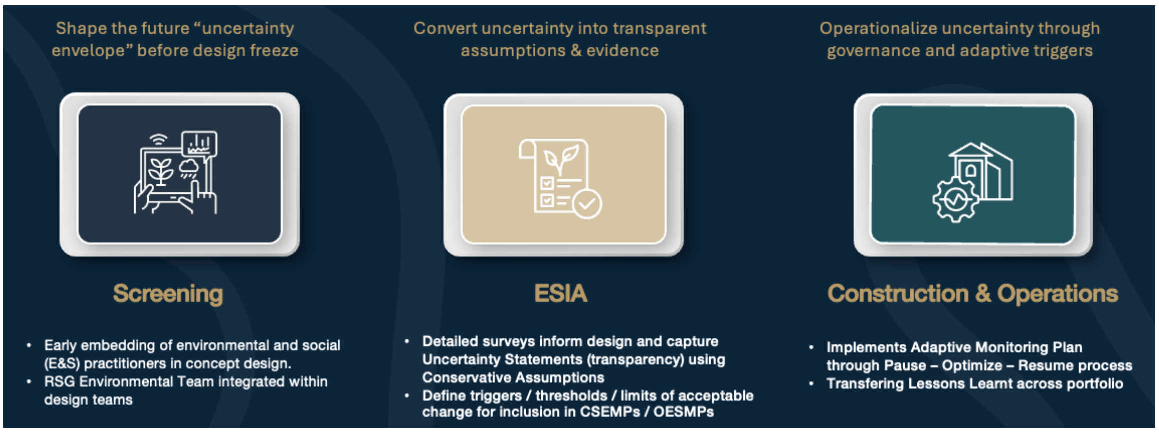
(i) design uncertainty driven by iterative layouts and engineering strategies;
(ii) baseline uncertainty due to incomplete or seasonal environmental data;
(iii) temporal uncertainty arising from compressed programmes and narrow ecological windows for construction and operations;
(iv) governance uncertainty linked to evolving operational models and multiple contractors; and
(v) cumulative uncertainty that requires a destination wide understanding of impacts as new projects are brought online. In practice, this means each individual project's residual impacts and remaining data gaps must be assessed together (not in isolation), because small uncertainties and effects can add up across multiple developments and push the destination beyond ecological or regulatory limits

Rather than eliminating uncertainty, effective impact assessment seeks to bound, declare, and operationalise it within decision-making frameworks, not only for the relevant regulatory bodies but for decision makers within multi-stakeholder teams.

Methodological Response: An Uncertainty Management Toolkit

The approach is deliberately front-loaded and designed to shift uncertainty management upstream in the project lifecycle. Firstly, E&S practitioners are embedded during concept and optioneering stages to influence geometry, access strategies, construction methods, and phasing, enabling avoidance-first outcomes through the application of the mitigation hierarchy , as avoidance is cheaper than retrofitting certainty. Secondly, evidence-based assessment combines credible secondary datasets with targeted early baseline surveys, paired with explicit uncertainty statements and conservative assumptions. Thirdly, adaptive management frameworks translate uncertainty into pre-agreed triggers, thresholds, and escalation pathways, embedded within Construction Environmental and Social Management Plans (CESMPs), where triggers turn uncertainty into predictable action. In practice, several months of design-support advisory work often precede the ESIA.

Because uncertainty spans the entire project lifecycle, each decision-maker interacts with it differently and benefits uniquely when it is structured rather than suppressed. Developers gain schedule certainty, clearer financing pathways, and reputational confidence by embedding avoidance measures early and accepting measurable, enforceable conditions instead of indefinite redesign cycles. Regulators benefit from transparent trade-offs, auditable triggers, and defensible approvals that set clear boundaries for acceptable uncertainty. Consultants benefit through more defensible assessments, reduced iteration loops, and clearer lines of evidence linking assumptions to decisions. Contractors also gain from structured uncertainty, as trigger-based management provides predictable stop–go decisions, reduces downtime, and minimises disputes or rework. Together, these shared benefits transform uncertainty from a risk into a coordinated management mechanism that aligns all parties toward predictable, credible environmental performance.



Three-Phase Uncertainty Management Cycle with the Management / Decision-Making roles

While developed in the Red Sea context, this framework is transferable to other fast-tracked infrastructure and tourism developments globally.

Case Study: Subsea Fibre-Optic Cable in a Semi-Enclosed Lagoon

This case study involved installation of a 31.22 km subsea fibre-optic cable through a shallow, semi-enclosed lagoon. The project faced routing, design and construction methodology uncertainty, navigating evolving utility and navigation corridors, and a narrow marine installation window due to ecological sensitivity found within the lagoon. This combination of constraints made it an ideal test case for applying structured uncertainty management in practice. It primarily reflects design, baseline, and temporal uncertainty, with governance elements introduced during construction.

Based on secondary datasets coupled with initial baseline surveys, habitat maps identified the area having high environmental sensitivity with coral, seagrass, and turtle nesting areas present. From the screening phase, four routing options were screened using a multi-critera analysis with two options identified to be taken into the ESIA phase. Within these two routing options there were four construction methodologies assessed. These included onshore tranching; shallow trenching and airlifting; deep sea cable laying; and Horizontal Directional Drilling (HDD).

It was identified that using the traditional trenching method within the marine environment would have resulted in considerable impacts. Through an alternatives assessment process (ESIA Phase), routing through previously disturbed areas together with avoidance-by-design was achieved through the adoption of a deep subsea cable laying, HDD and onshore trenching helped avoid sensitive habitats. In addition, airlifting and deep see divers will be employed for micrositing around mapped habitats (Construction Phase).

HDD is a widely used tunnelling method across various industries. Adaptive management measures were included within the Construction Environmental and Social Management Plan where clear guidance is provided to contractors for thresholds above which construction needs to pause. These thresholds were for turbidity, underwater noise, and fauna presence. The approach was a clear pause, optimise, or resume actions, enabling completion of works within the critical schedule window while maintaining defensible environmental performance.

Examples of this in practice are:

a. Monitoring bouys were deployed at selected locations based on metocean conditions to monitor sediment levels.
b. Visual megafauna / marine mammal observations were scanning the surrounding waters prior to and during construction activities
c. Hydrophones were used to monitor real-time in-water noise levels during high impact noise generating activities.

The construction methodology also considered the temporary access platforms used to bridge the marine – land transition of the cable. These platforms were reduced in length and sequenced to avoid ecologically sensitive periods to reduce risk in the shallowest reaches. For the high sensitivity areas the HDD routing avoided the sensitive coastlines completely. As a belts and braces approach, scuba divers are to be deployed to guide micrositing and avoidance of sensitive areas during the construction and installation process.

Outcomes of the assessment were therefore dominated by localised, temporary effects that included:

- very small direct habitat losses due to temporary platforms and trenching,
- short-lived turbidity plumes constrained by double curtains and weather windows, and
- transient underwater noise peaks mitigated to performance targets.

Pre-agreed threshold values and clear escalation pathways preserved the critical installation window while maintaining defensible compliance. An estimated 2km of HDD was employed to avoid the highly sensitive marine environment encircling the islands and near shores.

The preferred route resulted in reduced impacts compared to the alternative route with a 69% reduction in onshore trenching (1.42km for preferred route vs 4.6km for the alternative) and a

71% reduction in direct impact to corals (0.73km for the preferred route vs 2.5km for the alternative). Relocation and compensation will be undertaken for impacted areas as required by the regulators.

Strengths and trade-offs

The strengths of the approach include the following:

- Early avoidance-by-design reduced direct impacts
- Performance-based thresholds improved decision clarity
- Adaptive management supported schedule certainty

The trade-offs of the approach include the following:

- The partial HDD option was more complex and expensive than the traditional method of installing subsea cables
- Silt curtain performance varies with bathymetry and alignment;
- Elevated background turbidity and cumulative metals / nutrients added complexity to the modeling and in determining thresholds;
- In coral reefs already stressed by heat, adjusting activities seasonally can help lower added pressures, but it cannot stop the broader effects of regional climate change

Table: The three-phase uncertainty management cycle with decion-making roles

Phase	Core purpose	Key uncertainty tasks	Primary decision-makers & roles
1. Screening	Shape uncertainty before design freeze	• Early constraints & opportunities mapping • Early habitat & seasonal sensitivity screening • Keeping alternatives alive longer • Agreeing early principles of avoidance-first design & NbS integration • Identifying baseline gaps and what level of data is “good enough” to proceed	**Developers/Proponent:** Set project flexibility; commit to early E&S integration; ensure design freeze is firm. **Environmental Consultants:** Provide strategic advisory related to ESIA execution plan; identify critical gaps and sensitivities; map uncertainty explicitly. **Regulators:** Provide early guidance on acceptable uncertainty, seasonality considerations, and data sufficiency. **Contractors (if early-appointed):** Provide

			clarity on construction methodology inclduing any constructability constraints affecting uncertainty.
2. ESIA	Convert uncertainty into transparent assumptions and evidence	• Apply realistic ~~conservative~~ assumptions where data limited • Integrate secondary datasets transparently • Document uncertainties and data gaps clearly • Present conditional approvals based on measurable conditions • Demonstrate avoidance/minimisation already embedded	**Environmental Consultants:** Follow Screening guidance, lead uncertainty analysis and modeling in ESIA; justify assumptions; quantify ranges. **Developers/Proponents:** Accept binding measurable conditions; provide refinements to reduce uncertainty impacts. **Regulators:** Test proportionality of assumptions; require clarity on triggers, thresholds, and monitoring expectations. **Contractors:** Provide method statements and quantitative input to noise/plume/footprint modelling.
3. Construction & Operations	Operationalise uncertainty through governance and adaptive triggers	• Embed triggers, thresholds, and escalation pathways into CESMPs/OESMPs • Implement adaptive monitoring for turbidity, NTU, noise, fauna, lighting, etc. • Use real-time data to pause–optimise–resume works • Maintain transparent response logs and compliance maps • Avoid shifting	**Contractors:** Execute adaptive controls; pause or modify works when triggers are exceeded. **Developers/Proponents:** Ensure governance escalation pathways, contractor oversight, and programme flexibility. **Regulators:** Audit compliance; require evidence of responses; enforce cumulative considerations. **Environmental**

		baselines with sentinels & harmonised QA/QC	**Consultants:** Monitor implementation of CESMPs, undertake post construction baseline, Verify data quality; update predictions; advise real-time optimisation; maintain defensible records.

Conclusions and Implications for Practice

This paper demonstrates that uncertainty is an inherent condition of fast-tracked development, but not a barrier to decision-making when it is explicitly structured and governed. The case study demonstrates that robust decisions can still be made when uncertainty is surfaced early, bounded transparently, and governed through measurable and enforceable triggers.

The RSG experience demonstrates that expedited approvals do not inherently weaken impact assessment. Uncertainty management through early E&S embedding of environmental specialists within the mutli-disciplenary design teams, transparent evidence and assumptions, and trigger-based adaptive governance enables informed, defensible decisions without delaying delivery. For practitioners, the key lessons are to keep design approvals around measurable conditions, and prioritise verifiable outcomes over generic commitments. These approaches are transferable to fast-tracked coastal and infrastructure developments globally.

The key conclusions are as follows:

- **Uncertainty must be addressed early**
  The greatest opportunity to manage uncertainty lies before design freeze, where avoidance remains achievable.
- **Transparency strengthens decision-making**
  Explicit assumptions, limitations, and uncertainty statements improve regulatory confidence rather than weaken it.
- **Adaptive management is most effective when pre-defined**
  Trigger-based frameworks transform uncertainty into clear, actionable decisions.
- **Impact assessment must evolve from prediction to governance**
  The role of IA is shifting from forecasting outcomes to managing dynamic systems.

Ultimately, the ability to structure and govern uncertainty will define the effectiveness of impact assessment in supporting faster, more credible decisions worldwide.