AI SUSTEIN
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Showcase #6

Sustainable Development for Oil and Gas Infrastructure from Risk, Reliability, and Resilience Perspectives

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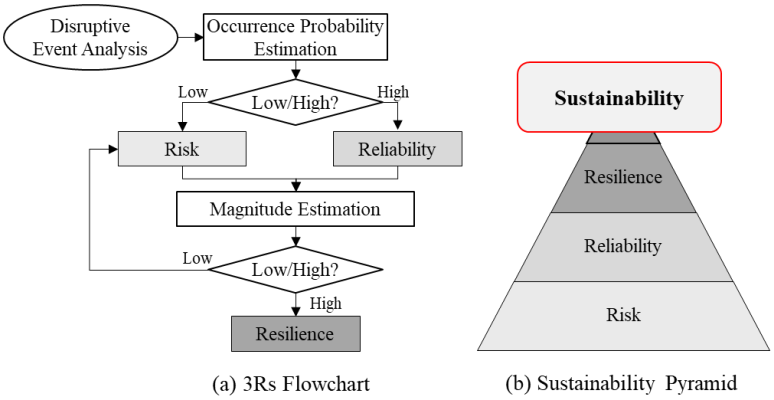
Background

As the world approaches renewable energy sources, the oil and gas (O&G) industry must incorporate sustainable development practices in its infrastructure and operations. This will enable a smooth transition to future renewable energy generation. A robust O&G infrastructure that is free of risks, reliable, and resilient towards expected or unexpected threats can ensure an uninterrupted supply of O&G to downstream stakeholders, competitive customer prices, and a better environmental footprint. Given the complexity of the O&G infrastructure, it is essential to continuously integrate sustainable development practices at every dimension to achieve the ultimate goal of long-term sustainability. This showcase proposes an innovative and comprehensive approach to achieving sustainable development for O&G infrastructure through a holistic risk, reliability, and resilience (3Rs) perspective.

Approach

In the context of O&G pipeline infrastructure, risk, reliability, and resilience (3Rs) are vital. While pipelines are a secure and efficient means of transporting O&G, they are still susceptible to various natural and human-induced hazards. Implementing the 3Rs approaches, as illustrated in Figure 1 (a), can help to minimize the likelihood and severity of these hazards. It is essential to consider risk, reliability, and resilience in tandem with sustainability towards sustainable development in the O&G industry, as they complement each other, as shown in Figure 1 (b).



(a) 3Rs Flowchart (b) Sustainability Pyramid

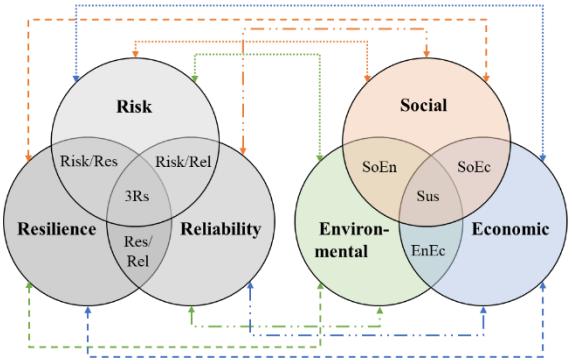
Figure 1 – Conceptual relationship of 3Rs and their relation to sustainability

(1) Risk is commonly defined as the probability of an unexpected event or outcome occurring. In risk assessment, possible outcome events can be predicted quantitatively with an assigned probability. However, the actual outcome is uncertain until the event occurs. A risk control plan can be formulated beforehand to account for all possible outcomes. Since there is a pre-mitigation plan in place, the negative magnitude of an outcome can typically be reduced to a low-magnitude probability event if the outcome occurs.
(2) Reliability, on the other hand, concerns the probability of a failure event expected to occur within the design life cycle. Therefore, the occurrence probability is higher compared to the risk. To increase reliability, maintenance or redundancy is often approached.
(3) Resilience is typically associated with extreme, rare, and uncertain events where the occurrence and impact cannot be quantified with an assigned probability. Unlike risk and reliability, failure is often expected in resilience and cannot be mitigated, although the occurrence probability of this outcome is usually low.
(4) Sustainability is often regarded as a long-term objective, whereas sustainable development refers to the various routes to achieve sustainability. Sustainability is typically characterized by three interconnected

dimensions, which include social, economic, and environmental aspects or goals. Thus, to attain the sustainability objective, sustainable development concentrates on enhancing each dimension or pillar (i.e., social, economic, and environmental) while considering their relationship or impact on the other factors. In this way, sustainable development aims to create a harmonious balance between the different aspects of sustainability.

Results and Discussion

The concept of 3Rs can be integrated iteratively into each of the three pillars of sustainability (as shown in Figure 2 (a)). Therefore, practitioners can contribute to sustainable development from any aspect of these pillars. This integrated approach leads to a sustainable development 3Rs matrix, consisting of a fundamental matrix and a coupling matrix (as shown in Figure 2 (b)).



(a) Integrated Sustainable Development

Risk Reliability Resilience
Social Economic Environmental

	Sustainability		
3Rs	**Social**	**Economic**	**Environmental**
Risk	Social Risk	Economic Risk	Environmental Risk
Reliability	Social Reliability	Economic Reliability	Environmental Reliability
Resilience	Social Resilience	Economic Resilience	Environmental Resilience

Coupling Matrix

Fundamental Matrix

(b) Sustainable Development 3Rs Matrix

Figure 2 – (a) the 3Rs integrated sustainable development approach and (b) the sustainable development 3Rs matrix.

The fundamental matrix for sustainable development focuses on the direct and immediate impacts of a particular activity or process on the environment, economy, and society. These fundamental effects can often be measured and quantified, including emissions, water usage, land use changes, operational costs, and other indices for measuring social welfare. To reduce the complexity of the multi-faceted sustainable development, the fundamental matrix suggests targeted 3Rs efforts to each of the social, economic, and environmental pillars of sustainability. However, since the social, economic, and environmental influences often cannot be entirely distinguished from one another, the fundamental matrix for sustainable development can be further expanded to include the coupling effect from the individual sustainability pillar.

The coupling matrix considers the indirect or long-term impacts of an activity or processes toward achieving sustainability. Although the coupling effects may not be immediately apparent, they can be significant and wide-ranging. The coupling effect is significant in sustainable development because it highlights the interconnectedness of environmental, social, and economic pillars and emphasizes the need for a more holistic and integrated approach to sustainable development that considers both the direct and indirect impacts of human activities.

To summarize, all the risk, reliability, and resilience concept can aid as the foundation for achieving sustainability in the O&G industry and beyond. By considering the 3Rs fundamental and coupling matrices of sustainable development in the O&G application, stakeholders and policymakers can understand the impacts of O&G activities and work to achieve sustainability by minimizing negative impacts and maximizing positive ones.

For more detailed information, please refer to the **Full article**: Sustainable Development for Oil and Gas Infrastructure from Risk, Reliability, and Resilience Perspectives