Sustainability Assessment of Economic and Environmental Impacts: A Critical Systems Thinking Approach to Tackle Complex Environmental Challenges

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ABSTRACT: Complex and interconnected vicious cycles of problems such as climate change, epidemics, poverty, and pollution create wicked environmental challenges. These transcend both conceptual and spatial boundaries, presenting a formidable challenge to contemporary society. Recognizing the diverse perspectives held by different quality individuals, this paper explores the necessity of involving key stakeholders in decision-making processes to effectively address these challenges. However, the exclusion of stakeholders from power-sharing mechanisms within existing social systems is a significant impediment. To address these multifaceted issues, an additional focus on emancipatory commitment and methodologies is required. One approach that holds promise in this regard is Ulrich's critical systems heuristics, a critical systems methodology that provides practical tools for achieving the goal. Through a comprehensive case analysis of a gas blow-out tragedy, this paper explores the application of critical systems heuristics and underscores the importance of extending its use beyond planning situations to encompass a critical evaluation of existing institutions. Introducing the contextual background of the mishap, it explores the extensive social, economic, political, and environmental consequences resulting from the incident. It highlights the fundamental cause of the wicked problem and employs the critical systems approach as a prospective tool to augment accountability and involve stakeholders in overcoming such wicked socio-environmental challenges.

KEYWORDS: Environmental problems; ecological economy, critical systems thinking; Ulrich's heuristics, accountability, stakeholders' involvement.

GRAPHICAL ABSTRACT
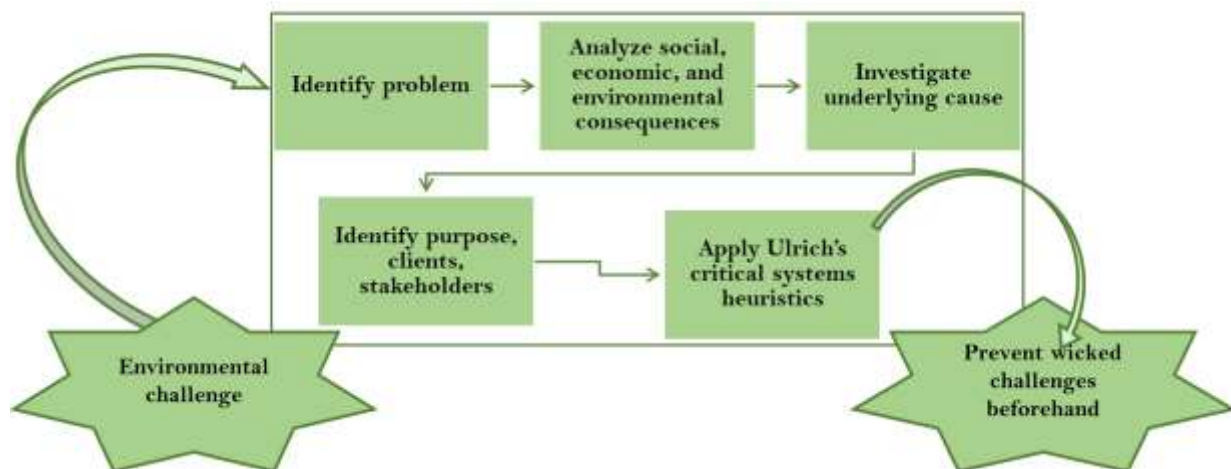
I. INTRODUCTION

Socio-environmental problems frequently exhibit a wicked nature, evolving within the intricate tapestry. These dilemmas, ranging from poverty, pollution, climate change to epidemics, present a formidable challenge for today's world. Due to their propensity to cross conceptual and spatial barriers as well as the wide range of perspectives, they are complex in nature

Sustainability Assessment of Economic and Environmental Impacts: A Critical Systems Thinking Approach to Tackle Complex Environmental Challenges

(McIntyre, 2009). Effective resolution of these wicked problems demands the active engagement of systems thinking approach in the decision-making process. Several research endeavors have been dedicated to exploring these types of complex challenges and employing a framework of critical systems thinking.

Jackson (2020) investigated the complexity of Covid-19 pandemic, concentrating in particular on the difficulties brought on by "structural complexity," "organizational complexity," and "cognitive complexity". The study argued that traditional approaches fall short in addressing pandemic intricacies. Instead, the study suggested using "critical systems thinking" (CST) and "critical systems practice" (CSP) for better solutions. The author introduces five "systemic perspectives" - "machine," "organism," "cultural/political," "societal/environmental," and "interrelationships" - as a comprehensive framework. Applied to that pandemic, these perspectives showcase how CST and CSP could have enhanced preparedness and response, revealing insights from resource gaps to marginalized group impacts (Jackson, 2020). For the same challenge, Elias (2021) developed a reference mode to capture the behavior of Kerala's Covid-19 curve, identified, and analyzed stakeholders involved in the case, and created an overall system thinking design.

Nguyen et al. (2023) examined how CST is perceived and applied in policymaking. The study revealed CST's potential benefits and feasibility in practice in public policy. Various CST tools, such as causal loop diagrams and participatory modeling, were identified in the study for understanding systems, facilitating collaboration, and co-designing solutions. The claimed benefits of CST included its ability to comprehend complex issues, promote stakeholder participation, shift thinking towards holistic approaches, aid in learning and decision support, and potentially impact policy and practice (Nguyen et al., 2023). While CST has been the focus of several issues, very few research demonstrated its implementation in the context of socio-environmental disasters.

The objective of this study is to comprehensively analyze and address the intricate and interrelated vicious cycles of a socio-environmental issue that collectively give rise to a range of complex and wicked environmental challenges. The research aims to identify the underlying mechanisms driving these cycles, quantify their impacts, and propose holistic strategies that can effectively mitigate the compounding effects by applying Ulrich's critical systems heuristics on both local and global scales.

II. METHOD: OVERALL RESEARCH FRAMEWORK

The comprehensive research framework (depicted in Figure 1) was formulated and thoroughly deliberated upon in the subsequent sections. This framework serves a dual purpose: not only does it address the consequences of intricate challenges known as wicked problems, but it also serves as a proactive measure to avert the emergence of such problems in the first place. This leads to long-term solutions, efficient resource allocation, and enhanced preparedness. Collaboration among stakeholders is facilitated, ultimately resulting in reduced risks and positive socio-environmental impact.
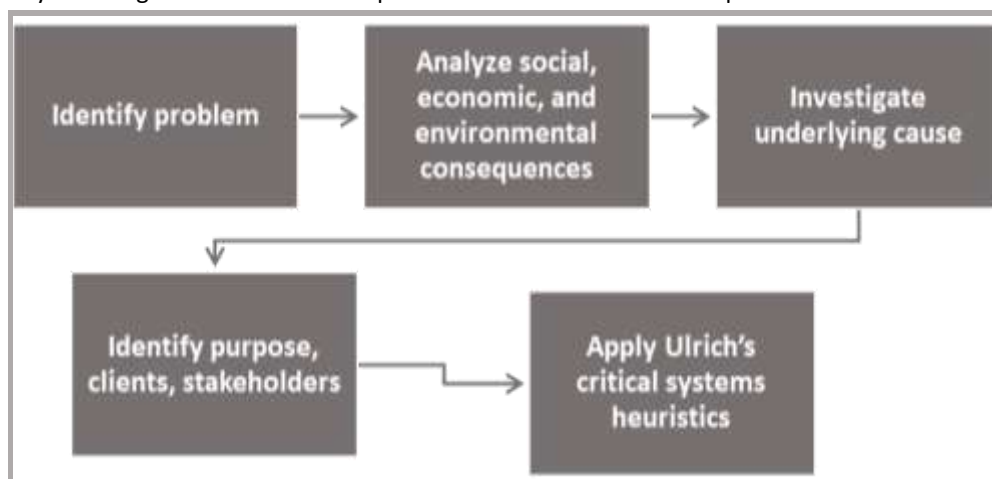

Figure 1. Comprehensive research framework

A. Overview of the Wicked Challenge

A massive gas blow-out took place in the *Chattak*-2 (known as *Magurchara*) gas field at midnight on June 14, 1997, which caused severe damage to the environment, economy, and social life of Bangladesh (Alam et al., 2022). The blow-out started with a huge explosion; rail lines adjacent to the gas field were closed for five months. The primary exploration company, Occidental, which contracted out the work to another company, Unocal, was not able to control the 500-feet fire for about six months (Siddiqui, 2010). As a result, the blow-out was not sealed for the next six months. Surrounding people were evacuated from their property

and that enormous fire destroyed nearby national forest as well as many important flora and fauna of the region (Siddiqui, 2001; Khan & Nasin, 2014).

A number of managerial, legal, environmental, and human rights issues were raised after the incident. Apparently, the question that arises from that blow-out is -whether the affected would get proper compensation in terms of damage management. During that period, impoverished individuals were unable to consider the environmental harm, which subsequently led to significant detrimental consequences. Unfortunately, Occidental company easily shifted their burden by selling their share to another drilling company- Unocal, afterwards Unocal shifted their share to Chevron (Deb, 2020). People sought clarification about the prolonged governmental silence concerning compensation claim resolution (Khan & Nasir, 2014).

B. Social, Economic, And Environmental Consequences

Situated a mere 600 meters from the nearest inhabited area, the *Magurchara* gas field was in close proximity to the dwellings of the Khasia tribal people, who relied heavily on cultivation for their livelihood (Uddin et al., 2007). Tragically, the incident not only obliterated their farmlands but also forced their displacement from the region, creating a housing predicament that posed challenges for the government. The explosion during the accident left some children with hearing impairments due to the deafening noise (Alamgir Hussain, 2015). In a gesture of compensation, Occidental provided them with an insignificant amount, which hardly addressed the magnitude of their suffering.

The repercussions of the blow-out extended far beyond the immediate site. The disruption caused to the Dhaka-Sylhet (two cities of the country) highway and railway had far-reaching economic ramifications, severely impacting producers reliant on railways for transporting goods between the two cities. An additional casualty was the devastation inflicted upon 29 adjacent tea gardens, with experts predicting a bleak prognosis for tea cultivation in the area for the next five decades (Khan & Nasir, 2014). The incident also inflicted damage on the Power Development Board's power line emanating from the national grid.

During the incident, an estimated 250 billion cubic feet of natural gas was damaged, resulting in a staggering total loss of $12 billion (Deb, 2020). After a long negotiation, Occidental provided compensation of $58.24 million, a mere fraction of the incurred losses. More than two decades have passed since the Magurchhara incident but the biodiversity-destroyed forest and its vicinity areas have not been restored properly (Deb, 2020). In order to delve into this ongoing compensation dilemma, the subsequent section establishes the political and economic backdrop surrounding the *Magurchara* incident.

The blow-out cast a calamitous impact on the local ecosystems, decimating dense natural forests and severely affecting the soil composition. The soil fertility was irrevocably compromised, rendering it unsuitable for supporting substantial structures. The inferno caused by the gas blow-out devastated the 700-acre *Magurchara* reserved forest, which was a sanctuary for diverse flora and fauna, including 63 species of animals (Uddin et al., 2007; Dev 2020). Soil experts forecast that the lands impacted by the blow-out will remain unsuitable for growing tea, trees, crops, and vegetables due to the soil contamination by heavy metals resulting from that incident (Alam et al., 2022).

C. Cause Analysis

According to the Australian Public Service Commissioner, Briggs (2009), "wicked problems" refer to intricate challenges in public policy that cannot be effectively addressed using conventional analytical methods due to their complexity, changing nature, interdependencies, conflicting objectives, and multiple causes. The Production Share Contract (PSC) of Bangladesh was grappling with several such complex issues. The country was heavily dependent on foreign investments, yet foreign companies often lack a long-term stake in the welfare of an investing country. Immediate profit motives frequently guide their decisions, potentially leading to environmentally hazardous choices (Islam, 2000). The PSC between International Oil Companies (IOCs) and the government, designed to safeguard the interests of both parties, inadvertently favors the IOCs. The contract lacked provisions for ensuring accountability and transparency, and it fails to delineate responsibility in case of any mishap.

IOCs engaged in gas and oil production in the country operate under PSCs with the government. The terms oblige the government to purchase gas at a higher rate fixed by the companies, while the government sells the same gas in the domestic market at a subsidized rate (Islam, 2000), resulting in substantial annual losses for the government. This policy stems from global energy politics and donor group pressures. Despite the emergence of capable national companies with proven track records, world politics impeded their involvement in exploration.

The lack of transparency allowed a foreign company to operate without sufficient accountability. In government collaborations with foreign entities, control was established through formal contracts, specifying service standards and performance criteria. Nonetheless, accountability could become convoluted, making it difficult for users to determine who was ultimately responsible for the services provided or the achieved outcomes (Briggs, 2009). As Briggs (2009) noted, while the approach of government by

network may alter operations, ultimate accountability remains with officials responsible for public expenditure. In practice, accountability can become blurred, necessitating clear delineation of responsibility to maintain effective governance.

D. Ulrich's Critical Systems Heuristics

Ulrich's critical systems heuristics, introduced in 1983, furnishes practical tools for revealing the normative underpinnings of applied inquiries or proposed interventions, facilitating a constructive dialogue between planners and concerned citizens (Ulrich, 1993). Central to this approach are the concepts of boundary judgment and its application, as elucidated by Ulrich in 1993. Boundary judgment encapsulates inherent a priori assumptions that inform applied inquiries and a posteriori implication (Ulrich, 1993). Although these judgments are vital constituents of the systems concept, they are often overlooked and assumed to be objective. Boundaries extend beyond mere physical confines; they encompass temporal and social dimensions, collectively influencing the normative essence of the inquiry or intervention (Ulrich, 1993).

The notion of boundary judgment serves as a tool to unpack the normative societal and ecological ramifications of system design. Ulrich identified 12 categories of boundary judgments that invariably underlie any systems design, categorized into four groups, each addressing a critical aspect of normative design (Ulrich, 1993):

1) **Design's basis of value:** This group investigates the sources of motivation, purpose, and success criteria of the design. Whose purposes are being served, and what measures gauge success?
2) **Design's basis of power:** This group scrutinizes control sources within the design, decision-making authority, and the environment beyond their jurisdiction.
3) **Design's basis of knowledge**: This group explores sources of expertise, practical experience, organizational design skills, and the role of expertise in design.
4) **Design's basis of legitimization:** This group examines sources of legitimacy vis-à-vis those affected but not involved yet, as well as mechanisms for self-reflection and responsibility, encompassing marginalized voices and nature.

While the first three groups pertain to the roles and interests of involved stakeholders in the planning process, the fourth group addresses those impacted but excluded from involvement (Ulrich, 1993). However, the concept of boundary judgment is not solely a tool for introspection. Ulrich (1993) argues that self-reflection is not guaranteed, particularly if it relies solely on the goodwill of planners. Due to the complexity of exposing the normative essence of plans, additional heuristic support is necessary (Ulrich, 1983). Furthermore, solely reflective planning detached from experiential constraints and absent input from those affected lacks democratic legitimacy. To rectify this, Ulrich emphasizes the importance of equal engagement between planners and affected citizens, fostering a dialogue that allows the boundary judgments of the plan.

III. RESULTS AND IMPLICATIONS: APPLY ULRICH'S HEURISTICS TO ENHANCE ACCOUNTABILITY

The *Magurchara* gas blow-out incident sheds light on a multitude of ethical issues concerning gas exploration and compensation following gas well blow-outs. In this section, Ulrich's critical unfolding approach was employed to tackle the complexity inherent in such problems. Ulrich's critical systems heuristics offer empirical support for both social planners and citizens impacted by plans, facilitating reflection and criticism of underlying value assumptions and implications (Maru & Woodford, 2001).

Accountability demands a comprehensive consideration of social, cultural, economic, and environmental factors, an approach that "sweeps in" and "unfolds" the multifaceted dimensions (McIntyre, 2005). In this case study, the end users were the citizens of the country who lived in that surrounding area. With the main focus on natural gas exploration and production, the relevant ministry could have assigned the responsibility to domestic companies, ensuring accountability throughout the entire process. This high level of accountability would help minimize the chances of negligence or any unwanted incident. In contrast, IOCs like Occidental lacked accountability, operating with unchecked authority. According to McIntyre & Vries (2009), enhancing the ability of people to engage actively in designing policy can make a difference to governance, provided they are encouraged to think critically and systemically about the future.

Occidental held unilateral decision-making power over drilling activities, contracts, and economic gains, avoiding environmental concerns. They disregarded the fact that climate change is not an issue of any particular country and hence everybody would bear severe consequences of it (Ball, 2009). Occidental omitted social and environmental risk assessments before initiating their operations, neglecting the global ramifications of environmental disasters. Their actions contradicted the principle that environmental impacts are evenly distributed worldwide, implicating all nations.

The overarching planning authority of Occidental led to unchecked decisions. They overlooked geographic, environmental, and soil characteristics and excluded local experts, employing only their own experts who lacked knowledge of the regional

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geological and soil characteristics. Addressing climate change necessitates collaborative action between nations, public and private sectors, civil society, and individuals to achieve shared goals (McIntyre & Vries, 2009).

Systemic governance seeks to a conceptual and spatial boundary through a design of inquiring systems approach, involving questioning and applying questions about the existing and desired conditions for those affected by decisions (McIntyre & Vries, 2009). Employing Ulrich's critical unfolding approach (Table 1), the study investigated what was the case and what ought to be the case, utilizing a questioning framework to illuminate the ethical dimensions of the *Magurchara* gas blow-out incident.

Table 1. Applying Ulrich's critical systems heuristics in *Magurchara* incident.

Concern focus	What was the case	What ought to be the case
Actual Client	Government was the client of Occidental company.	Citizens of Bangladesh ought to be the end user and they ought to be treated as customers.
Actual purpose	Actual purpose of the system was making profit was the actual purpose.	To extract natural gas without hampering people, society and environment.
Measure of success	They measured their success in quantitative scale; they did not consider about client or environment.	Measures ought to be qualitative to the client, environment and next generation.
Decision maker	Government and Occidental company were decision makers.	As the end users are the citizens, they along with other stakeholders ought to be involved in decision making process.
What conditions are controlled	Only economic conditions (related with their benefits) were controlled.	They ought to control social, environmental and political conditions; determine consequences for self and others.
What conditions are not controlled	Environmental effect and risks associate the drilling project were not controlled by the decision-maker.	Before starting the drilling project decision – makers ought to assess the risk and environmental impact assessment.
Actual planner	Occidental company was the planner.	They ought to involve other key stakeholders in this case (for e.g. soil scientist, concerned ministry, local experts, experts from local drilling operation offices)
Who involved as experts	Occidental company contracted out the drilling works to Dewtech- a German company. They were worked as experts.	Local experts from domestic drilling operation projects, soil scientists, environmentalist, geologist, and petroleum engineer ought to be included in that case.
From where they seek guarantee	Occidental was overconfident about their previous success experience.	They ought to seek guarantee by addressing local, social, and environment justice properly.
Who may be affected without being involved	Local people, wild animals, local forest, ecosystem, biodiversity, and environment were directly affected.	As they were not involved with the system, they should not be affected by that incident.
What was the fate of the affected	Nobody considered anything about the affected people, environment, and ecosystem. At that time, they were only busy with calculating their own loss.	After that incident, the affected stakeholders, ecosystem, biodiversity, and environment ought to get top priority.

In the process of policy design, it is imperative to consider accountability and performance management frameworks, as they shape the comprehension and resolution of issues. In the context of the *Magurchara* gas blow-out incident, it becomes essential for the government to establish benchmarking standards for making contracts. Additionally, stakeholders' involvement and regular reviews and evaluations conducted by local experts should be integrated into the system.

IV. SUMMARY AND CONCLUSIONS

The notion of social and environmental justice transcends geographical boundaries, highlighting the interconnectedness of global issues (McIntyre, 2005). To forge a path toward a sustainable future, accountability must extend beyond the conventional triple bottom line accounting, encompassing a comprehensive spectrum of social, cultural, political, economic, and environmental accountability factors. This expanded perspective is essential for delineating and addressing issues at local, national, and international levels (McIntyre, 2005).

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The aftermath of the *Magurchara* gas blow-out incident underscored a confluence of managerial, legal, environmental, and human rights challenges. This catastrophe prompts several significant inquiries: did the compensation suffice to alleviate the extensive environmental, economic, and social damage, and what measures could have been taken to prevent such an occurrence? Notably, this disaster unfolded in a climate where heightened attention was focused on the environmental and human rights consequences of natural resource exploitation. Regrettably, the upstream sectors of these industries have been harmed by instances of severe environmental degradation and human rights violations.

Effective accountability is intrinsically linked to a democratic and participatory approach, where communication transcends a unilateral flow of information. Sincere accountability necessitates a dialogue, inherently involving two-way communication with citizens. Critical systemic thinking serves as a crucial tool for unravelling stakeholder values and comprehensively encompassing the social, political, economic, and environmental dimensions (McIntyre, 2005).
In conclusion, the imperative of applying critical systemic thinking in policy formulation and implementation is undeniable. By embracing this approach, accountability can be authentically advanced. The multifaceted nature of contemporary challenges demands an approach that integrates diverse perspectives and considers broader implications, fostering transparency, fairness, and sustainable progress. Employing Ulrich's critical systems heuristics beforehand can serve as a potential defence against confronting such challenges.

DECLARATIONS
Competing Interests: The authors declare no conflict of interest.

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