Introducing the REPAIR Framework for Sustainable Environmental Restoration: Lessons from Lake Urmia, Iran

Authors:

1- Hamdi Farahmand, PhD student, hamid.farahmand75@sharif.edu (Corresponding author):
   - Department of Civil Engineering, Sharif University of Technology, Tehran, Iran

Address: Tehran, Azadi Ave, P932

2- Mohammad Taghi Isaai, PhD, isaai@sharif.edu:
   - Graduate School of Management and Economics, Sharif University of Technology, Tehran, Iran

3- Massoud Tajrishy, PhD, tajrishy@sharif.edu:
   - Department of Civil Engineering, Sharif University of Technology, Tehran, Iran

4- Mohammad Ghoreishi, PhD (Postdoctoral fellow), mohammad.ghoreishi@usask.ca:
   - School of Environment and Sustainability, University of Saskatchewan, Canada
   - Global Institute for Water Security, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

5- Mohammadreza Mohammadi, Graduate student., mrm.mohammadie@gmail.com:
   - Department of Civil Engineering, Sharif University of Technology, Tehran, Iran

Abstract

Achieving long-term sustainability in environmental restoration requires integrating behavioral science into policy design, yet cognitive biases that shape agricultural decisions remain overlooked. This study introduces the REPAIR framework, a novel interdisciplinary approach that addresses these biases to improve water management strategies. Using a qualitative case study of 148 farmers in Mahabad, Iran, we apply a grounded theory approach to identify key biases—such as confirmation bias, status quo bias, and the bandwagon effect—that reinforce unsustainable irrigation practices and limit farmers' responsiveness to ecological risks. The REPAIR framework (Revenue, Experience, Participation, Availability, Insight, and Relationship) provides structured interventions, incorporating incentive structures, experiential learning, and collective action mechanisms. By integrating insights from Ostrom's Design Principles and behavioral decision-making theories, REPAIR enhances policy effectiveness in common-pool resource governance. This study underscores the necessity of embedding behavioral science into environmental restoration, offering a scalable, evidence-based tool for policymakers and conservation practitioners. To conclude, addressing cognitive biases is not just complementary to ecological restoration—it is fundamental to ensuring lasting environmental and socio-economic resilience.

Keywords: Farmer Decision-Making, Cognitive Biases, Environmental Restoration, Sustainability, Water Management

1. Introduction

There is widespread evidence that human activity is a primary driver of the environmental catastrophe facing the world [1]. Consequently, numerous large-scale international initiatives such as the Bonn Challenge and Forest and Landscape Restoration (FLR) Programs, have been launched with significant funding, including billions of dollars in private capital [2,3]. The urgency of this issue was further underscored by the UN's 2019 declaration of the "Decade for Ecosystem Restoration" [4]. However, despite these significant budgetary allocations [5–9], the success of projects addressing diverse environmental crises is not guaranteed and their outcomes heavily depend on meticulous planning and effective implementation. Long-term success depends on individual decision-making, making it crucial to understand human behavior. Overlooking this aspect in restoration projects reduces effectiveness and risks wasting substantial funds [10].

Understanding local people's attitudes and behaviors is essential to tackling these issues since their choices have a significant impact on the environment. This is where the idea of the "tyranny of small decisions" comes into play: a number of seemingly unimportant decisions made by individuals, when aggregated over time, can result in severe environmental harm on a global scale and ultimately lead to the failure of restoration projects [11]. However, the complexity of human behavior and its influential factors, such as cognitive biases, make it challenging to effectively address these issues.

People's attitudes and behaviors regarding conservation are shaped by a multitude of factors within the social, cultural, institutional, and economic domains [12]. It is commonly acknowledged that public support is essential to the success of restoration projects [13]. It is still difficult to determine the true effects of ecological restoration plans on local socioeconomic dynamics because there are insufficient data and no rigorous control studies [14]. Many initiatives promote sustainable behavior, but replicability, lesson retention, and measuring success remain challenges [1]. While most interventions have the potential to foster pro-environmental behaviors, reviews consistently show significant variability in study results [15]. For instance, the rebound phenomenon in irrigation systems shows how neglecting behavioral dynamics can undermine sustainability efforts [16,17]. These inconsistencies underscore the need for a systematic framework that accounts for cognitive biases in environmental restoration. Many initiatives still rely on outdated ecological models, overlooking human behavior and limiting their effectiveness [18–21].

Various frameworks have been developed to address the complexities of social-ecological systems (SES), with each providing unique and valuable insights. However, a closer analysis reveals that these frameworks frequently neglect to directly address changing human behavior

[22]. For example, while the Social-Ecological Systems Framework (SESF) [23] offers a comprehensive understanding of human-ecological interactions, it lacks practical tools for influencing behavioral change, particularly cognitive biases. Similarly, the Sustainable Livelihoods Approach (SLA) [24] and the Vulnerability Framework (VF) [25] may not fully consider the psychological foundations of unsustainable behaviors. Other frameworks like the Management and Transition Framework (MTF) [26] and the Human-Environment Systems Framework (HES) [27] while touching on human and social aspects, do not offer specific strategies for fostering long-term behavioral change. Overemphasis on ecological aspects often neglects cultural and community dynamics, reducing alignment with local conservation interests [26].

A critical framework shaping common-pool resource (CPR) governance is Ostrom's Design Principles (DPs) [28], which emphasize institutional robustness and collective action. However, these principles exhibit limitations, particularly in addressing factors such as social capital, trust, external interventions, and cognitive biases [29]. Studies argue that excludability and subtractability are not inherent physical attributes but rather socially constructed, implying that governance models must consider ethical, legal, and historical contexts [30]. Recent advancements in behavioral science emphasize integrating cognitive and social factors into governance models [31]. The HuB-CC framework attempts to bridge this gap by mapping decision-making theories to sustainability challenges, yet it remains largely theoretical [32]. To bridge this gap, this study presents the REPAIR framework, integrating behavioral science into sustainability efforts by addressing key cognitive biases like confirmation bias, status quo bias, and loss aversion.

This necessity becomes particularly evident in the case of environmental crises such as large-scale lake desiccation, where governance models often fail to account for behavioral drivers of resource depletion. The drying of Lake Urmia provides a compelling case study for examining how cognitive biases shape decision-making in water management and how the REPAIR framework can address these challenges.

The drying of saltwater lakes like Lake Urmia poses serious environmental and public health risks, as exposed lake beds release harmful salts, worsening air quality and respiratory issues. Declining water levels also disrupt ecosystems, threatening regional water supplies and biodiversity. Similar patterns have been observed in other major saline lakes, like Owens Lake and the Aral Sea, with profound socio-environmental consequences. The Great Salt Lake, Lake Urmia, and the Aral Sea have all had national restoration initiatives, though their degrees of success have varied [33].

In response to this need, and based on an in-depth examination of the Urmia Lake Restoration Program (ULRP), we developed the REPAIR framework to enhance environmental restoration strategies by integrating behavioral insights. The Lake Urmia case study shaped this framework, highlighting its role in improving sustainability strategies that bridge ecological and social considerations. Our research provides policymakers with a practical tool, ensuring that overlooked behavioral factors are systematically addressed, leading to socially inclusive and ecologically sustainable projects.

2. Case Study

Unsustainable agricultural practices, including excessive groundwater extraction and widespread irrigation, have severely depleted Lake Urmia, one of the world's largest saltwater lakes [34,35]. In response, the Iranian government launched the ULRP in 2013, focusing on modifying agricultural practices to decrease water consumption [36]. While the program has stabilized water levels to some extent, concerns persist regarding long-term sustainability due to potential mismanagement in the agricultural sector [33].

Beside Lake Urmia lies the Mahabad Plain, which is located in northwest Iran (Figure 1). The region consists of 21 communities with approximately 10,000 farmers [37]. Agriculture is the primary economic activity, consuming over 90% of the region's water resources [38]. The 12,000 hectares of arable land are predominantly used for cultivating sugar beet, wheat, apples, and alfalfa, accounting for about 94% of the total cultivated area. Irrigation water is supplied by