Chapter 4
Neutrosophic Sets for Decision-Making in Natural Disasters and Environmental Recovery

Ajoy Kanti Das
http://orcid.org/0000-0002-9326-1677
Tripura University, India

Nandini Gupta
http://orcid.org/0009-0000-5450-9783
Bir Bikram Memorial College, India

Rajat Das
http://orcid.org/0009-0000-3355-3582
Tripura University, India

Carlos Granados
http://orcid.org/0000-0002-7754-1468
Universidad de Sucre, Colombia

Suman Das
National Institute of Technology, Agartala, India

ABSTRACT

Natural disasters and environmental crises involve complex decision-making under uncertainty, where traditional models struggle with incomplete or contradictory data. This chapter explores neutrosophic sets—a generalization of fuzzy logic that independently models truth (T), indeterminacy (I), and falsity (F)—as a robust

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framework for disaster response and recovery. We demonstrate its applications in flood risk assessment, wildfire management, and sustainable technology selection, highlighting how neutrosophic logic outperforms classical methods by quantifying ambiguity and conflicts. Case studies illustrate its integration with multi-criteria decision-making (MCDM) to optimize resource allocation and policy planning. Challenges like computational complexity and future directions for real-time systems and interdisciplinary adoption are discussed. Neutrosophic sets offer a transformative approach to resilience in an era of climate volatility, bridging advanced mathematics with practical crisis management.

INTRODUCTION

In recent decades, the frequency and severity of natural disasters—such as hurricanes, wildfires, and floods—have increased due to climate change and unsustainable development. Responding to these events requires rapid decision-making under extreme uncertainty. Decision-makers must consider multiple, often conflicting, pieces of information: sensor data, expert opinion, community needs, and environmental variables.

Traditional models struggle with the inherent indeterminacy of such data. Neutrosophic logic, an extension of the fuzzy set theory developed by Florentin Smarandache, incorporates truth (T), indeterminacy (I), and falsity (F) as independent components. This triad makes neutrosophic sets particularly useful for modeling real-world phenomena where truth is not binary and where contradictions or unknowns are integral to the system.

The complexity and uncertainty inherent in natural disasters and environmental recovery pose significant challenges for decision-makers. Traditional mathematical and computational models often struggle to accommodate the ambiguity, imprecision, and indeterminacy that characterize real-world disaster scenarios. To overcome these limitations, advanced frameworks grounded in soft computing have emerged, notably those based on fuzzy set theory introduced by Zadeh (1965), intuitionistic fuzzy sets developed by Atanassov (1986), and neutrosophic sets proposed by Smarandache (1998, 2005). These frameworks offer increasingly refined mechanisms to model uncertainty, particularly in dynamic and high-stakes environments such as disaster response and environmental management.

Neutrosophic sets, in particular, represent a powerful generalization of previous models by incorporating degrees of truth, indeterminacy, and falsity independently, thereby allowing more flexible and comprehensive representations of uncertain and incomplete information. (Smarandache, 1998, 2005). This unique capacity has spurred a wave of research leveraging neutrosophic theory in diverse decision-

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