Chapter 14
Cost Effective Sampling Techniques in Environmental Monitoring

Manzoor A. Khanday
https://orcid.org/0000-0002-0053-098X
Lovely Professional University, India

Trushal Hirani
https://orcid.org/0009-0008-4478-6179
Lovely Professional University, India

ABSTRACT

Environmental monitoring is vital for assessing ecosystem health and detecting pollution, but traditional methods often require extensive data collection, resulting in high costs. This study proposes a cost-effective sampling approach that compares SRS, stratified, cluster, and adaptive sampling techniques to optimize resource allocation without compromising data quality. The research uses the NLA 2022 dataset from the U.S. Environmental Protection Agency to reduce sampling costs while maintaining accurate water quality assessments. Key parameters such as geographical location, lake size, and urban/rural classification will be used to estimate travel, labor, and analysis costs. The methods used highlight the strengths of stratified sampling to ensure geographic coverage, cluster sampling to reduce travel costs, and adaptive sampling to focus on areas of higher environmental variability. This research provides a practical comparison for environmental agencies to implement more cost-effective monitoring strategies while maintaining high-quality data collection.

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1. INTRODUCTION

Recently, the face of sustainable development has become environmental sustainability. It matters for the protection of biodiversity, water security, and air quality, as well as for the continuing ecosystem. The three pillars of sustainability point to the need for balanced methodology in data collection that protects capital without jeopardizing economic efficiency. The chapter will address how environmental monitoring practices can be transformed to align with all three pillars. By implementing cost-effective sampling techniques, agencies can maximize the coverage and accuracy of ecological data while minimizing operational expenses. This supports economic sustainability by ensuring that monitoring programs are financially viable, while social sustainability is enhanced through ethical stewardship of ecosystems that serve both current and future generations. Cost-effective environmental monitoring thus provides a comprehensive approach to sustainability, reinforcing the importance of responsible and efficient use of resources particularly in large or remote areas where travel and sampling costs can quickly accumulate. Consequently, environmental agencies and policymakers are trying to find new ways of more cost-effective methods for gathering high-quality environmental data.

Traditional sampling methods in environmental science, such as stratified sampling, cluster sampling, and adaptive sampling, have long been used to guide data collection. Stratified sampling involves dividing a population into distinct subgroups to ensure different regions or categories are adequately represented, which is useful for capturing regional variability. Cluster sampling groups geographically proximate or similar sites, reducing travel distances and related costs. Adaptive sampling, which adjusts sampling intensity based on initial observations, allows for a more targeted data collection approach by focusing resources on areas with higher environmental variability.

This paper proposes and assesses a sampling design that explores elements of stratified, cluster, and adaptive sampling in order to achieve cost savings while ensuring the reliability of precision of estimates., making it a valuable tool for policymakers and environmental agencies. Ultimately, this sampling techniques aims to bridge the gap between comprehensive environmental monitoring and sustainable resource management, contributing to make better and more efficient choices and impactful environmental protection practices.