

Assessment of Surface Water Quality Using Indices and Methods: A SWOT-Based Integrated Approach
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INTRODUCTION & AIMS

Surface waters represent dynamic ecosystems whose quality fluctuates in both space and time under the influence of physical, chemical, and biological factors. Because no single metric can fully capture water health, multi-parameter tools are required. Among these, Water Quality Indices (WQIs) integrate complex datasets into a unified value to facilitate interpretation and communication across stakeholders.

This study aims to assess the performance and applicability of the most relevant water quality indicators commonly used to evaluate the ecological status and quality of surface water.

METHODS

The study employed an integrated methodological framework combining bibliometric analysis and a strengths, weaknesses, opportunities, threats (SWOT) based evaluation model.

Figure 1 summarizes the overall research process, while Figure 2 details the integrated SWOT framework used to assess the main water quality indices, such as: Water Quality Index (WQI), Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI), Oregon Water Quality Index (OWQI), Trophic State Index (TSI), and Heavy Metal Pollution Index (HPI) and complementary analytical tools such as multivariate statistics, biological assessment, ecological risk analysis, geographic information systems (GIS), remote sensing, and modelling.

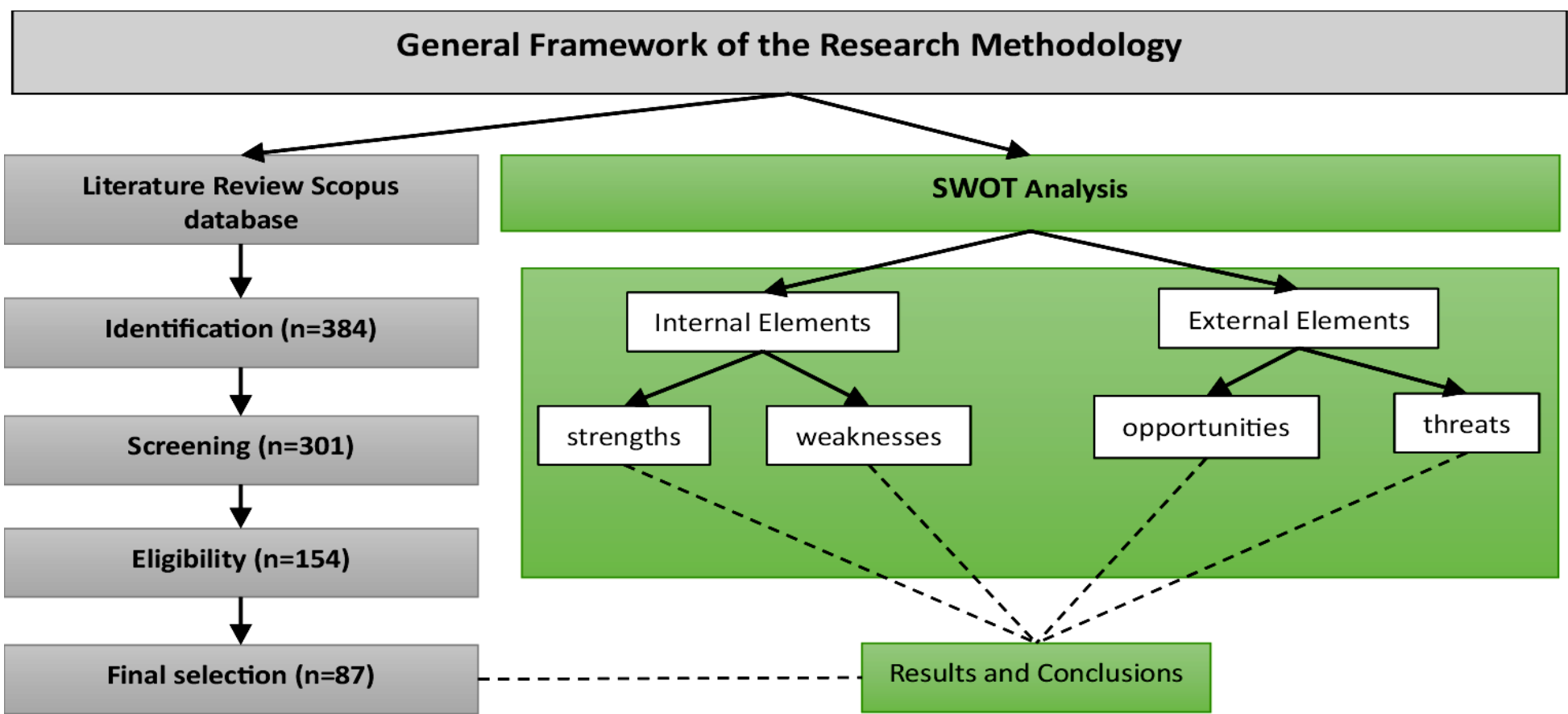


Figure 1. General Framework of the Research Methodology

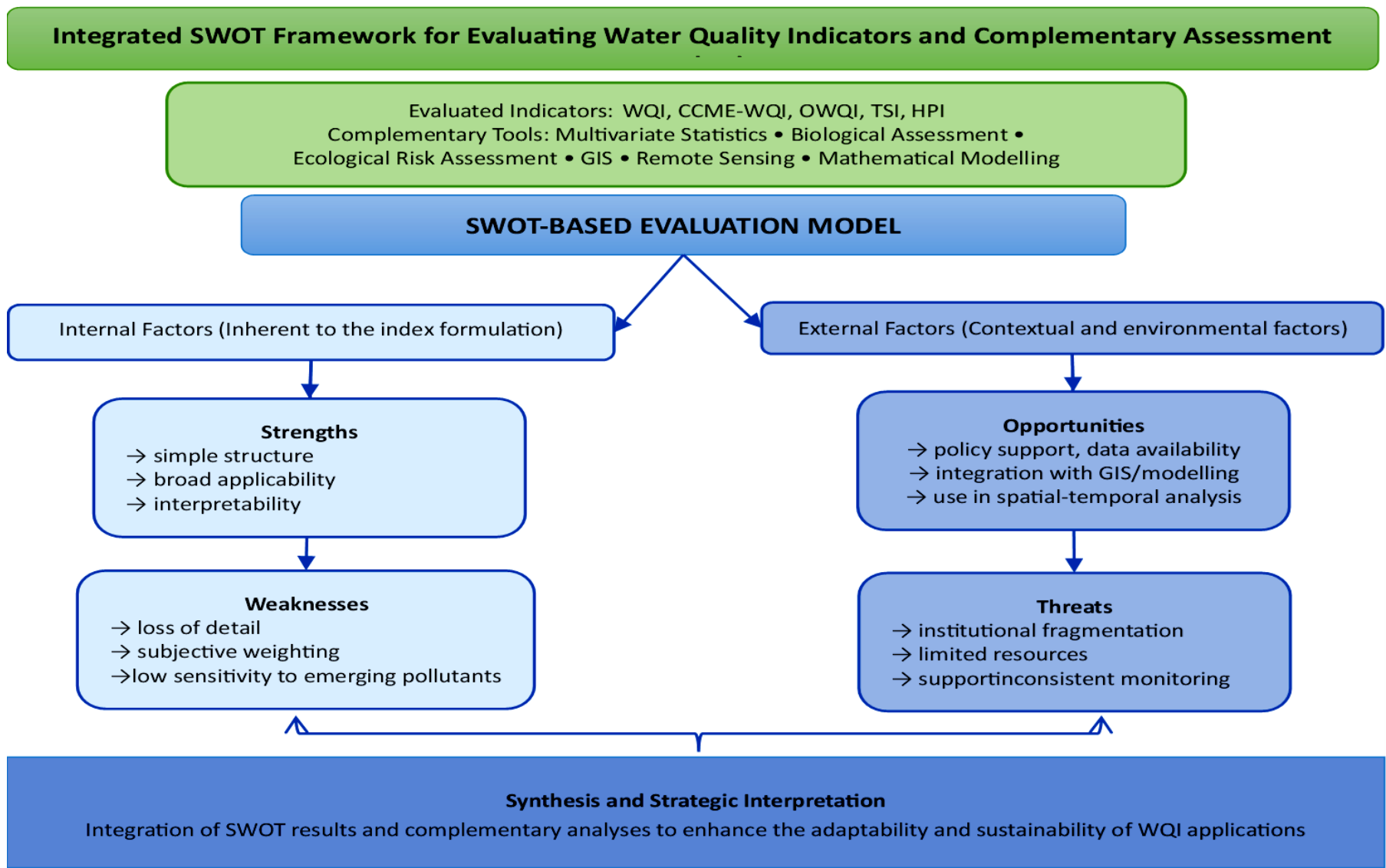


Figure 2. Integrated SWOT Framework for Evaluating Water Quality Indicators and Complementary Assessment Methods

RESULTS & DISCUSSION

Table 1 and Figure 3 summarize the SWOT analysis outcomes for the main water quality indices (WQI, CCME-WQI, OWQI, TSI, HPI) and complementary assessment methods. The results provide a comparative perspective on the strengths, weaknesses, opportunities, and threats influencing their applicability in surface water quality evaluation.

Table 1. Comparative SWOT framework of key surface water quality indices and their complementary assessment methods

Water Quality Index	SWOT Analysis			
	Strengths	Internal Weaknesses	External Opportunities	External Threats
Oregon Water Quality Index (OWQI)	Provides a simple and intuitive interpretation of water quality data. Effective for tracking spatio-temporal variations in surface waters.	Fixed parameter structure limits adaptability. Sensitive to missing data and seasonal fluctuations.	Integration with GIS and remote sensing improves regional-scale assessment.	Dependence on consistent monitoring networks and data quality.
Trophic Status Index (TSI)	Efficient indicator of eutrophication and nutrient loading in surface waters.	Limited to parameters such as chlorophyll-a, phosphorus, and Secchi depth. Fails to capture emerging pollutants.	Valuable for lake management and ecological modelling.	Less effective in rivers and transitional waters.
Canadian Council of Ministers' Water Quality Index (CCME-WQI)	Flexible weighting and scalable across spatial and temporal contexts. Broad international applicability. Quantifies heavy metal contamination efficiently. Useful for identifying toxic pollution sources.	Requires full datasets and expert judgement. Complex for small monitoring programs.	Suitable for integration with sustainability frameworks and SDG indicators.	Limited harmonization across national datasets.
Heavy Metal Pollution Index (HPI)		Excludes non-metal pollutants and biological impacts.	Can be combined with ecological risk and multivariate analysis to improve accuracy.	Limited by low monitoring frequency and lack of standardized thresholds

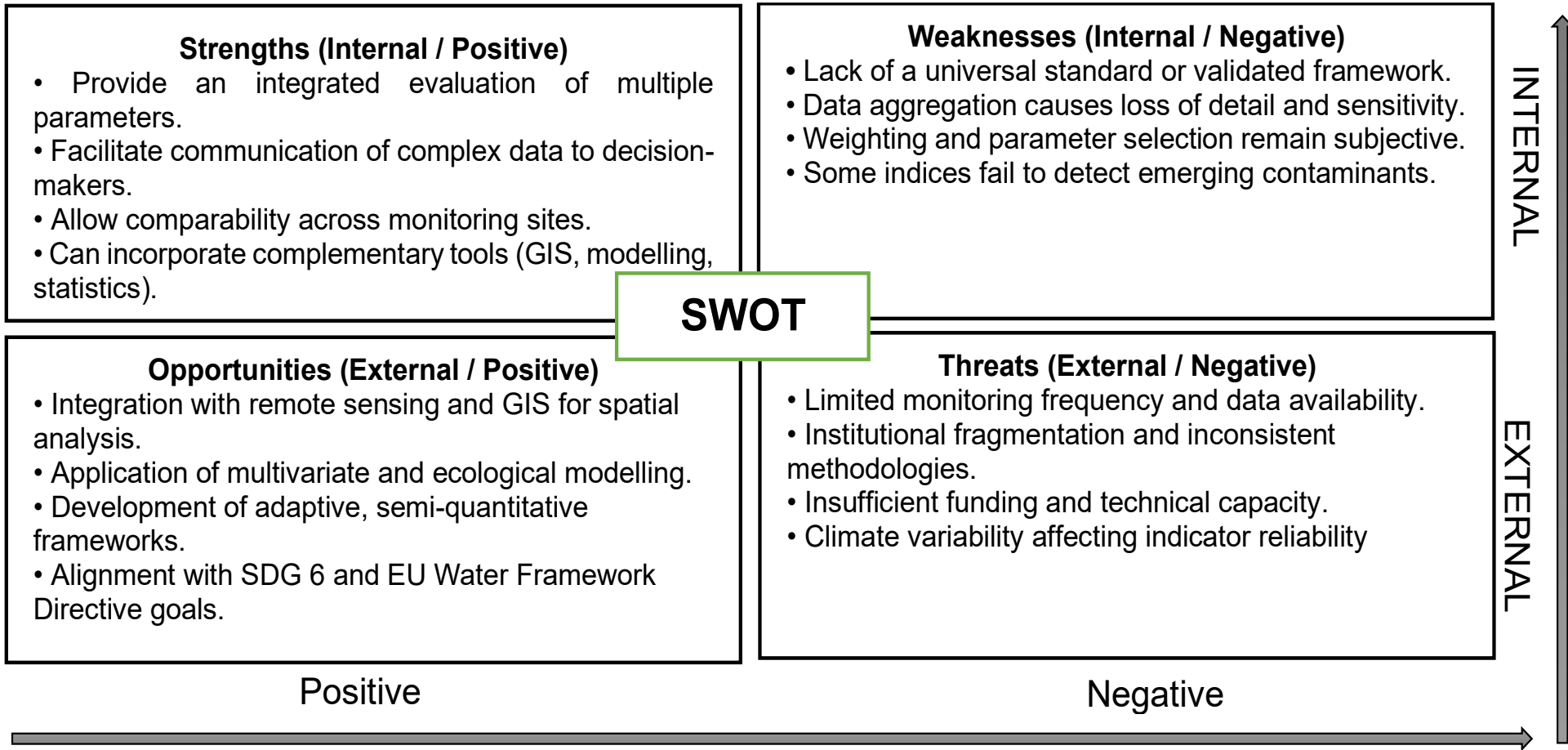


Figure 3. SWOT framework illustrating strengths, weaknesses, opportunities, and threats of water quality indicators and supporting analytical methods

CONCLUSIONS

→Some indices (WQI, TSI, HPI) show limitations related to rigidity, ambiguity, and low sensitivity to critical parameters.

→ The CCME-WQI proves more flexible and adaptable to diverse environmental contexts.

→ Objective, data-driven approaches can enhance the accuracy and robustness of index-based water quality assessments.

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