

**PCS 7: Elizabeth Marshall, Ganapati Patil, and James Shortle
 Prioritization and Ranking for Environmental Policy Using Indicators Resulting
 from Data Envelopment Analysis and Stochastic Frontier Analysis**

The National Academy of Engineering Report on Industrial Environmental Performance Metrics: Challenges and Opportunities (1999) recommends adoption of quantitative environmental goals and improvement of methods of ranking and prioritizing environmental impacts. It further suggests (p. 206) that efforts must be undertaken to develop an acceptable system for prioritizing the issues of greatest environmental concern.

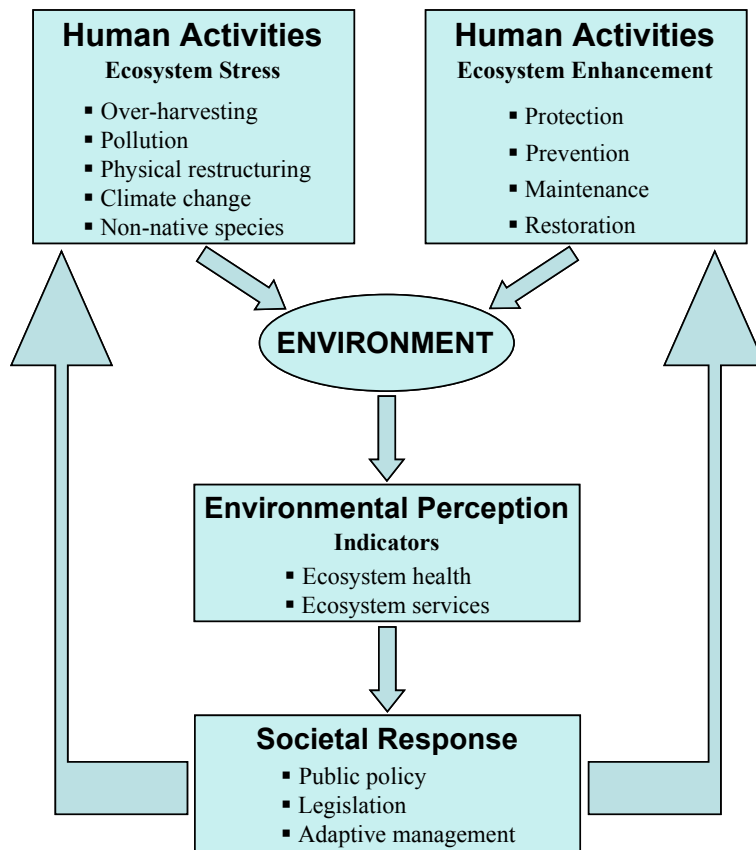
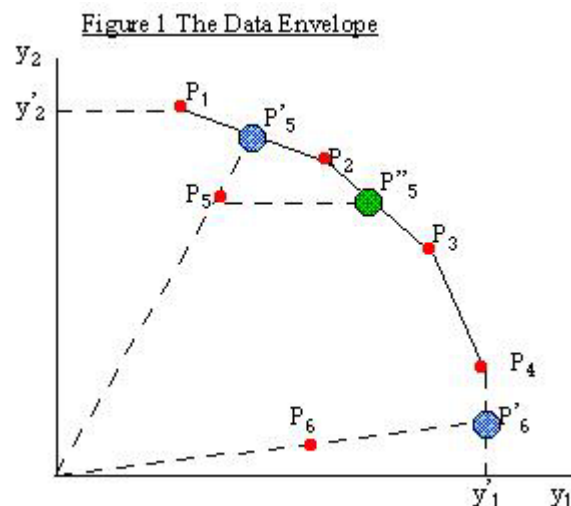


Figure 1. Focal areas of concern in the environment-human society feedback loop.

The methods of data envelopment analysis (DEA) and stochastic frontier analysis (SFA) have long been used in production economics to address issues of productivity and efficiency in the use of inputs and generation of outputs. These same methods are beginning to broaden their sphere of application to natural resource management and environmental policy, among others. We propose to apply these approaches to the measurement of quality of life as a policy product, and to the efficiency of different regions in producing that outcome. The concept of efficiency espoused in the frontiers approaches is fundamentally different than that arrived at through fully ordered sets in

that the frontiers assume that no single reference point for “efficiency” exists in the production of quality of life. Quality of life can be explored along many dimensions, including social, economic and environmental. This approach acknowledges that there may be implicit tradeoffs necessary in the pursuit of QOL measures (between, for instance, maximization of economic opportunity and maximization of environmental quality) and that regions may choose to go in different directions in determining how they will pursue QOL.

In production economics, DEA is a non-parametric approach to relative efficiency measurement in the presence of multiple incommensurate inputs and outputs. Using linear programming methods to measure the relative performance of organized units, DEA provides an efficiency measure for each decision-making unit that does not rely on the application of a common, and often arbitrary, weighting of the inputs and outputs. Additionally, the method identifies peer units and targets for inefficient units that illustrate which inputs are being used inefficiently, relative to similar units, and to what extent such inputs or outputs should be adjusted in order to achieve a level of efficiency comparable to that of the peer units.



Stochastic frontier analysis, on the other hand, is a parametric approach to frontier generation. The stochastic nature of the analysis permits the separation of stochastic noise from true differences in efficiency production. This analysis also estimates an efficiency frontier and measures the position of units relative to this frontier. Like DEA, SFA also identifies particular changes in input or output combination that will allow a decision-making unit to achieve maximum efficiency. It is possible using both methods to differentiate between environmental inputs and other inputs in measuring relative efficiency, and therefore to identify for particular decision-making units how environmental inputs must be adjusted to achieve efficient production of overall quality of life.

In an effort to develop an acceptable system for prioritizing environmental issues, we propose to compare QOL rankings based on SFA, DEA, and poset prioritization, and in

particular to explore the role of environmental indicators in generating those rankings. In partnership with the Atlantic Slope Consortium (2001) of the EPA STAR Program, we will identify watersheds and counties within the Atlantic Slope region to prioritize according to suitable quality of life indicators along multiple dimensions—social, economic, and environmental—and we will explore in particular the role that environmental indicators play in determining a region’s relative efficiency in generating quality of life for its residents.

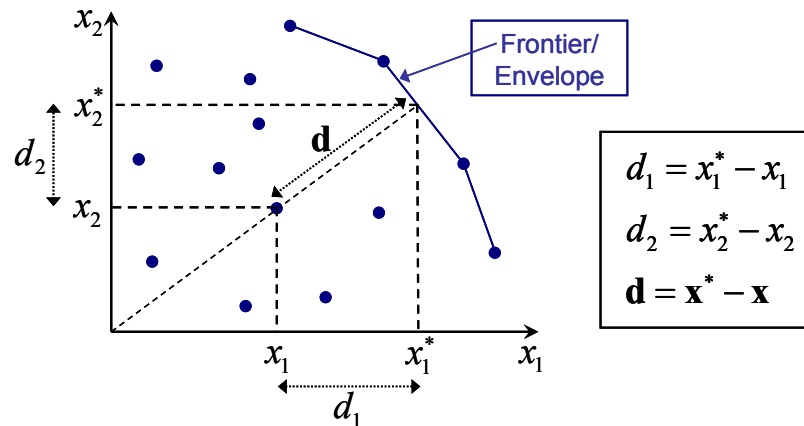


Figure 2. Scatter plot in a two-dimensional indicator space. The frontier or envelope determines optimality in particular directions while the shortfall or degree of sub-optimality is the distance to the frontier.

In an effort to develop an acceptable system for prioritizing as sought for in the NAE/NRC report, we plan to apply the project-proposed poset prioritization tool to the data matrix given by the DEA-produced performance indicator components of the performance/inefficiency vector in conjunction with the SFA-produced differential weights for the performance indicator components. A typical data matrix (for two indicators) is shown in Figure 3. We will identify suitable watersheds and counties to prioritize and rank in light of suitable quality of life indicators measured on the watersheds and counties of Atlantic Slope Consortium (2001) of EPA STAR Program.

Typical Data Matrix

Entity	Original Indicators		Shortfall Values		
	x_1	x_2	d_1	d_2	\mathbf{d}
1					
2					
.					
.					
.					

Figure 3. A typical data matrix for application of the prioritization tools in the study. In general, there would be more than two indicators.

References

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