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Response to Bossel. 2001. "Assessing Viability and Sustainability: a Systems-based Approach for Deriving Comprehensive Indicator Sets"

Integrating Methods for Developing Sustainability Indicators to Facilitate Learning and Action

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ABSTRACT. Bossel's (2001) systems-based approach for deriving comprehensive indicator sets provides one of the most holistic frameworks for developing sustainability indicators. It ensures that indicators cover all important aspects of system viability, performance, and sustainability, and recognizes that a system cannot be assessed in isolation from the systems upon which it depends and which in turn depend upon it. In this reply, we show how Bossel's approach is part of a wider convergence toward integrating participatory and reductionist approaches to measure progress toward sustainable development. However, we also show that further integration of these approaches may be able to improve the accuracy and reliability of indicators to better stimulate community learning and action. Only through active community involvement can indicators facilitate progress toward sustainable development goals. To engage communities effectively in the application of indicators, these communities must be actively involved in developing, and even in proposing, indicators. The accuracy, reliability, and sensitivity of the indicators derived from local communities can be ensured through an iterative process of empirical and community evaluation. Communities are unlikely to invest in measuring sustainability indicators unless monitoring provides immediate and clear benefits. However, in the context of goals, targets, and/or baselines, sustainability indicators can more effectively contribute to a process of development that matches local priorities and engages the interests of local people.

Key Words: *sustainability Indicators; community empowerment; stakeholders; local participation*

INTRODUCTION

Bossel's (2001) systems-based approach for deriving comprehensive indicator sets, published in this journal, provides one of the most holistic and rationalized frameworks for developing sustainability indicators. Unlike many other approaches, it ensures that indicators cover all important aspects of system viability, performance, and sustainability, which are defined a priori, and recognizes that a system cannot be assessed in isolation from the systems upon which it depends, and which in turn depend upon it. The result is a framework of indicators that represent seven "orientors,&#8221 namely, extistence, effectiveness, freedom of action, security, adaptability, coexistence, and psychological needs. These orientors are grouped into three subsystems identified as human, support, and natural. To determine the sustainability of each subsystem and its respective contribution to the total system requires 7 x 3 x 2 = 42 indicators. The advantage of Bossel's approach is, as the author himself points out, avoidance of the " ... arbitrariness implicit in current and proposed indicator sets. It turns the focus from an uncertain ad hoc search and bargaining process to a much more systematic procedure with a clear goal: to find indicators that represent all the important aspects of viability, sustainability, and performance."

Of course, even within such a structured framework there is scope for variation in the selection of

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specific indicators. For any given system it is possible to arrive at many indicators for each of the orientors, and some subjectivity is inevitable. Bossel addresses this by setting out a set of guidelines or rules for the selection of indicators, including the "weakest-link" or limiting-factor approach.

In the article, Bossel also identifies the need for the participation of user communities in the selection of indicators, but this takes place within the limits created by the framework. Since the publication of Bossel's paper, a number of key papers and books have been added to the literature (e.g., Riley 2001, Bell and Morse, 2002, 2004, Gunderson and Holling 2002, Reed and Dougill 2002) that stress the importance of participation. There is also a long history of participation within the broader development community stemming not just from a desire to 'do' development faster, cheaper, or more effectively, but also from concerns about the ethics of human justice and dignity. People should be involved as a matter of fundamental right in processes that affect their lives and well-being. In addition, the notion of community participation has been further entrenched in policy through the Johannesburg Declaration and a number of United Nations conventions.

Still, how far can we go in matching structured indicator frameworks such as Bossel's with this desire to involve people? How much bargaining over what to include is allowed here? What compromises have to be made, how, and by whom? This brings us back to a common issue in sustainability: where do borders or boundaries reside? In practical terms, boundaries are typically lines on a map, but there are many others, including Bossel's conceptual system boundaries between the human, support, and natural subsystems. There is another boundary between "top down" or expert-driven and "bottom up" or participatory systems. As a result, we think it is relevant and timely to revisit Bossel's important article and situate it within a wider debate on the role of scientific and local knowledge in developing indicators of sustainable development.

THE NEED FOR FURTHER INTEGRATION OF METHODOLOGICAL APPROACHES

The literature on developing sustainability indicators falls into two broad methodological paradigms (Bell and Morse 2001): reductionist and participatory. Reductionist frameworks such as that of Bossel tend toward the expert-led development of universally applicable indicators. They acknowledge the need for indicators to quantify the complexities of system dynamics, but do not necessarily emphasize the complex variety of resource-user perspectives. The second paradigm is based on a bottom-up, participatory philosophy. Scholars in this tradition focus on the importance of understanding local context and contest the way in which experts set goals and establish priorities. They insist that sustainability monitoring should be an ongoing learning process for both communities and researchers (Freebairn and King 2003) and that for this reason the process of developing indicators can be as important as their application (Innes and Booher 1999). At one extreme, there is the abandonment of any structure or limits in choice in order to explore richness and create a blank canvas for learning to occur.

The interdisciplinary demands of working with people in their socioeconomic and environmental contexts have led many researchers from the participatory paradigm to a combination of the qualitative and the quantitative methods. Even in supposedly "blank sheet" participatory approaches, people will bring their existing knowledge and biases to the table, and this may well include previous exposure to and knowledge of sustainability indicator sets. Also, although participatory approaches can generate cross-fertilization of ideas and insights, there may well be a need to temper some of the resulting indicators in the light of "expert-led" technical knowledge. Almost inevitably, there is an increasing cross-fertilization of ideas from participatory and reductionist approaches.

Table 1 shows how a number of methodological frameworks can be classified according to their roots in participatory or reductionist approaches. However, recent applications of these frameworks show increasing convergence. For example, researchers and policy makers applying the OECD's (1993) pressure-state-response family of frameworks typically identify stakeholders only to understand the source of human pressures on the environment (e.g., Christesen 2002). However, there are an increasing number of examples in which this framework has been applied in close collaboration with stakeholders (e.g., Kammerbauer et al. 2001, La Jeunesse et al. 2003). The single word

"participation" has many guises, and there are old echoes here stretching back to Sherry Arnstein's (1969) classic Ladder of Participation and progressing through more recent analyses of participation as the practical realization of postmodernism in development (Sellamna 1999). Arnstein's ladder is a spectrum that ranges from top-down control at one end to citizen action at the other. In any given indicator project, the location along the ladder, i.e., the balance between top-down and bottom-up, will reside at a location influenced by many factors, including who funds the project, the availability of resources, the time scale for outputs to be achieved, the desires and wishes of those involved, commitment, and so on. Indeed, in any one project, the location along the ladder can change. People may have no voice at the start or inception or at the end, i.e., evaluation, but be heavily involved in the middle. Also, different stakeholders will have different perspectives as to where the indicator project exists along the ladder. Some will see it more toward the bottom; others, toward the top.

Bossel's work traced a similar trajectory that resulted in the increasing involvement of user communities in the identification and application of sustainability indicators. This convergence has the potential to enhance the overall understanding of environmental and social problems, facilitate community empowerment, and guide policy decision making and community development. To deliver these benefits effectively, indicators must be relevant to local people, and the methods used to collect, interpret, and display data must be easily and effectively used by nonspecialists. However, they must also provide accurate, reliable, and sensitive information. This can cause tensions, because, although the scientifically rigorous indicators used in the reductionist paradigm may be objective, they may also be difficult to use and impose constraints at odds with the complex and diverse lives that people lead. In some ways, therefore, objectivity may come at the expense of usability (Breckenridge et al. 1995, Deutsch et al. 2003). Similarly, although participatory frameworks tend to be easy to use, indicators have been criticized for not being objective enough (Lingayah and Sommer 2001, Freebairn and King 2003).

Although this may seem like an insurmountable divide, preliminary evidence suggests that it may not be all that difficult to bridge. In regions in which expert- and community-selected indicators have been compared, it seems that there is a great deal of overlap between expert-led and community approaches (Stocking and Murnaghan 2001). For example, in our research experience, both farmers and scientific experts in the Kalahari (Botswana) independently selected rain-use efficiency as a key indicator of rangeland degradation (Reed and Dougill 2003). There were differences in how scientists and farmers measured rain-use intensity in that the method used by researchers required extensive training and equipment, whereas farmers used a simplified method based on assessing the vigor of plant growth after a rain event. More widely, Reed and Dougill (2003) then tested the validity of all the indicators elicited from the community. There was an empirical basis for the majority of the indicators tested. Indicators that could not be supported empirically were discussed in focus groups that pointed out methodological flaws in the scientific work, e.g., the timing of field work in relation to the seasonality of some indicators. Although empirical research validated most of the community indicators, it was possible to reject indicators that were insufficiently accurate, reliable, or sensitive, and give priority to the most useful indicators. By combining Bossel's approach with empirical and community evaluation, it proved possible to select indicators that adequately represented the total system and its essential component systems, and that could be used accurately and reliably by local users.

The capacity for Bossel's approach to facilitate learning and action among users may also be limited unless clear goals with corresponding targets and/or baselines are established. Although Bossel's orientors are a useful guide for selecting appropriate indicators, they may not adequately reflect perceived local needs and objectives. Also, an apparently rigid framework such as this, even if intended to aid progress to a goal, can be taken as a given and not questioned by those involved. Their task then becomes how to fit indicators into the categories rather than consider the categories themselves as mutable and open to question. Learning is not just about the imbibing of valued knowledge from an expert; it is also about being able to question and reason for oneself.

It is clear that communities are unlikely to invest in collecting data on sustainability indicators unless monitoring provides immediate and clear benefits that they can see and feel (Freebairn and King 2003).

Table 1. Selected methodological frameworks for developing and applying sustainability indicators showing their roots in participatory or reductionist approaches.

Selected examples	Brief description	Key reference
	Participatory	
Soft systems analysis	Builds on systems thinking (von Bertalanffy 1968) and experiential learning (Kolb 1984) to develop indicators as part of a participatory learning process to enhance sustainability with stakeholders	Checkland (1981)
Sustainable livelihoods analysis	Develops indicators of livelihood sustainability that can monitor changes in natural, physical, human, social, and financial capital based on entitlements theory	Scoones (1998), Carney (1998)
Classification hierarchy framework	Identifies indicators by incrementally increasing the resolution of the system component being assessed, e.g., element = soil, property = productivity, descriptor = soil fertility, indicator = % organic matter	Bellows (1995)
The Natural Step	Develops indicators to represent four conditions for a sustainable society to identify sustainability problems, visions, and strategies	Holmberg et al. (1996), TNS (2004)
	Reductionist	
Panarchy theory and adaptive management	Uses three broad categories of indicators to identify where complex systems exist on an adaptive cycle. Based on a model that assesses how ecosystems respond to disturbance, the panarchy framework suggests that key indicators fall into one of three categories: wealth, connectivity, diversity. Wealthy, connected, and simple systems are the most vulnerable to disturbances, which may cause them to collapse, releasing wealth, and revert to a more diverse and less connected state	Gunderson and Holling (2002)
Pressure-state-response (PSR, DSR, and DPSIR)	Identifies environmental indicators based on human pressures on the environment, the environmental states this leads to, and societal responses to change for a series of environmental themes. Later versions replaced pressure with driving forces, which can be both positive and negative, unlike pressures that are negative (DSR) and included environmental impacts (DPSIR)	OECD (1993), Gallopín (1997), EEA (1998)
Framework for evaluating sustainable land management	A systematic procedure for developing indicators and thresholds of sustainability to maintain environmental, economic, and social opportunities for present and future generations while maintaining and enhancing the quality of the land	J. Dumanski, H. Eswaran, and C. A. King (*unpublished manuscript*)
Well-being assessment	Uses four indexes to measure human and ecosystem well-being: a human well-being index, an ecosystem well-being index, a combined ecosystem and human well-being index, and a fourth index quantifying the impact of improvements in human well-being on ecosystem health. The first two indices consist of a suite of indicators that are rated to give performance scores that are plotted as coordinates on a two-dimensional scale to yield a visual representation called a 'barometer of sustainability,	Prescott-Allen (2001), CIT (2002)
Thematic indicator development	Identifies indicators in each of the following sectors or themes: environmental, economic, social, and institutional, often subdividing these into policy issues	UNCSD (2001)

By linking indicators to community visions and goals, potentially in response to different future scenarios, communities are more likely to become actively engaged in the development and application of indicators. Goals may be articulated as targets or simply the desire to move in a particular direction in relation to a baseline or reference condition. Local involvement can also ensure that indicators are dynamic, evolving over time as goals are met or circumstances change (Carruthers and Tinning 2003). In the context of goals, targets, and/or baselines, sustainability indicators can more effectively contribute to a process of development that matches local priorities and engages the interests of local people.

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LITERATURE CITED

Arnstein, S. R.1969. A ladder of citizen participation. *Journal of the American Planning Association* **35**:216-224.

Bell, S., and S. Morse. 2001. Breaking through the glass ceiling: who really cares about sustainability indicators? *Local Environment* **6**:291-309.

Bell, S., and S. Morse. 2002. *Measuring sustainability; learning by doing.* Earthscan, London, UK.

Bellows, B. C. 1995. Principles and practices for implementing participatory and intersectoral assessments of indicators of sustainability: outputs from the workshop sessions. Page 243-268 *in Proceedings of the SANREM CRSP Conference on Indicators of Sustainability.* Research Report 1/95. Sustainable Agriculture and Natural Resource Management, Collaborative Research Support Program, Athens, Georgia, USA.

Bossel, H. 2001. Assessing viability and sustainability: a systems-based approach for deriving comprehensive indicator sets. *Conservation Ecology* **5:**12. (online) URL: http://www.ecologyandsociety.org/vol5/iss2/art12/ .

Breckenridge, R. P., W. G. Kepner, and D. A. Mouat.1995. A process for selecting indicators for monitoring conditions of rangeland health. *Environmental Monitoring and Assessment* **36**:45-60.

Carney, D., editor. 1998. *Sustainable rural livelihoods: what contribution can we make?* Department for International Development, London, UK.

Carruthers, G., and G. Tinning. 2003. Where, and how, do monitoring and sustainability indicators fit into environmental management systems? *Australian Journal of Experimental Agriculture* **43**:307-323.

Checkland, P. 1981. *Systems thinking, systems practice.* John Wiley, Chichester, UK.

Christesen, L. 2002. Dairy farming and river condition: investigating the sustainable use of water resources in an agricultural area. *Water Science and Technology* **45**:21-28.

Coast Information Team (CIT). 2002. *Analyses: wellbeing assessment.* CIT Secretariat, Victoria, British Columbia, Canada.

Deutsch, L., C. Folke, and K. Skanberg. 2003. The critical natural capital of ecosystem performance as insurance for human well-being. *Ecological Economics* **44**:205-217.

European Environment Agency (EEA). 1998. *Identification of indicators for a transport and environment reporting system; final report.* Office for Official Publications of the European Communities, Brussels, Belgium.

Freebairn, D. M., and C. A. King. 2003. Reflections on collectively working toward sustainability: indicators for indicators! *Australian Journal of Experimental Agriculture* **43**:223-238.

Gallopín, G. 1997. Indicators and their use: information for decision making. Pages 13-27 *in* B. Moldan and S. Billharz, editors. *Sustainability indicators: report on the Project on Indicators of Sustainable Development.* John Wiley, Chichester, UK.

Gunderson, L., and C. S. Holling. 2002. *Panarchy: understanding transformations in human and natural systems.* Island Press, Washington, D.C., USA.

Holmberg, J., K. H. Robèrt, and K. E. Eriksson.

1996. Socio-ecological principles for sustainability. Pages 17-48 in R. Costanze, S. Olman, and J. Martinez-Alier, editors. *Getting down to earth: practical applications of ecological economics.* Island Press, Washington, D.C., USA.

Innes, J. E., and D. E. Booher. 1999. *Indicators for sustainable communities: a strategy building on complexity theory and distributed intelligence.* Institute of Urban and Regional Development Working Paper 99-04. University of California, Berkeley, California, USA.

Kammerbauer, J., B. Cordoba, R. Escolan, S. Flores, V. Ramirez, and J. Zeledon. 2001. Identification of development indicators in tropical mountainous regions and some implications for natural resource policy designs: an integrated community case study. *Ecological Economics* **36**:45-60.

Kolb, D. A. 1984. *Experiential learning: experience as the source of learning and development.* Prentice-Hall, Englewood Cliffs, New Jersey, USA.

La Jeunesse, I., M. Rounsevell, and M. Vanclooster. 2003. Delivering a decision support system tool to a river contract: a way to implement the participatory approach principle at the catchment scale? *Physics and Chemistry of the Earth* **28**:547-554.

Lingayah, S., and F. Sommer. 2001. *Communities count: the LITMUS Test.* New Economics Foundation, London, UK.

Organisation for Economic Co-operation and Development (OECD). 1993. *OECD core set of indicators for environmental performance reviews: a synthesis report by the Group on the State of the Environment.* OECD, Paris, France.

Prescott-Allen, R. 2001. *The wellbeing of nations: a country-by country index of quality of life and the environment.* Island Press, Washington, D.C., USA.

Reed, M. S., and A. J. Dougill. 2002. Participatory selection process for indicators of rangeland condition in the Kalahari. *Geographical Journal* **168**:224-234.

Reed, M. S., and A. J. Dougill. 2003. *Facilitating grass-roots sustainable development through sustainability indicators: a Kalahari case study.* Available online at : http://www.env.leeds.ac.uk/~mreed/Reed%202003b.doc.

Riley, J. 2001. Multidisciplinary indicators of impact and change: key issues for identification and summary. *Agriculture, Ecosystems & Environment* **87**:245-259.

Scoones, I. 1998. *Sustainable rural livelihoods: a framework for analysis.* IDS Working Paper 72. Institute of Development Studies, Brighton, UK.

Sellamna, N. E. 1999. *Relativism in agricultural research and development: is participation a post-modern concept?* ODI Working Paper 119. Overseas Development Institute, London, UK.

Stocking, M. A., and N. Murnaghan. 2001. *Handbook for the field assessment of land degradation.* Earthscan, London, UK.

The Natural Step (TNS). 2004. *The Natural Step.* Available online at: http://www.naturalstep.org/.

United Nations Commission on Sustainable Development (UNCSD). 2001. *Indicators of sustainable development: framework and methodologies.* Background Paper Number 3. United Nations, New York, New York, USA.

von Bertalanffy, K. L. 1968. *General system theory: foundations, development, applications.* Braziller, New York, New York, USA.