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Valuation for Sustainable Development – The Role of Multicriteria Evaluation

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Summary: Multicriteria methods were found to be useful tools to support decision-making about complex situations – such as those concerned with sustainable development issues – and to deal with conflicts in a structured and transparent way. Increasingly multicriteria evaluation (MCE) is also seen as a constructive response to the critique of cost-benefit analysis. MCE enables decision-makers to take multiple dimensions of impacts of the considered projects into account without the need for full monetarisation. A great number of multicriteria algorithms are now available. The algorithms differ in fundamental ways. Besides the algorithms also the implementation of the valuation technique is important for the outcome. In order to address issues like uncertainty, multiple legitimate perspectives and the need for learning during the decision process, ecological economists apply MCE mostly by combining the analytical tool with participatory techniques.

Zusammenfassung: Multikriterienmethoden erweisen sich als nützlich, um die Entscheidungsfindung in komplexen Situationen – wie solche eine nachhaltige Entwicklung betreffend – zu unterstützen und um mit Konflikten in einer strukturierten und transparenten Art umzugehen. Zunehmend wird multikriterielle Bewertung auch als konstruktive Antwort auf die Kritik der Kosten-Nutzen-Analyse gesehen. Die multikriterielle Bewertung ermöglicht es EntscheidungsträgerInnen, die verschiedenen Dimensionen der Auswirkungen der zur Auswahl stehenden Projekte zu berücksichtigen, ohne diese gänzlich monetarisieren zu müssen. Eine Vielzahl von grundlegend verschiedenen mathematischen Algorithmen für die multikriterielle Bewertung steht zur Verfügung. Außer dem Algorithmus beeinflusst auch die Implementierung der Bewertungsmethode das Ergebnis. Um Probleme wie Unsicherheit, unterschiedliche legitime Problemsichtweisen und die Notwendigkeit von Lernen während des Entscheidungsprozesses zu adressieren, setzen ökologische ÖkonomInnen multikriterielle Bewertung vor allem in Kombination mit partizipativen Methoden ein.

1 Introduction

The method chosen for including environmental resources and ecosystem services in decision processes determines how far they are taken into account with results affecting the quality of our lives and those of future generations. A persistent argument has been that monetary valuation is essential if complex environmental and social systems are to be included in government and business decisions on sustainable development. Environmental cost-benefit analysis was developed by environmental economists in order to achieve the monetarization of environmental entities so that the prices in market economies might be adjusted. A range of methods were developed including travel cost, hedonic pricing, pro-

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duction function analysis, contingent valuation and choice modelling (Hanley and Spash 1993). The cost-benefit approach has met with some success in that various national and international agencies have commissioned monetary valuation studies as part of their overall assessment of projects. However, there has also been criticism of environmental cost-benefit analysis. Critiques can be broadly grouped into those concerned with the theoretical foundations of economic values, and those looking at the validity of specific numbers being produced and the tools employed (Spash et al. 2004).

An alternative method of valuation, which is increasingly used in the context of sustainable development, is multicriteria evaluation (MCE). It also aims to account for the various dimensions of effects of different projects, such as environmental, social and economic impacts. However, here the impacts in the various dimensions can be measured in different units, i.e. monetarization of all impacts is no longer necessary. This way not so strong assumptions about the commensurability and comparability of values are necessary, compared to cost-benefit analysis (Martinez-Alier et al. 1998 and 1999).

This paper highlights the benefits of MCE for environmental valuation, which are

a) avoidance of need for full monetarisation and
b) potential for being combined with participatory processes.

It starts in section two with reviewing the most widely used MCE methods and grouping them. Section three lays out the main assumptions of ecological economic analysis and discusses the consequences for environmental valuation, or more specifically for the application of MCE methods. The paper concludes by arguing that it is not only the method (CBA or MCE), which matters, but equally important is how the method is implemented.

2 Multicriteria Evaluation Methods

Multicriteria methods were found to be useful for their ability to address problems marked by: (a) various conflicting evaluations (Nijkamp et al. 1991, Beinat and Nijkamp 1998, Janssen and Munda 1999); and (b) to deal with incommensurable values (Munda et al. 1995, O'Neill 1997, Martinez-Alier et al. 1998).

In general a multicriteria problem (with a discrete number of alternatives) may be described as follows: A is a finite set of n feasible actions (or alternatives); m is the number of different points of view or evaluation criteria $f_i (i = 1, 2, \ldots, m)$ considered relevant in a decision problem, where the action a is evaluated to be better than action b (both belonging to the set A) according to the i-th point of view if $f_i(a) > f_i(b)$. In this way a decision problem may be represented in a tabular or matrix form. Given the sets A (of alternatives) and G (of evaluation criteria) and assuming the existence of n alternatives and m criteria, it is possible to build an $n \times m$ matrix P called evaluation or impact matrix whose typical element $p_{ij} (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n)$ represents the evaluation of the j-th alternative by means of the i-th criterion (Janssen and Munda 1999: 837).

Many multicriteria methods also have decision makers assign weights to the different criteria. They can be interpreted either as "scaling factors" (weights as conversion factors) or "coefficients of importance" (weights as measures of relative importance of criteria); in case of non-compensatory methods[1] the intercriteria information required is a relation of relative importance between coalitions of criteria (Munda 1993). For example, the weights capture how important the environmental criteria are for decision-makers in relation to the social criteria. They also capture how important one environmental or social criterion is compared to another environmental or social one.

Utility-Based Multicriteria Algorithms

The algorithms in the group of utility-based multicriteria algorithms enable the user to define actions by an index and to evaluate it with variable weights in a comprehensive manner. Examples include MAUT (Multiple Attribute Utility Theory), MAVT (Multi Attribute Value Theory), SMART (Simple Multi Attribute Rating Technique), SWING, Compromise and Composite Programming. Most prominently MAUT was developed by Keeney and Raiffa (1976) and is based on the usual concepts of rational decision-making and utility theory. The actions are evaluated by non-negative weights g_i (normally positive with a sum of 1 or 100), die evaluation of impacts a_i (e.g. emissions, costs, biodiversity index) of the i-th attribute of action a with a value function $u_i(a_i)$, which (for all i) represents utility or dis-utility and (in the standard version of multiattribute value theory) the summary of these evaluations to the weighted sum

$$U(a) = \sum_i g_i * u_i(a_i).$$

This index is an overall evaluation of the extent of goal achievement of action x, which is based on the relative importance of the different goals.

Being based on utility theory and rational expectations, these algorithms are subject to the same criticism as the theories on which they are built. Initially these MCE algorithms were applied for production planning and financial portfolio choices and geared towards individual decision-makers.

Outranking Algorithms

In parallel to the development of the algorithms described above Roy (1974) and Brans (1986) developed MCE algorithms which are based on weaker assumptions than utility-based multicriteria algorithms (e.g. no additive utility function necessary) and less information is required from decision makers (preference intensities, substitution rates). Examples include ELECTRE I, IS, II, III, IV, TRI (wherey ELECTRE stands for *El*imination *e*t *C*hoix *T*raduisant la *R*éalité) PROMETHEE I, II (*P*reference *R*anking *O*rganization *Meth*od for *E*nrichment *E*valuations). The aim is not so much to identify an optimal solution but rather to facilitate the identification of compromise solutions in a transparent and fair way. For example, PROMETHEE is a widely used multicriteria evaluation method (Brans et al. 1986). With this algorithm alternatives are compared in pairs for each criterion. The preference is

1 An aggregation convention is non-compensatory, if no trade-off occurs. It represents a lexicographic decision rule (Fishburn 1974).

expressed by a number in the interval [0; 1] (0 for no preference or indifference to 1 for strict preference). A multicriteria preference index is formed for each pair of alternatives as a weighted average of the corresponding preferences computed in the last step for each criterion. The index $\Pi(a, b)$ (in the interval [0; 1]) expresses the preference of action *a* over action *b* considering all criteria. The weighting factors express the relative importance of each criterion. Alternative actions can be ranked by a positive or a negative flow.

1. The sum of indices $\Pi(a, i)$ indicating preference of action a over all the other actions. It is termed "leaving flow" $\phi^{+}(a)$ and shows how "good" alternative *a* is. The alternative with the higher leaving flow is superior.

2. The sum of indices $\Pi(i, a)$ indicating preference of all other actions compared to *a*. It is termed "entering flow" $\phi^{-}(a)$ and shows how much alternative *a* is inferior.

The action with the lower entering flow is superior. According to PROMETHEE I, alternative *a* is superior to alternative *b* if the leaving flow of *a* is greater than the leaving flow of *b* and the entering flow of *a* is smaller than the entering flow if *b*. *a* outranks *b* if : $\phi^{+}(a) \geq \phi^{+}(b)$ and $\phi^{-}(a) \leq \phi^{-}(b)$. Equality in ϕ^{+} and ϕ^{-} indicates indifference between the two compared alternatives. In the case where the leaving flows indicate that *a* is better than *b*, while the entering flows indicate the reverse the two actions are considered incomparable. PROMETHEE II uses the net flow (the difference of leaving minus entering flows), which permits a complete ranking of all actions.

More recently Munda (1995) developled an outranking method which is extended by fuzzy numbers[2] (to address uncertainty) and by linguistic variables (to allow for qualitative impact assessments).

While MCE methods enable us to overcome the difficulties caused by the monetarization of impacts on environmental resources and ecosystem services, there are other issues, which also need to be considered in sustainability-related decision-making.

3 Challenges for Knowing and Understanding

Mounting knowledge of what influences the changes of nature and societies has brought us the insight that in the end we will not know everything. We have to learn to live in a complex world with high uncertainties and unclear future. How to make "good" decisions under these circumstances? This is the key challenge.

Ecological economists have understood that substantial advances in our understanding of how natural and social systems interact over long time periods and along the spatial scale, need to be substantiated by democratic mechanisms which can deal with the inherent problems of continuous change, uncertainty and multiple legitimate perspectives of systems. In environmental decision-making therefore the focus has been shifting away from

2 A fuzzy number is a number whose value is imprecise, rather than exact as is the case with "ordinary" (single-valued) numbers. Hence, they can capture situations where a value is only known "roughly", "nearly", "about" or "crudely". A fuzzy number can be thought of as a function whose domain is a specified set (usually a set of real numbers).

the outcome and towards the process (Funtowicz and Ravetz 1990, O'Connor et al. 1996). It is anticipated that inclusive and deliberative processes should not only lead to more broadly accepted, but also to higher-quality decisions. Tacconi (2000: 53) calls this move away from "carrying out analyses of environmental issues in a snapshot approach" towards a "process approach" one of the achievements of ecological economics.

In this sense, the challenge to researchers is not only one of interdisciplinary discourse, but also of contributing to the forming of novel democratic institutions. But we have only recently set foot on this path. The theoretical foundations for new methods to support a deliberative democracy are still weak. However, this should not keep us from experimenting with them, but rather lead to a co-evolutionary development of theories and methods. This endeavour requires considerable efforts to build bridges between scientific disciplines, especially political sciences, social psychology, economics and environmental sciences.

In learning processes in general actors try to understand and explain the societal phenomena, which we observe, but also to bring about personal liberation and social transformation. In this view a theory is a set of propositions to guide communication between people, whose purpose it is to bring about these transformations and which is validated by (1) its acceptance by the actors addressed in a non-coercive situation and (2) its efficacy in bringing about the desired transformations (Habermas 1974, as discussed in Parson and Clark 1995).

3.1 Evolving Complex Systems, Uncertainty and Indeterminacy

Social and natural systems are evolving, which means that they are characterised by qualitative change, surprises and novelty and irreversibility (Hodgson 2002). But they are also complex systems. Complexity is often the outcome of individuals interacting and changing their behaviour. Because individual decisions are governed by the subjective experiences of each actor, then actors cannot know what the other actors will decide, and hence will experience interactions and events that they are unable to predict (Allen 2001). Social systems and their institutions are the main drivers to reduce complexity by making individual behaviour more predictable. The systems provide structures of meaning; the meaning resides in knowledge, norms, values and worldviews. At the same time, social systems create or preserve complexity by offering complex organisational and functional differentiation through socialised roles (Luhmann after Webler et al. 2001).

Omnipresent change in systems causes problems for the knowledge about consequences. Systems theory claims that the complexity of social actions and the multitude of potential interventions with its infinite number of possible outcomes prevent any reliable prediction of the connections between individual choices and observed outcomes. Martinez-Alier et al. (1998) argued that in such systems we can only hope for weak comparability, i.e. there is an irreducible value conflict when deciding what measure should be used to rank alternative actions. This acknowledges that different stakeholders can exhibit different "rational choices" when facing the same specific situation. For example, it is completely normal for a developer to value a piece of land by its monetary value. However, for ornithologists or conservationists the number of (bird) species living on the piece of land is what determines the value of this piece of land for them. Weak comparability does however not imply that "rationality" cannot be pursued when deciding. Rather it implies that "substantive rationality", which requires strong comparability, must be replaced by "procedural rationality".

Procedural rationality is based on the acknowledgement of ignorance, uncertainty and the existence of multiple legitimate perspectives (Simon 1976, Faucheux et al. 1997).

Uncertainty and indeterminacy cause severe problems for the ability to know consequences and thus for the role of science. Funtowicz and Ravetz (1990) argued that if facts are uncertain, values in dispute, stakes are high and decisions urgent, decisions need to be supported by Post-Normal Science. This includes the introduction of extended peer-communities, i.e. the involvement of laypersons through participatory processes. This provides a convincing case for participation.

> "The extent of uncertainty seen in the scientific knowledge base is itself a subjective function of complex social and cultural factors. Scientific uncertainty can be enlarged by social uncertainties in the context of its practical interpretation, and it can be reduced by opposite social forces" (Wynne 1992b).

With social uncertainties Wynne points to bias or value ladenness and the insufficient exploration of rival problem framings. Munda (forthcoming) developed this idea further and distinguishes between social and technical uncertainty.

3.2 Multiple Legitimate Perspectives

Pluralist societies are characterised by different value systems and worldviews, and increasingly so. In addition to this social and political trend, the complex nature of social systems means that they cannot be captured when using a single perspective (Funtowicz et al. 1999).

> "The assumptions of representative democracy have been progressively undermined by the scale and complexity of contemporary societies and their rate of change. Elected representatives can rarely capture the diverse values and social and economic interests of their constituents, while the uncertainties generated by novel threats argue for the inclusion of a wider range of knowledges in decision-making" (Dryzek 1990).

According to cultural theory the understanding of the world is mediated through value and belief systems and forms of social organisation. Wynne (1992a) argued that the validity of knowledge is conditional upon the model of rationality. If knowledge creation is handled differently by each cultural bias, then the only way to create shared understanding and agreement for action is to produce meaning that lie outside of the territory of individual cultural biases. Effective policy for a society depends on successful creation of shared meaning among – not within – cultural groups. Two points are particularly relevant here:

1. Shared social values as well as shared meanings do not exist a priori, nor are they merely the intersection of individual values. Instead, they are created through effective social interaction.

2. The only effective way to achieve this kind of interaction is through open dialogue.

3.3 From this Follows a Social Learning Perspective

The standard utility-based static framework is criticised in this article for several reasons:

- the framing of the problem shapes revealed preferences;
- the information base may change during the decision process;
- preferences may change driven by the attempts to reduce regret and cognitive dissonance;
- and a decision is not instantaneous but a process.

This is why being aware of framing effects; accounting for state-dependent and changing preferences (Festinger 1957, von Weizsäcker 1971, Pollak 1978, Dietz and Stern 1995, Bowles 1998); addressing uncertainty by use of stochastic[3] and fuzzy variables; and analysing the decision process have recently became central in decision theory. This has at least one important implication for decision-making, namely that once information is allowed to be imperfect the relationship between learning and acting becomes central so that preferences are no longer exogenous, complete and predetermined; decision frameworks must allow for some flexibility in the face of new information, calling for an evolutionary approach.

Under the conditions described in sections 3.1 to 3.3 decision-making can only be perceived as an adaptive process, where the actors involved are continuously learning. If decision-making is not simply a strategic action to satisfy individual actors alone, but rather a social learning process, this requires the stimulation of trust, identity and solidarity within the respective society. These are social phenomena, which are products of communication and mutual understanding. Elements of social life, which require mutuality, also require constant feedback in order to reach stability. They are fuelled by reciprocal actions and exchange of symbols that reaffirm shared values and convictions (O'Connor 2000).

Public participation, which includes deliberation and inclusion (Bloomfield et al. 2001), "can initiate social learning processes which translate uncoordinated individual actions into collective actions that support and reflect collective needs and understanding" (Webler et al. 1995). Fiorino (1990) and Laird (1993) emphasise that citizen participation should enhance learning.

Hall (1993: 278) defines social learning as a "deliberate attempt to adjust the goals or techniques of policy in response to past experience and new information. Learning is indicated when policy changes as the result of such a process". Generally, social learning is a process of coordinated learning with cognitive and normative dimensions, from the individual learning in a social context to policy changes on the international level.

> "Social learning refers to the process by which changes in the social condition occur – particularly changes in popular awareness and changes in how individuals see their private interests linked with the shared interests of their fellow citizens. This is a product of individuals learning how to solve their shared problems in a manner that is responsible to both, factual correctness and normative consent (meaning legal and social responsibilities)" (Webler et al. 1995).

3 Pertaining to a series of random processes.

The two most enduring tensions in the modern debate on social learning are also central concerns in participatory decision processes: (1) "the roles of the individual and of society in the creation and validation of knowledge; and (2) the appropriate relationship between a learning, conversing public and political or expert authority in public decision making".

The main goal of participatory processes is to make better decisions. This raises the question of, what we mean by "better"? Because of the characteristics of evolving complex systems, uncertainty, indeterminacy and multiple legitimate perspectives, we have trouble to evaluate the quality of the decision outcomes and therefore focus on the decision process. Then the question remains, what is a decision process that has higher chances to lead to better decisions? In an attempt to answer this, Webler et al. (1995) define three key quality criteria for participatory decision processes, namely fairness, competence and social learning. To this end, they consider it essential to embed contributions of participants in a dialogue setting that guarantees mutual exchange of arguments and information, provides all participants with opportunities to add and challenge claims, and to create active understanding among all participants. This can be helped by multicriteria evaluation, which aims for a transparent representation of the problem, so that it is easily communicable to others, and procedurally acceptable and justifiable in light of the available information and the adopted problem definition. However, much more research on good practice and required quality standards of participatory processes is necessary.

Recently we have applied multicriteria evaluation in combination with a participatory process for the comparison of different energy scenarios for the UK (Stagl 2004). Citizens from different regions of the UK were invited to participate in two-day deliberative workshops in order to be exposed to information from different sources about electricity generation options, to bring own information, to discuss and weigh the different options (scenarios) and to give recommendations for the upcoming Energy White Paper. Besides calculating a ranking alternatives, the multicriteria method helped to structure the information, generate a transparent database and focus the discussion on the key issues.

4 Conclusions

MCE is a tool which has proven to be successful for aiding decision-making in the context of sustainable development. In addition, MCE helps to overcome some of the problems with monetary valuation. If framed within a social learning perspective MCE can facilitate decision-making in evolving complex systems. A collective understanding of the need to combine analytical and participatory methods was developed over the last few years. As shown above, the participatory process is essential for addressing the problems arising from complexity of systems, uncertainty, indeterminacy and multiple legitimate perspectives. However, the effectiveness of public participation is still unclear and there is still considerable tension between public participation and legislatively delegated authority. With public participation mixing democratic-like procedures into the processes of administrative agencies, which are themselves responsible to democratically elected officials, public lines of deciding become crossed. Hence, the largest potential of MCE for decision-making on sustainable development lies in the implementation of multicriteria algorithms in combination with participatory techniques, but at the same time it is also where key questions still need to be studied.

References

Allen, P.M. (2001): Knowledge, ignorance and the evolution of complex systems. In: J.S. Metcalfe (ed.): *Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy*. Cheltenham, Edward Elgar, 313–350.

Beinat, E. and P. Nijkamp (eds.) (1998): *Multicriteria Evaluation in Land-Use Management: Methodologies and Case Studies*. Dordrecht, Kluwer.

Bloomfield, D., K. Collins, C. Fry and R. Munton (2001): Deliberation and inclusion: vehicles for increasing trust in UK public governance? *Environment and Planning C: Government and Policy*, 19, 501–513.

Bowles, S. (1998): Endogenous preferences: The cultural consequences of markets and other economic institutions. *Journal of Economic Literature*, 36, 75–111.

Brans, J.-P., B. Mareschal and P. Vincke (1986): How to select and how to rank projects. The PROMETHEE method. *European Journal of Operational Research*, 24, 228–238.

Dietz, T. and P.C. Stern (1995): Toward a theory of choice: socially embedded preference construction. *The Journal of Socio-Economics*, 24 (2), 261–279.

Dryzek, J. (1990): *Discursive Democracy: Politics, Policy and Political Science*. Cambridge, Cambridge University Press.

Faucheux, S., G. Froger and G. Munda (1997): Toward an integration of uncertainty, irreversibility, and complexity in environmental decision making. In: J.C.J.M. van den Bergh and J. van den Straaten (eds.): *Economy and Ecosystems in Change: Analytical and Historical Approaches*. Cheltenham, Edward Elgar, 50–74.

Festinger, L. (1957): *A Theory of Cognitive Dissonance*. Stanford, Stanford University Press.

Fishburn, P.S. (1974): Lexicographic orders, utilities and decision rules: A survey. *Management Science*, 20, 1442–1471.

Funtowicz, S.O., J. Martinez-Alier, G. Munda and R.J. Ravetz (1999): *Information Tools for Environmental Policy under Conditions of Complexity*. Copenhagen, European Environment Agency.

Funtowicz, S.O. and J. Ravetz (1990): *Uncertainty and Quality in Science for Policy*. Dordrecht, Kluwer.

Hall, P. (1993): Policy paradigms, social learning, and the state. *Comparative Politics*, 25 (3), 275–296.

Hanley, N. and C. Spash (1993): *Cost-Benefit Analysis and the Environment*. Aldershot, Edward Elgar.

Hodgson, G.M. (2002): Darwinism in economics: from analogy to ontology. *Journal of Evolutionary Economics*, 12, 259–281.

Janssen, R. and G. Munda (1999): Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems. In: J.C.J.M. van den Bergh (ed.): *Handbook of Environmental and Resource Economics*. Cheltenham/Northampton, MA, Edward Elgar, 837–852.

Keeney, R.L. and H. Raiffa (1976): *Decision with Multiple Objectives. Preferences and Value Trade-Offs*. New York, Wiley.

Martinez-Alier, J., G. Munda and J. O'Neill (1998): Weak comparability of values as a foundation for ecological economics. *Ecological Economics*, 26 (3), 277–286.

Martinez-Alier, J., G. Munda and J. O'Neill (1999): Incommensurability of values in ecological economics. In: C. Spash (ed.): *Valuation and the Environment: Theory, Method and Practice*. Cheltenham, Edward Elgar, 37–57.

Munda, G. (1993): Multiple-criteria decision aid: some epistemological considerations. *Journal of Multi-Critera Decision Analysis*, 2, 41–55.
Munda, G. (1995): *Multicriteria Evaluation in a Fuzzy Environment: Theory and Applications in Ecological Economics*. Heidelberg, Physica-Verlag.
Munda, G. (2004): Social multi-criteria evaluation: Methodological foundations and operational consequences. *European Journal of Operational Research* (forthcoming).
Munda, G., P. Nijkamp and P. Rietveld (1995): Monetary and non-monetary evaluation methods in sustainable development planning. *Environment Valuation*, 2, 545-563.
Nijkamp, P., S. A. Rienstra and H. Voogd (1991): *Multicriteria Evaluation in Physical Planning*. Amsterdam, North-Holland.
O'Connor, M. (2000): Pathways for environmental evaluation: A walk in the (Hanging) Gardens of Babylon. *Ecological Economics*, 34, 175–193.
O'Connor, M., S. Faucheux, G. Forger, S. Funtowicz and G. Munda (1996): Emergent complexity and procedural rationality: Post-normal science for sustainability. In: R. Costanza, O. Segura and J. Martinez-Alier (eds.): *Getting Down to Earth – Practical Applications of Ecological Economics*. Washington, D.C., Island Press, 223–248.
O'Neill, J. (1997): Value pluralism, incommensurability and institutions. In: J. Foster (ed.): *Ecology, Policy and Politics: Human Well-Being and the Natural World*. London, Routledge, 75–88.
Parson, E. A. and W. C. Clark (1995): Sustainable development as social learning: Theoretical perspectives and practical challenges for the design of a research program. In: L. H. Gunderson, C. S. Holling and S. S. Light (eds.): *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York, Columbia University Press, 428–460.
Pollak, R. A. (1978): Endogenous tastes in demand and welfare analysis. *American Economic Review*, 68 (2), 374–379.
Roy, B. (1974): Critères multiples et modélisation des préférences: l'apport des relations de surclassement. *Revue d'Economie Politique*, 1, 1–44.
Simon, H. E. (1976): From substantive to procedural rationality. In: J. S. Latsis (ed.): *Methods and Appraisal in Economics*. Cambridge, Cambridge University Press, 129–148.
Spash, C. L., S. Stagl and M. Getzner (2004): Introduction. In: M. Getzner, C. L. Spash and S. Stagl (eds.): *Alternatives for Environmental Valuation*. London, Routledge, 1–8.
Stagl, S. (2004): *Multicriteria Evaluation and Public Participation: The Case of UK Energy Policy*. Land Use Policy (forthcoming).
Tacconi, L. (2000): *Biodiversity and Ecological Economics*. London, Earthscan.
Webler, T., H. Kastenholz and O. Renn (1995): Public participation in impact assessment: A social learning perspective. *Environmental Impact Assessment Review*, 15, 443–463.
Webler, T., E. A. Rosa, C. C. Jaeger and O. Renn (2001): *Risk, Uncertainty and Rational Action*. London, Earthscan.
Weizsäcker, C. C. von (1971): Notes on endogenous change of tastes. *Journal of Economic Theory*, 3, 345–372.
Wynne, B. (1992a): Risk and social learning: Reification to engagement. In: S. Krimsky and D. Golding (eds.): *Social Theories of Risk*. Westport, CT, Praeger, 276–297.
Wynne, B. (1992b): Uncertainty and environmental learning – reconceiving science and policy in the preventive paradigm. *Global Environmental Change,* June, 111–127.