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METHODS

Conceptualizing sustainable development
An assessment methodology connecting values, knowledge, worldviews and scenarios

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ABSTRACT

Sustainability science poses severe challenges to classical disciplinary science. To bring the perspectives of diverse disciplines together in a meaningful way, we describe a novel methodology for sustainability assessment of a particular social-ecological system, or country. Starting point is that a sustainability assessment should investigate the ability to continue and develop a desirable way of living vis-à-vis later generations and life elsewhere on the planet. Evidently, people hold different values and beliefs about the way societies sustain quality of life for their members. The first step, therefore, is to analyze people's value orientations and the way in which they interpret sustainability problems i.e. their beliefs. The next step is to translate the resulting worldviews into model-based narratives, i.e. scenarios. The qualitative and quantitative outcomes are then investigated in terms of associated risks and opportunities and robustness of policy options.

The Netherlands Environmental Assessment Agency (PBL) has followed this methodology, using extensive surveys among the Dutch population. In its First Sustainability Outlook (2004), the resulting archetypical worldviews became the basis for four different scenarios for policy analysis, with emphases on the domains of transport, energy and food. The goal of the agency's Sustainability Outlooks is to show that choices are inevitable in policy making for sustainable development, to indicate which positive and negative impacts one can expect of these choices (trade-offs), and to identify options that may be robust under several worldviews. The conceptualization proposed here is both clear and applicable in practical sustainability assessments for policy making.

1. Introduction

Begin to make order, and names arise.
Names lead to more names –
And to knowing when to stop.
Lao Tzu

The idea of sustainable development reflects one of the leading aspirations of humankind in the 21st century, not unlike the idea of socialism in the early 20th century and the Declaration of Human Rights after World War II. The words "sustainability" and "sustainable development," however, have got an eerie ring and risk becoming just another one of those buzzwords with a lifespan of a decade, at the most. Hence, the importance of working on appropriate operationalizations.

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Initially, the concept of sustainable development was thought to be applied by establishing an ecologically or environmentally desired or target value. A formal indicator of sustainability would then measure the difference in the actual and the desired time path of the selected variable, often related to some reconstructed pre-industrial "natural" situation. In the 1990s, the interference by social scientists and notably economists made it clear that the setting of such a desired or target value in relation to sustainable development, could not legitimately be based on ecological-environmental criteria alone. First, there was a choice to be made of which indicators to use — should not economic and social aspects be part of the decision-making, too? Second, if there is agreement on the indicators, their future desired or target levels have to be – at least partly – the outcome of a societal negotiating process that is informed, but not determined by scientific assessments of risks and uncertainties related to the possible crossing of critical thresholds. Moreover, such an outcome could be renegotiated at any moment, in the face of changes in knowledge and values. These considerations have led economists to argue that the quest for sustainable development can be founded on welfare economics and approaches, such as societal cost–benefit analyses. Scientists with a background in ecology but also in institutional economy and other social sciences tend to disagree, bringing in their own observations, concepts and theories.

It is against this background that the Netherlands Environmental Assessment Agency (PBL)[1] has developed its own methodology for sustainability assessment. The word "methodology" is understood here to be a context-specific combination of formal, analytical methods (tools, models) and participatory methods (expert elicitation, games). The objective of the methodology is to assist in the construction of more comprehensive and adequate models of (non-)sustainable development and to help politicians and citizens to formulate strategies for action. In this paper, we communicate the sustainability assessment methodology that was developed at the Netherlands Environmental Assessment Agency and was applied in its First Sustainability Outlook (MNP, 2004; van den Heiligenberg, 2005; Petersen, 2006a). The paper proposes a truly transdisciplinary methodology and starts with a sketch of the conceptual framework, followed by a reflection on the notions of values and beliefs. Subsequently, the construction of scenarios on the basis of worldviews and models is presented. We end with a discussion of how the methodology has been and can be used in (public) policy on sustainability issues.

2. Sustainable development and quality of life

Hundreds of definitions of sustainable development have been given since the notion emerged in the 1980s, as a desirable guiding principle for the world community. To highlight the inherent pluralism in this notion, we consider sustainable development to be a quest for developing and sustaining "qualities of life." In this way, it encompasses the subjective and objective dimensions of human well-being, inviting a truly transdisciplinary approach. Thus, people should act *here and now* in such a way that the conditions for a (decent/high) quality of life *later and elsewhere* will not be eroded. The nexus between sustainability and quality of life is the degree to which developing and/or maintaining a quality of life for a given (human) population has consequences which impair the options for developing and/or maintaining an aspired quality of life, later and/or elsewhere. Continuation and allocation are, thus, keywords around the kernel of the ends–means field of tension.

There is a long history of reflecting on the tension between ends and means. The keyword may be *scarcity*. Is scarcity an ontological fact or is it a social construct, pre-eminent in certain times and places? In ancient societies, needs surely structured social order to some extent: priests played a role in securing food during periods of bad harvests, while farmers and soldiers had a sometimes troublesome alliance in the search for food and security. In modern times, the ends–means connection has become looser and more complex for large parts of the population. Scarcity is increasingly seen as a socio-psychological construct, with values and knowledge as affective and cognitive mediators in ends–means configurations (Douglas et al., 1998).

The scientific discipline *par excellence* to deal with ends and means is economic science: the dismal science which "studies human behaviour as a relationship between ends and scarce means which have alternative uses" in the 1932 description of Robbins (1935). In welfare economics, the study of the ends–means relationship is operationalized by reducing human needs and wants to known preferences of individuals, with optimizing behavior under known constraints. Utilitarianism extended it to the societal objective of "the most happiness for the largest number of people." The formal notion of welfare is empty: it makes no value judgments about which ends are met. Its focus is on efficiency and means rationality – the optimization – and on regulation of individual behavior that is considered dangerous or undesirable by the community (criminal, immoral etc.) – the constraints. Behavior, if not regulated, gives rise to negative "externalities." The socialist and environmental movements were and are both, in a way, corrections of too narrow a notion of welfare.

The notion of welfare has also been criticized within economic science (e.g., Sen, 1982) for its insistence on the "neutrality assumption" – that is, that when states of affairs are compared their character should not matter directly; only individual welfares in those states matter – and now more attention is given, both in economics and in other social sciences, to the broader notion of "quality of life" or "human well-being" (e.g., Nussbaum and Sen, 1993; Dasgupta, 1993; Cobb, 2000; Costanza et al., 2007). As a concept, quality of life is less "empty" than the concept of welfare, where it recognizes that personal needs and wants are at least partly the outcome of continuous interaction among human beings and are intrinsically social and systemic (see, e.g., Douglas et al., 1998, p. 259).

An explicit attempt to operationalize a broader notion of quality of life has been given by Sen in what is called the

[1] The Dutch name of the agency is currently "Planbureau voor de Leefomgeving" (acronym PBL). The agency made part of the Dutch National Institute for Public Health and the Environment (acronym RIVM) until January 2006 and used as its Dutch name "Milieu- en Natuurplanbureau" (acronym MNP) until May 2008.

capability approach (e.g., Sen, 1993). The core concept here is a person's capability, that is, what a person might wish and is capable to achieve. Capabilities are opportunities, a set of options from which an individual can choose. A realized option is called a *functioning*, that is, something people manage to do or be in leading their life. Thus, a person's capabilities reflect the alternative combinations of functionings which he or she can realize (Nussbaum and Sen, 1993, p. 31). There is empirical evidence for the fact that not only realized but also non-realized options contribute to the experience of a good quality of life — hence, both capabilities and functionings matter. The capability approach connects the subjective experience of a good quality of life (*freedom to choose and [not] realize ends*) with the objective resource-oriented aspects (*means to realize ends*) (cf. Costanza et al., 2007). Well-being (or happiness) is derived from the individual's choice of functionings, but the choices available are given with the capabilities which, in turn, depend on (access to) resources. The conversion of resources into capabilities has a personal, as well as a collective (environmental, social, institutional) dimension (see, e.g., Ibrahim, 2006). An unstable climate, polluted drinking water or a corrupt police force are examples of limitations to capabilities and, hence, to functionings in the environmental and institutional (or governance) domain.

Another approach of the tension between the physical and social/psychological, the objective and the subjective is the *Human Scale Development* (HSD) theory (Max-Neef, 1991). It starts from three (normative) postulates: development is about people and not about objects; the best development process is one that allows the greatest improvement in people's quality of life; and quality of life depends on the possibilities people have to adequately satisfy their fundamental human needs. As in the capability approach, the HSD theory explicitly recognizes that (the satisfaction of) needs will influence (the satisfaction of) other needs, in terms of effectiveness and over time, and that (the satisfaction of) the needs of an individual will influence and be influenced by those of others.

The capability and HSD approaches broaden the notion of (economic) welfare by including options for fulfilling needs and wants and by recognizing the multiple interactions between them. Both approaches can and should be extended to group or collective capabilities, to include the social and systemic aspect of a satisfactory life (Stewart, 2005; Ibrahim, 2006). Yet another way to approach quality of life is to ask people directly whether they are (un)happy and (dis)content with their life – the Subjective Well-Being (SWB) approach (see, e.g., Veenhoven, 1996; van Praag and Ferrer-i-Carbonell, 2004). Extensive happiness survey outcomes have been published for individuals and as aggregates for nations (e.g., see World Values Survey and European Values Study, analyzed for changes in people's basic values and beliefs by Inglehart and Welzel, 2005). One of the findings for the USA and the UK, is that the fraction of happy people has hardly changed over the last half a century despite a threefold increase in income. It should be noted, however, that as a consequence of the way happiness is measured, happiness data over time constitute a relatively insensitive measure of quality of life (Johns and Ormerod, 2007). Still, the empirical evidence suggests that income plays only a partial and indirect role in the seven factors that really matter for an individual's experience of "being happy," in order of importance: family ties, financial situation, work, social environment, health, personal freedom and philosophy of life (Layard, 2005). This has been a recurrent theme in economic science — for instance, Scitovsky (1976) argued that quality of life suffered from an overdose of comfort and safety oriented consumption activities at the expense of more challenging and joyful elements.

3. A conceptual framework

In this paper, we propose the scheme of Fig. 1 as the conceptual framework for sustainability assessment methodology. On the one hand, there are the natural (physical) resources. Engineers focus on the knowledge and skills (technology) to use them. Ecologists call this part the life-support system, which provides ecological/environmental services. Both propose physical indicators as part of the quality of life or the system. This means-oriented approach tends to focus on observable resource opportunities and constraints. It has a certain objectivity, at the cost of excluding the experiential aspect. The natural "unit" of study appears to be the "social-ecological system," defined by the Resilience Alliance (www.resalliance.org) as being an integrated system of ecosystems and human society with reciprocal feedback and interdependence.

On the other hand, there is the subjective experience of well-being. This ends-oriented approach emphasizes the subjective individual experience. Social scientists derive it from questioning individuals, with the associated methodological problems. Economists have joined efforts and constructed indicators using social-economic statistical data (see, e.g., Nourry, 2008; Distaso, 2007). Their implementation will increasingly be based upon social survey data, to include the subjective element. In this case, the natural "unit" of study is a culture which, for historical and statistical reasons, in practice often means: the nation-state.

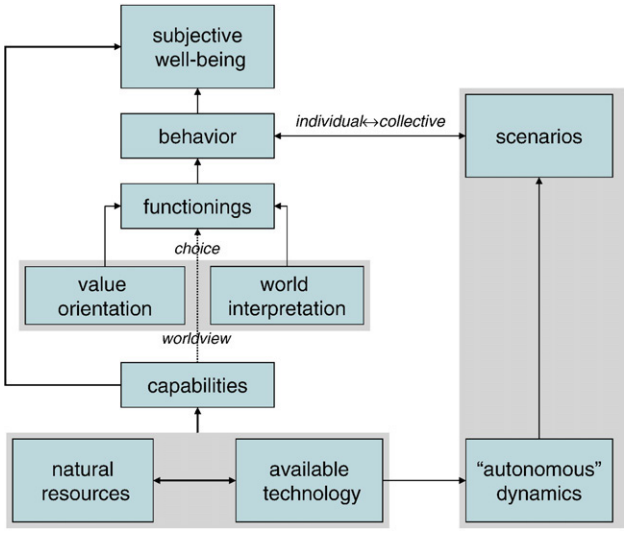

Fig. 1 – Conceptual framework for sustainability assessment.

To be useful in a sustainability assessment, the middle ground in Fig. 1 needs to be worked out. It is the domain between the natural sciences (bottom) and the social sciences (top). Some economists argue that welfare economics covers this middle ground with all that is needed for the discourse on sustainable development (see, e.g., den Butter and Dietz, 2004). Like Sen (1993), Dasgupta (1993) and others, we disagree. Welfare economics reduces human behavior, if not in theory then in application, to the individual person optimizing to satisfy unmet desires in the form of rankable preferences, narrowing capabilities to a person's purchasing power in the market. Not surprisingly, income is the indicator *par excellence* in this approach. The capability–functionings approach offers a broader ends–means connection, but, like other well-being oriented approaches, it is faced with the empirical difficulty of measurement (Saith, 2001, and references therein). One of the theoretical and empirical problems is the interaction between capabilities. This is particularly evident at the societal level, where limited resources have to be allocated to needs, such as health and education, and where the provision of one affects the nature and effect of others. The same holds for functionings, where realized behavior by one person causes externalities which influence the capabilities and functionings of others. These issues are, of course, well-known in economic science and its applications.

However, even if we are able to agree upon a list of capabilities and on ways of measuring functionings for a particular group of people, connecting these with sustainability issues is still not straightforward. For capabilities to exist, people need to have access to resources and the skills to use them and they need to find ways to deal with externalities. Some aspects of the present environmental quality, for instance, absence of pollution, can be considered to be a constituent of the present quality of life (see, e.g., Distaso, 2007). However, how to conceptualize the connection between the present quality of life and its impact on the *future* quality of life through, for instance, changing environmental quality, is less straightforward (Robeyns and van der Veen, 2007). This is even more difficult if one uses a broader notion of sustainability and tries to deal with issues of economic stability and social coherence. Another conceptual problem arises from the fact that, in order to realize capabilities in the form of functionings, people need to have information about these functionings and about the consequences of choosing them.

At this point, we propose to introduce *worldviews* as the linchpin between resources (and their conversion to capabilities) on the one hand and individual and collective behavior (as realized capabilities or functionings) on the other. Worldviews are defined here as being combinations of value orientations and world interpretations, at the individual level. Subjective well-being is then perceived to be a result of the dynamic development of individual and collective aspirations under resource and systemic constraints. The first argument for this is that insights into people's *value orientations* will give an indication about which capabilities/functionings are the most preferred — including the balance between individual and collective, or the market and the government. The second argument is that people's actual choices in favor of capabilities/functionings depend, in a sustainable development context, on their understanding of how their choices affect the (future) quality of life for themselves, as well as for people living in the future and/or elsewhere. Such an understanding can be formalized into a model (broadly defined) and will be denoted here as a *cognitive or mental map*.

Individual behavior has collective manifestations in society – the micro-macro tension. In our framework, the individual values and cognitive maps are translated into *scenarios*, that is, model-based narratives (or storylines) (de Vries, 2007). This is done on the basis of an assumption which, in a limited way, is corroborated empirically, namely that a dominant worldview can plausibly be associated with particular events and behaviors in the system under consideration. The actual introduction of worldviews into the narrative is done by choosing particular sets of model parameter/relation assumptions (see, e.g., de Vries et al., 2000; de Vries, 2001). A last ingredient is represented by "autonomous" developments: those system events and behaviors which are not explicitly considered part of the scenario exercise. Examples are random events such as natural disasters or trends in natural systems, which seem inevitable and are only partly known and possibly anthropogenic, such as climate change impacts. It may also be a mixture of both, as in the case of technological breakthroughs. In the following sections, we will deal with values, cognitive maps and scenarios, in more detail.

4. Values and their measurement

The idea of quality of life is inherently linked to what people value. The notion of value is a complex one and definitions abound in the social science literature, mostly suggesting that values express a belief about a desired end, which guides individual action (Dietz et al., 2005; Hitlin and Piliavin, 2004). We use the definition that "a value is a prescriptive conviction about desirable behavior and goals, in particular in a longer-term perspective" (Aalbers, 2006, p. 11). Values tend to change only slowly, at both individual and societal levels, although sudden changes (catharsis, revolution) cannot be excluded. Values can develop and be expressed freely upon reflection (this, at least, is the case in most societies and situations; appreciating such freedom is itself an important value). They can be ranked according to various methods, each with its pros and cons. Around both personal and societal values, often there is tension between a desired situation and/or valued behavior – an ideal – and the actual situation and/or behavior. The tensions make up the individual and social forces for change.

There are various ways to *measure values*. Most widely known and applied is the survey approach, in which people are questioned directly about their values. A second approach is the experimental approach in psychology, which can be extended with computer simulation experiments. A third approach is the ethnographic approach with in-depth interviews. Because this last one is labor-intensive and because the experimental one has limited external validity and generalizability, empirical research of values is predominantly done using surveys.

There is a growing number of data sets on what people value, both in the private (marketing) and the public domain (governments). As part of the Sustainability Outlooks,

extensive value surveys have been held between 2003 and 2006, to investigate the relationship between people's values, their worldviews and their behavior (Fig. 2; Visser et al., 2007). Data on thousands of people, over longer periods of time, have been analyzed, ranking them in a multi-dimensional value space. Eight value clusters have been derived by combining them with other datasets. These can be grouped around four aggregated axes, derived from cluster analysis and 2-dimensional principal component analysis of the survey outcomes (Aalbers, 2006; Table 1). Such a characterization of "value space", with the help of four pairs of opposites, is a useful heuristic for linking values to the perception of and beliefs about sustainability issues.

On the basis of interviews, the value clusters have been given "an identity" in the sense of a qualitative, detailed description of the most characteristic values, attitudes and behavior. The clusters have been given neutral and clear names, and a proximate distribution of the Dutch population over the clusters has been constructed (Fig. 2). Tests on other scales, such as lifestyle, (lack of) self-control and egoism, indicate good correlations with the clusters. For instance, business-oriented people are most active and in control of their lives, whereas caring people score highest on affection and group-orientation. Comparative research on the basis of different and/or more extensive sets of values, suggests that the Rokeach-based value space is universal, in the sense of context-independent and trans-situational. The relative position, however, was found to differ between countries.

Other public domain, value-related surveys are the Eurobarometer (http://europa.eu.int/comm/public_opinion/index_en.htm) which, since 1973, has been measuring the evolution of public opinion within the EU Member States, the European Values Study (http://www.gesis.org/EN/data_service/evs) and the World Values Survey (http://www.worldvaluessurvey.org). An example of an environment-oriented survey is the poll conducted in 2004 by the European Commission (EC, 2004). This poll showed that 70% of EU citizens felt that the state of the environment influenced their quality of life – however, people felt the same about economic and social factors, namely 78% and 72%, respectively. This illustrates the importance of an integrated approach to quality of life.

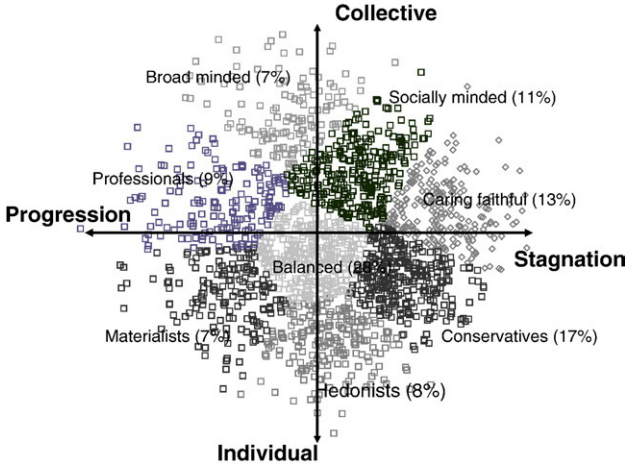

Fig. 2 – Value orientations in the Dutch population (Aalbers, 2006, p. 18). Each dot represents an individual respondent.

Table 1 – Characterization of "value space"

Axis 1 (left–right)	Axis 2 (up–down)
Progress–stagnation	Other oriented–self oriented
Openness for change–conservation	Self-transcendence–self-enhancement
Find your own way–conformism	Social oriented–individual oriented
Freedom–order	We–me
Axis 3 (upper left–lower right)	**Axis 4 (upper right–lower left)**
Big, unlimited world–small, limited world	To give: achieve for others–to take: achieve for self
Universalism–conformity	Benevolence–achievement
Freedom–family life	Relations–performance

5. Understanding and its formalization

Values determine a person's actions and goals in life, including the intention and motivation to perform. Yet, values are not predictors of behavior: similar behavior may have different determinants. Value orientations, in combination with capabilities, do yield insights into the underlying motivations for particular choices and behavior, such as air travel, nature walks or participation in NGOs. A crucial link between values and actions are the cognitive maps, which are like values based upon a lifelong experience with parents, neighbors, community leaders and institutions and all kinds of formal and informal education. Cognition is needed to guide action, in particular when making difficult and conscious decisions. A person uses cognitive representations of how the realization of valued outcomes – in terms of their (expected and perceived) quality of life – is connected to world events. In this paper, we do not focus on the various theories in the social sciences of structuring the complex interplay between values, beliefs, attitudes, norms and behavior and their social manifestation (see, e.g., Robeyns and van der Veen, 2007; Steg and Vlek, 2009; Fehr and Gintis, 2007). For instance, people are often guided by repetition, imitation and comparison in choosing their behavior (see, e.g., Jager et al., 2000). For the moment, however, we will confine the discussion to conscious, deliberate choice situations which are dominant during periods of experienced change.

What is the role of knowledge in this? In essence, humans are carriers of knowledge, or better yet, of knowing, which gradually builds up during their lifetime (cf. Gilbert and Doran, 1994). Knowing is a complex, social phenomenon and always has a tacit dimension, as far as it is embedded in language and concepts inherited from other people (Polanyi, 1962). It is a mixture of "personal knowledge" and "community knowledge." In secular western society, science – with its explicit and formal methods, rules and beliefs – has deeply penetrated the latter. The former constitutes a unique individual, emotional and mental appraisal of whatever knowledge is being acquired.

Ideally, one would like to empirically investigate people's cognitive maps – which can be named a mental map or model or, less formally, understanding, interpretation, belief, conviction. This will be difficult, in view of the huge variety of individuals, the agility of the human mind and the complex relations with effects and emotions. However, it is possible to construct a limited number of archetypical cognitive maps about certain issues and to get an impression of their adequacy. Here, we introduce a "quality" aspect of knowledge: the notion of *strong knowledge* (Groenewold, 1981). It posits that three elements have been strengthened in the evolution of scientific knowledge: a formal body of concepts and rules; observations reframed in an experimental setting; and hypotheses which connect the observations via logical operations. A scientific theory becomes stronger and matures by eliminating "weak" elements, such as false logic. The dominant body of knowledge is called scientific and is largely shared, or at least accessible, via journals, the media and experts. The archetypical cognitive maps usually are approximate and simplified versions of scientific insights – and are called metamodels, "stylized facts," or simply correlations.

Why is this relevant for the sustainability discourse? Sustainability science, being an inherently problem-driven and transdisciplinary activity, has to deal with the dynamics of social-ecological systems (see Section 3). Its objects of investigation are systems with non-linear behavior over time, across scales in time and space, with multiple causes, and are evolutionary in character. To acquire strong knowledge, in the above sense, about such complex systems turns out to be harder than is suggested by the highly successful, empirical reductionism of the natural sciences. Given this situation, we must elaborate on the notion of *complexity*.

In an epistemological framework, one may distinguish two forms of complexity. The first refers to complexity in terms of the number, diversity and heterogeneity of the elements of the system under consideration and of their interactions – the vertical axis in Fig. 3. The second is about the extent to which knowledge concerns the external, material world versus the internal, mental/spiritual world — the horizontal axis in Fig. 3. The first, vertical axis is rather widely considered a determinant of complexity and is associated with phenomena such as self-organization and emergence (see, e.g., Nicolis and Prigogine, 1989; Kauffman, 1995). One major impediment to making strong statements about such systems is the difficulty of performing controlled experiments — as the case of climate science is showing us, all too well (see, e.g., Petersen, 2006b). The second, horizontal axis of the external/objective versus the internal/subjective is an essential aspect of cognitive psychology and evolutionary economics and is also an ingredient in the formulation of agents in simulation models (Dopfer, 2005; Ferber, 2007; Hollis, 2007). It is less common in discussions on complexity, although here, the tension between the natural and the social sciences is most intense.

In the context of sustainability science, an increase in *aggregated complexity* of a system is indicated as a movement along the arrow from the lower left to the upper right, in Fig. 3. The lower left represents the world of the natural sciences and its applications: the technosphere. Knowledge is acquired in observation and description and strengthened and made "objective" in controlled experiments open to reproduction and falsification. The tools of mathematics – such as differential calculus – have been and still are essential in this process. In going to the upper right, one has to probe into complex systems, such as social-ecological systems, in new ways. Recent developments in complex systems science and interactive simulation experiments, offer promising prospects in this area, in combination with ever-increasing computing power and data availability. Yet, scientists will be confronted with uncertainty and ignorance, for a long time to come, if not forever.

An important consequence of this uncertainty and ignorance, is that cognitive maps about most sustainability issues are incomplete, controversial and value-laden. Knowledge about environmental problems is often deficient, as is shown by people who confuse the ozone hole with climate change. Dynamic implications in particular, are misunderstood by

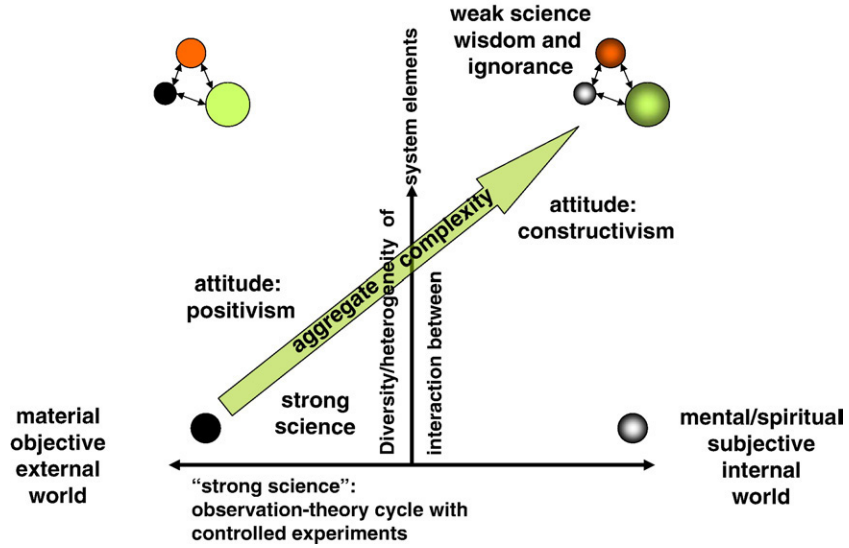

Fig. 3 – Aggregate complexity as an increase in diversity of and interaction between system elements and in subjective cognition.

many people (Sterman and Sweeney, 2002). Economic phenomena, often, are equally obscure. For instance, in a recent Eurobarometer inquiry, only 1 out of 8 EU citizens gave an answer which was within the ±20% of correct answers to questions on economic growth rate, inflation and unemployment (EC, 2008). One may presume similar results around scientific facts and insights into social-cultural phenomena.

As indicated before, we like to address this difficult situation by constructing archetypical cognitive maps which "we the people" use for judgment. In many situations, such as when traveling to work or shopping, a simple cognitive map, based on experiential local information and rules, suffices. It is adequate. But, for many actions which matter in a sustainability context, peripheral beliefs play a role. For instance, the belief that eating meat will have negative consequences for health. Or in a broader perspective, the belief that jobs will be endangered by the expansion of the European Union. Such cognitive maps directly or indirectly guide action and, even for an expert, it is not easy to validate or falsify such beliefs, if only because the truth in a complex world is so often context-specific. These are, in essence, simplifications for reducing a complex, diverse and contingent reality to manageable proportions.

To illustrate this point, let us briefly discuss a few cases of divergent cognitive maps with significant consequences for the sustainable development path to be followed. A prime example is the debate on the mechanism of *climate change* due to enhanced greenhouse-gas concentrations and the long-term consequences (IPCC, 2007a,b). The causal mechanisms have not been completely resolved, yet; the probabilities of some known non-linear feedbacks remain uncertain — not mentioning those which are still unknown; and how climate change will work out at the local/regional level is equally uncertain for many situations. Another area of scientific uncertainty and contestation is "the mystery of economic growth" (Helpman, 2004). Convergence, innovations, trade and institutions are all known to play a role, but the – often indirect and proxy – evidence supports quite divergent assessments. This is similar for the debate on which economic system is the most successful. The traditional economist view is that the competitive and flexible capitalist system of the USA is optimal for the generation of welfare. However, leaving aside the narrowness of the yardstick, even the more social-democratic coordinated economies of Western Europe have performed equally well in the period 1905–2004 (Beugelsdijk and van Hoorn, 2006). There is no "best" institutional system and their different emphases on, for instance, equity are what should matter most in comparisons.

6. Worldviews and behavior

From the previous framework, it will be clear that the relationship between individual worldviews in a population and their individual and collective behavior is a complex one. Even if value pluralism can be established empirically, how to establish connections with archetypical cognitive maps? And how to relate the resulting worldview to quality of life? A person may contextualize quality of life and its development/continuation in space (here-there) and time (now-later) in an almost infinite number of ways, depending amongst others on his or her capabilities. One of the questions to be investigated is whether a particular worldview coincides with a particular situation of (access to) resources and capabilities, which in turn influences behavior and well-being (cf. Fig. 1). In the surveys held so far, some weak correlations have been established between value orientations and socio-economic indicators, such as income, age and education (Aalbers, 2006).

Transport may illustrate the case. For a majority of people, the preferred way of transport will reflect personal end values. But the links from values to choice and behavior will be varied and variable — if only because each person often finds him/herself in a variety of roles: as an employee you may focus on speed, as a parent on safety, as a tourist on comfort etc. If a person scores high on the value orientation *broadthinking* and *engaged*, which correlates well with the instrumental values of honesty and trust and the end-values peace and freedom (Fig. 2; Aalbers, 2006, p. 76), his or her actual choice may include the argument that the Middle-East conflict is largely because of the oil addiction of the West — with terrorism and climate change as undesirable side-effects. Having a good income and being sensitive to other peoples' opinions, he or she might choose a hybrid car. Alternatively, he or she might interpret peace and freedom as the outcome of personal growth efforts and, thus, make no connection between values and transport choices. For other value orientations one can think of similar divergences.

From a cognitive science/artificial intelligence point of view, the task would be to make an adequate representation of a (human) agent with perception, beliefs and goals that are processed according to different modes, which would then, in combination with intentions and motivations, lead to action (see, e.g., Gilbert and Troitzsch, 1999; Phan and Amblard 2007). Increasingly sophisticated agent-based simulation models suggest mechanisms behind cooperative action, such as sudden, rapid changes in public perceptions and behaviors, and the spreading of diseases, information and innovations (see, e.g., Holland, 1996; Axelrod, 1997; Janssen, 2002; Nowak and Sigmund, 2004). Other important developments are the investigations in experimental, evolutionary and institutional economics about the design and role of rules and institutions in managing Common Pool Resources (CPR) (Ostrom et al., 2002; Gintis, 2005; Fehr and Gintis, 2007). All these developments refine our insights into the mechanisms which shape and trigger longer-term collective events and promise major advances in our understanding of the triangle of value orientation – world interpretation – behavior (cf. Fig. 1).

7. Scenarios for a sustainable future

The aspiration for sustainable development is to achieve change in behavior of the individual, which – at the physical, social-emotional and mental-spiritual plane – also has a collective or societal dimension. Is it possible to translate empirical and theoretical insights into the worldviews of individual people, into building blocks for a more sustainable development path or, slightly less ambitious, into a framework for critical reflection upon real-world events and trends? We opt for the *scenario method*, using qualitative narratives on

the one hand and "scientific" quantitative models on the other. This method has become widespread over the last few decades (de Vries, 2007). The many practitioners have given many definitions and prescriptions (see, e.g., van Notten et al., 2003).

Here, we define a "scenario" to be a consistent set containing worldview, storyline, underlying logic and model implementation. The *storyline* sketches a world in which particular worldviews will prevail in the societies and regions under consideration. The identification of the driving forces – "what keeps it going" – and of predetermined, slowly changing variables and their critical uncertainties, provide the structure or *logic* of a scenario (Schwartz, 1995). It reflects the prevalent mental maps and indicators of that particular scenario in the form of a reasoned chain of events. A formal *model* is then run with parameter assumptions – in the broadest sense – in line with a particular storyline and logic (see, e.g., Nakicenovic et al., 2000; de Vries, 2001, 2007). Given a particular storyline and logic, there are always more possible model implementations – but they should be different enough from other storyline-logic combinations to belong to a different "family." It should be clear that one cannot "choose" a scenario. A particular agent (actor, stakeholder) can make a plan or design a strategy, which is a set of chosen actions (the more complex the issue and its context, the more flexible and ambiguous such a set will – and should – be). However, such a plan is but one element in a higher-level narrative where not a single (group of) actors can decide upon which way to go — although an occasional politician, CEO or military commander may think differently. In this way, individual and partly shared, collective worldviews are translated into quantified pathways for important system variables, such as population size, age and health, income and income distribution, food and energy supply and costs, etc.

Ideally, the scenario dimensions are constructed as part of the sustainability assessment, in a participatory setting, with stakeholder involvement and capabilities to construct adequate (formal) models of relevant (strong) knowledge. In the First Sustainability Outlook we have relied on the IPCC-SRES greenhouse-gas emission scenarios, using the two dimensions (or axes) of globalizing versus regionalizing and private/material/market versus public/immaterial/government (Nakicenovic et al., 2000; de Vries, 2007). The shorthand names have become rather familiar: A1 for the market-oriented globalizing world (Global Market); B2 being its opposite: the community-oriented regionalizing world (Caring Region); A2 for the market-oriented protectionist world (Safe Region); and B1 being the government-oriented globalizing world (Global Solidarity).

Fig. 4 is an illustration of how a worldview can shape a scenario, with a focus on economic growth, which is still widely seen as a precondition for the continuation and

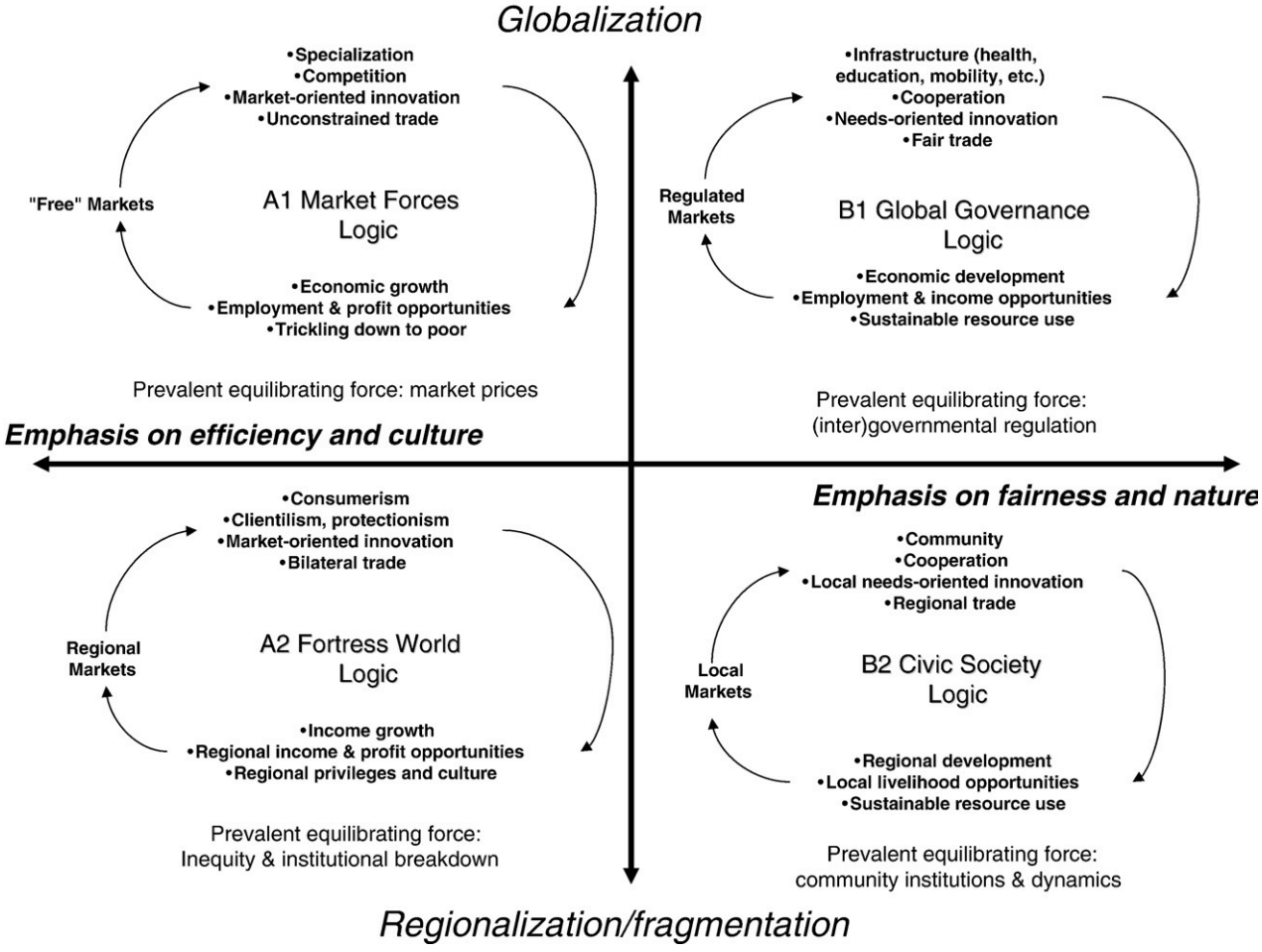

Fig. 4 – Scenario logic in the four IPCC-SRES quadrants: economic growth.

improvement of quality of life. Economic growth, or lack thereof, has serious consequences for poverty and inequality of income and wealth which, in turn, are often thought to be causal factors in practices of unsustainable resource use. Yet, there is no generally agreed explanation for the driving forces of economic growth. Fig. 4 shows the possible divergent interpretations within each worldview, or scenario, in such a situation. The Market Forces logic in the A1 world is that material wealth is the essential part of a good quality of life, that it can be acquired by specialized skills and a competitive and risk-taking attitude, that it is ensured by market-driven economic efficiency, and that government regulation and barriers to trade – goods, services, capital, labor, resources – should be minimal. The benefits may accrue to a small part of the population, but the poor people will benefit also when, in the future, wealth will "trickle down." Post-war performance of the USA is the most visible proof of the correctness of this view. The enormous achievements of the present-day global high-tech multinational corporations have only been possible because of the hard work, ingenuity, creativity and adventurism of entrepreneurs and business people. If these values and qualities are lacking or obstructed, society will become stagnant and backward.

But other people may value very different aspects of life: leisure time, small-scale enterprises, social and cultural traditions, community, nature (cf. Fig. 4 (B2)). They will express these values by protecting their small and local world through cooperation, solidarity, enclosure, and fencing-off intruders. Their civic-society view often clashes with the Market Logic, where notions such as large-scale and high-speed are appreciated for their competitive edge. In this B2 world, citizens may acquire an identity by cherishing what is local — be it their vernacular, the village church or a nearby forest. Their focus is on local needs and livelihoods, to which technology and governance should be geared. The B2 citizens cherish autonomy, but they cannot avoid a growing myriad of links with the larger world. Much to their discomfort, they are confronted with alarming stories about dwindling fish stocks, with water pollution and the threat of climate change, with displacement of local jobs, with desperate immigrants and famine. Blaming the A1 and A2 achievers and consumers is not a solution. Hence, many of them are inclined to go along with the B1 vision of Global Governance, where international cooperation and solidarity are needed for solving the large-scale and long-term social and environmental problems which the world is facing. This requires strong governments and institutions, commitment to the provision of basic needs in health and education, a long-term perspective on the planet and its inhabitants, and it requires mechanisms for fair distribution of benefits and costs, including aid and fair trade. The institutions and diplomacy of the European Union and the United Nations are their hope for the future.

Many people will dismiss the B1 logic as being a hierarchist utopia — "just look at the political quarrels, fraud and mismanagement in the UN organization," they might say. Not being able to join the "famous and wealthy" in the consumer paradise of the A1 world, B1 people may resort to a kind of realism which is a sometimes weird mix of consumerism, clientelism, nationalism/territorialism and fatalism (A2). Protectionism, opportunism and bilateralism will characterize trade, an inward orientation may emphasize military power, excessive consumerism may spur innovations, as well as envy and conflict, and semi-criminal organizations may penetrate regional government-business networks. This Fortress-World logic is fed by beliefs, such as "governments are not to be trusted," "they waste your tax money," "worldwide poverty is largely caused by overpopulation," "global firms overpower local and regional firms," and "nothing can be done against climate change, just watch the huge carbon emissions in China and India." Yet, as in each narrative, this world also has a lot to offer to parts of the population – think of opportunities for local/regional politicians and entrepreneurs and recognition and security for those who cherish traditional and religious values, practices and cultures.

Illustrative scenario-based model outcomes are population, economic output (GDP/capita), mobility patterns, transport-related air pollution, energy supply and trade, carbon emission pathways, food supply and trade, and food-related water pollution. The outcomes have been published widely, in a variety of projects (see, e.g., MNP, 2004; www.mnp.nl/image; www.eururalis.eu). Models are run with assumptions quantified on the basis of the scenario narrative/logic which, in turn, reflect a particular worldview. For instance, in an A1 world, GDP/capita keeps rising during the 21st century, which brings down the birth rate, leading to a stabilizing and then decreasing world population. In the B1 world the same happens, but due to different mechanisms. In an A2 future, the stagnation in trade slows down the innovation rate and, hence, economic productivity growth, while cultural isolation retards the demographic transition. Of course, these quantifications are full of uncertainties which have to be considered (see van Vuuren et al., in press).

8. Plausibility, empirical evidence and social dynamics

What can be said about the *plausibility* of such narratives (see Grübler and Nakicenovic, 2001; Schneider, 2001, on the plausibility of the IPCC-SRES scenarios)? Some argue that (neo-) liberal post-1990 globalizing capitalism has unleashed such forces that an A1 future is the only conceivable one, with all three other scenarios merely representing critical and/or regressive footnotes on social and environmental issues which, in due course, will be absorbed and resolved. Given the enormous concentration of wealth and power in the hands of those who exemplify the A1 worldview, they may be right. Adherents to a non-A1 world are then merely exercising a critical role: pointing out the side-effects of market capitalism, such as environmental destruction, child exploitation, erosion of community trust and coherence and the selling out of local cultural identities.

Reality is more complex, though. Much of globalization takes place in imagined worlds — and much of the (experience of) quality of life stems from very factual, local events, behavior and structures (Appadurai, 2005). One cannot simply dismiss a future in which a world government and associated bureaucracies (B1), repressive regimes of dictators and warlords or even regional/global war (A2), large but resilient rural populations and their traditional cultures (B2) or novel social-cultural influences from emerging regions, such as India and China,

will give the future a twist, distinctly different from modernist-liberal expectations.

A critical question could be: where is the *empirical evidence* of an understandable relationship between worldviews and scenarios? In the First Sustainability Outlook (MNP, 2004), a group of experts constructed coherent narratives with images for the four corners in the IPCC-SRES framework. To test the coherence and interpretation of the narratives, people were asked, during a series of interviews and a panel survey, to indicate the probability of certain consequences in the ecological, economic and social-cultural domain and their preferred narrative. The directions of the correlations between what people value (cf. Fig. 2) and their interpretation and preference for a particular world narrative, were as expected, but weak (Aalbers, 2006). For instance, Luxury seekers and Business people are in the A1 corner, whereas the Broad thinkers and Engaged people are nearer to the B1 corner (Fig. 5). Of course, many questions remain for future research.

A further, rather fundamental issue is that any narrative assuming constancy in worldviews and resource-technology parameters will itself not be "durable" — and implausible, if extended into the future for more than one or two decades. This is correct and begs the question of what kind of higher-order dynamics should be introduced. One view is that individual and collective value orientations are not at all leading and that, instead, evolution in the domains of *technology and resources* are the prime movers (cf. Fig. 1). There is indeed evidence of a dominant role of scientific discoveries and subsequent techno-economic applications as key determinants of world developments (see, e.g., Grübler, 1998). The relentless penetration of the Internet and mobile phones are early 21st century examples.

Yet, one may also defend the view that the dynamics of changes in *worldviews* and the consequences for real-world events, behaviors and structures, are a key determinant in future world development. In the last few decades, one can discern important changes in the appreciation and role of the political domain (government) in favor of a laissez-faire market economy; this is, in turn, under increasing pressure, now that the disadvantages and failures of deregulation and privatization are becoming apparent.

A simple metamodel of interacting agents can be used to describe such a higher-order dynamic. Each worldview is considered an attractor which produces its specific initial benefits and, upon crowding, problems. Too many adherents to a particular worldview generate centrifugal counterforces in response to crowding, as more and more individual people react with alternative views and actions. Resource conflicts and technological breakthroughs may then trigger a (local) avalanche switch to another worldview, especially when the system already is in a region of instability (Thompson et al., 1990). In the present context, it means that the preponderance of a particular scenario storyline shifts over time (cf. Fig. 4). Our methodology permits an explicit investigation of such a dynamic (for a preliminary exploration along these lines, see Janssen and de Vries, 1998).

9. Policies for a sustainable world

How useful is our methodology for carrying out a sustainability assessment? The quest for sustainable development unfolds into a series of *macro-problems*, which are high on aggregate complexity and low on consensus in values and

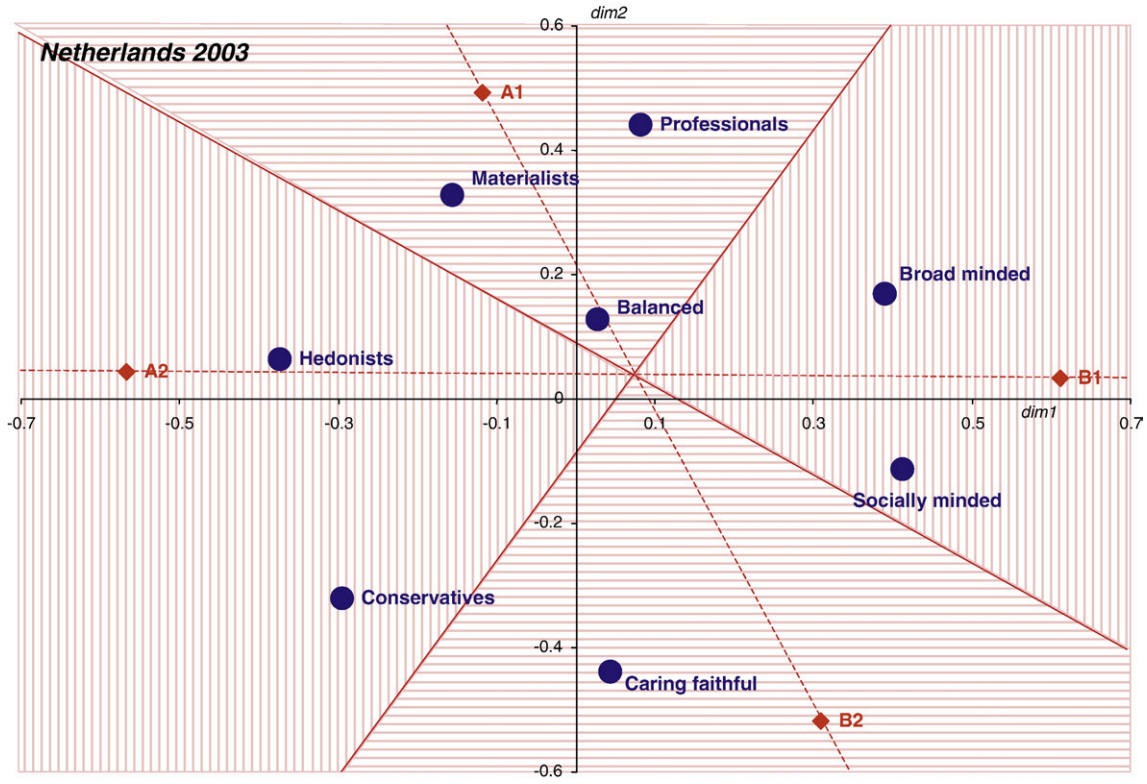

Fig. 5 – Positioning of people's value orientations in the IPCC-SRES scenario framework (Aalbers, 2006, p. 69).

knowledge (de Vries, 2007). They are characterized by lack of transparency and non-linear dynamics and are associated with post-normal science (Funtowicz and Ravetz, 1990; van der Sluijs et al., 2008; www.nusap.net). *Organizations,* and not individuals, are the actors in the societal networks which run the human world with its macro-problems – although every organization is the expression of individuals.

Therefore, a methodology is needed to support the formulation and design of *policy* problems and programs of public, private and civil organizations active in the sustainability arena. If the leadership of an organization, whether it is a government, firm or NGO, considers a series of past and anticipated events as serious threats to the quality of life of (some of) its stakeholders (citizens, employees, members), this becomes a public policy problem. What can be done about the undesired state, to prevent, mitigate and/or react against an unattractive development? We suggest that our methodology could increase the effectiveness and legitimacy of policies, in at least three ways.

The first one is to position oneself in the center of the worldview and scenario quadrant and, from there, perform an explicit elicitation of value orientations and construct a series of archetypical cognitive maps of how the world is believed to work. A further explication of the resulting worldviews involves the formulation of hopes and aspirations (utopia) and fears and concerns (dystopia), as well as their resource base and capabilities in terms of financial, economic, social and media power and control (Rotmans and de Vries, 1997; de Vries, 2001). The acknowledgement of worldview pluralism, probably the only basis for legitimacy in any modern democracy, is thus ensured. The trap of reducing the problem to a single solution for an – illusory – single constituency, is avoided. Novel tools and methods for involving stakeholders and expert knowledge, such as policy exercises and simulation games, are a helpful and timely development (see, e.g., Duke and Geurts, 2004).

Model-based quantification is the next step, as a check on consistency and an assessment of implications. Then, one evaluates the range of available policy options – taxing, subsidizing, regulatory controls, etc. – in terms of their compatibility and, therefore, chance of success or failure. For instance, counting on strict life-style oriented regulation will meet with stiff opposition and massive evasion in a Global Market world logic. In this way, it is possible to search for a mix of policy measures which is balanced, yet biased in the right direction. This is all done in order to formulate a policy program which is robust and resilient in the face of change, including surprise events in the natural system and sudden shifts in worldviews.

Such a "strategic" application has been made in the First Sustainability Outlook (MNP, 2004). In the area of mobility, it led to the conclusion that a mix of instruments is needed in order to avoid unrealistic and failure-prone policies:

- Market-based instruments (prices) are robust in almost all scenarios on the condition that they are legitimized on the grounds of reducing congestion *and* environmental problems;
- Regulation is necessary and effective from a Global Solidarity (B1) perspective, but it should incorporate the innovations of the A1 world and the concern about the local environment of the B2 world.

In similar fashion, we identified strategic outlooks on sustainable energy futures. A particularly important recommendation in this area was giving clear price signals, as a way to address concerns valid in different worldviews/scenarios, namely: reduced dependency on oil imports (security), incentives for entrepreneurs (innovation) and a commitment towards the reduction of greenhouse gases (climate). The analysis also ignited the first debates about the possibly ambiguous role of biofuels. A third case besides energy and transportation was that of the trade-offs in the global food arena. Here, large and difficult to resolve tensions are found between global concerns and solutions regarding poverty and biodiversity and their interactions on the one hand, and the more local concerns about water and soil pollution, application of genetically modified organisms (GMOs) and animal welfare, on the other.

A second way of using the methodology, is that of choosing one of the scenarios and working it out in such detail, that pros and cons become clear. Such a "partisan" exercise will provide warning signals: which values are promoted, which ones will be denied and give rise to opposition? Which cognitive maps have to be communicated — considering the pitfalls of lies and manipulation? Which strategic risks and opportunities are part of the narrative and how can models be used to quantify the more tangible economic risks and opportunities of the scenario? Which policies are (in)compatible with the presumed prevailing worldviews? From a public governance perspective, such an exercise should be done as part of the public discourse. The polarization by those who criticize "the powers that be" clarifies the underlying values, beliefs, motivations and interests.

A third way in which the worldview component of our methodology can be used, is exemplified in the Netherlands Environmental Assessment Agency's Second Sustainability Outlook (MNP, 2007). Instead of using the worldviews to facilitate deliberation on policy targets, one can start from policy goals that have already been internationally agreed upon, such as the European Union's two-degree target for climate change, the Convention on Biological Diversity's target for slowing down the biodiversity loss and the Millennium Development Goals. For the Second Sustainability Outlook, different policy options for meeting the given targets were assessed from the perspectives of different worldviews. This helped to make the likelihood of implementation of different measures explicit, and made it possible to search for robust solutions, that is, combinations of measures.

Last, but not least, our methodology serves as a framework for science to promote a more transdisciplinary, less fragmented approach to sustainable development issues, thus bridging the three divides of micro–macro, science–policy and natural science–social science. The explicit orientation on worldviews in our methodology may avoid a narrow self-regarding focus and help to overcome the science–policy divide. Both are real challenges for sustainability science, in view of exciting new insights and data/tools, on the one hand, and the apparently accelerating pace at which the human population races towards its destiny, on the other.

10. Conclusion

The transition towards a more sustainable relationship between the human species and its natural life-support system, is a major challenge for humanity in the 21st century. Based on extensive cooperation with scientists from a variety of disciplinary backgrounds and intense dialogue in a number of science–policy interfaces, we argue that an integrated framework for sustainability assessments is necessary and feasible. Its aim is to develop and continue quality of (human) life elsewhere and later, within the limits set by ecological and social constraints. The latter should be grounded in scientific knowledge about ecosystems, resources and technological developments, while acknowledging the plural realizations of quality of life by addressing the subjective values and beliefs of individuals, conceptually and empirically. We present a conceptual scheme, which broadens the economic notion of welfare with capabilities and with social and system aspects and which, in this way, permits a constructive resolution of the tensions between an objective and a subjective notion of sustainability and quality of life. The combination of value orientations and cognitive maps which make up worldviews in this scheme provides the basis for the construction of scenarios, that is, model-based narratives. Thus, sustainability assessments can support strategic decision-making, as well as heuristic exploration in complex sustainability related macro-problems. In incorporating explicit values and 'facts', one may hope that respect for diverse views and interests increases and irresponsible simplifications of the complex challenges ahead do not gain support. In our view, these are the preconditions for adequately facing the sustainability transition that lies ahead of us.

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