Long Abstract

Participatory Dynamic Modelling Framework for Integrated Sustainability Assessment

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Summary: In this paper we start by positioning Integrated Sustainability Assessment (ISA) in relation to other environmental and integrated assessment frameworks. We present a critical review of the tools that may guide and structure ISA processes, especially focusing on the role of participatory modelling. The paper resumes with the presentation and discussion of a new dynamic and participatory modelling framework, comprising five stages: scoping, visioning, model building, simulation/assessment and monitoring. The distinctive features of the framework include the dynamic modelling and analysis of long-term sustainability impacts against sustainability criteria, embedded in broad and continuous participatory processes exploring the integration of assessment methods in a coherent platform.

Keywords: integrated sustainability assessment; integrated assessment tools; participatory modelling; system dynamics.

1. Introduction

Despite some evidences of recovery and action to reverse the overshoot of the world's natural limits, unsustainable development trends still persist in relation to many issues, such as climate change and energy, production and consumption patterns, biodiversity loss and decline in ecosystem services, overexploitation of natural resources, poverty and social exclusion (CEC, 2006). These negative trends bring about a sense of urgency, calling for integrated methods and tools to better understand the dynamics and interrelationships between social and ecological systems.

The SUSTAINAMICS - "Dynamic Modelling for Integrated Sustainability Assessment" – research project aims at developing and implementing an innovative dynamic and participatory modelling methodology to support Integrated Sustainability Assessment (ISA) of existing policies and/or new proposals addressing the pressing sustainability challenges faced by our societies.

In this paper we present a conceptual framework for ISA, developed within the scope of SUSTAINAMICS, which was based on the lessons arising from a critical review and comparison of integrated assessment conceptions, methods and tools. The following sections present the rationale underlying the participatory modelling framework and present its distinctive features with respect to state-of-the-art ISA practices.

2. Analysis and Discussion

Integrated Assessment (IA) frameworks have been playing an important role in providing more holistic ways to support environmental policy making and appraisal. Recent studies underline the need to progress towards sustainability-based assessments, presenting new conceptions that are more forward looking and integrative, addressing human as well as ecological effects within complex systems, and focusing on sustaining long-term benefits of policies (Gibson, 2005). In conceptualising sustainability assessment several authors have distinguished between three broad IA frameworks: EIA-driven integrated assessment, objectives-led integrated assessment and ISA or "assessment for sustainability" (Pope et al., 2004; Weaver and Rotmans, 2006)(Table 1).

ISA arises as the next generation of assessments as a "cyclical, participatory process of scoping, envisioning, experimenting, and learning through which a shared interpretation of sustainability for a specific context is developed and applied in an integrated manner in order to explore solutions to persistent problems of unsustainable development" (Weaver and Rotmans, 2006). ISA covers intergenerational phenomenon, operates at multiple scale levels, and attempts to understand the interdependencies and co-evolution of social-cultural, economic and ecological systems.

Table 1 – Conceptions of integrated assessment frameworks (Adapted from Gibson, 2005; Pope et al., 2004; Weaver and Rotmans, 2006).

	EIA-driven integrated assessment	**Objectives-led integrated assessment**	**Integrated Sustainability Assessment**
Which are the origins? Which is the entry point in the policy-making process?	Project based Environmental Impact Assessment (EIA); Ex-post, at the end of the policy pipeline	Objectives-led Strategic Environmental Assessment (SEA); Ex-ante, at the beginning of the policy pipeline	Ex-ante, concomitant and ex-post; continuous, iterative process, integrated with governance structures
What is the purpose of the assessment?	Identification of environmental, social and economic impacts of a proposal; comparing impacts with baseline conditions to determine its acceptance	Determining the extent to which a proposal contributes to pre-defined environmental, social and economic objective; determining the best available option to achieve the goals	Aims to explore sustainable solutions to persistent problems; allows society to derive an interpretation of sustainability and then to compare initiatives against this proposal
How are trade-offs treated? Which is the relation to target?	Minimize negative outcomes on the triple bottom line; aims to ensure that impacts are not unacceptably negative in any of the	Maximise positive triple bottom line outcomes; aims to determine whether improvements towards TBL objectives can be	Trade-offs reducible or reconcilable; seeking synergies and holistic perspective; measures distance from target; potentially higher

	EIA-driven integrated assessment	Objectives-led integrated assessment	Integrated Sustainability Assessment
	TBL pillars; measures direction to target; it is most likely to result in weak sustainability and trade-offs between TBL categories	made; measures direction to target but it is difficult to determine if TBL objectives really reflect sustainability	impact on the socio-political context via social learning

In operationalising sustainability assessment, several methods and tools have been developed (Table 2). Considering the wide range of application contexts and domains, Rotmans (2006) argues that it is difficult for a single tool to grasp all ISA dimensions. He then calls for flexible approaches to linking elements together, since the IA toolkit is still not well enough equipped to address the multi-dimensional complexity of sustainability.

Table 2 – Methods and tools for sustainability assessment (Adapted from Gasparatos et al., 2007; Ness et al., 2007; de Ridder et al., 2007, Renn and Schweizer, 2008; Rotmans, 2006).

	Examples of methods and tools
Participation and deliberation	Focus groups, consensus conferences, in-depth interviews, citizen's juries, deliberative juries, workshops, deliberative visioning, Delphi method, citizen advisory committees, open forums, participatory modelling, ICT-Tools.
Multi-criteria Analysis	Weighted summation, analytic hierarchy process, PROMETHEE, NAIADE, REGIME, dominance method.
Cost-benefit and cost effectiveness analysis	Market methods, hedonic methods, travel cost method, contingent valuation.
Macroeconomic indicators and green accounting	Index of Sustainable Economic Welfare, Genuine Progress Indicator, Genuine Savings, Human Development Index, System of Environmental-Economic Accounting (SEEA).
Biophysical indicators and accounting systems	Ecological footprint, material flow analysis, global land use accounting, life cycle assessment.
Scenario tools	Modelling and simulating, interactive brainstorming, scenario workshops, integrated foresight management model.
Socio-economic and biophysical models	General economy models, demographic models, partial economic models, public health models.
	Climate models, hydrology models, biogeochemistry models.
Integrated models	Integrated assessment models, qualitative system analysis models, scenario building and planning tools.
Indicator sets	Environmental pressure indicators (*e.g.* Eurostat), sustainable development indicators (*e.g.* United Nations Commission on Sustainable Development).

In this paper we focus our analysis by exploring the role of integrated models and participatory model-building processes, as well as the integration of this approach with other methods and tools supporting ISA.

Recent calls for participation emphasise the need for considering “extended facts” in understanding the complexity of environmental phenomena and strengthening stakeholder involvement in decision-making (Guimarães Pereira et al., 2003). De Marchi and Ravetz (2001) defend that participation should be seen as a complement, rather than a substitute for existing decision-making modes. They recommend a context-specific approach to the use and design of participatory processes, in order to achieve three essential goals: widening the frame of policy issues including all sectors of society, delivering a decision-making style which is more responsive to democratic principles, and improving the quality of decisions through the inclusion of multiple perspectives. Hence, participatory platforms are needed to promote the careful discussion of the different values and viewpoints underlying decisions (Holmes and Scoones, 2000). This may be achieved through deliberative decision-making processes, which are characterized by social interaction (e.g. facilitated dialogues and debates, assisted by specific processes and tools) and are designed to explore the reflective capacity of participants (Bloomfield et al., 2001).

Combining the principles of IA with model building exercises allows for integrating different components of natural, economic and social systems in a computer model (De Marchi et al., 1998; Harris, 2002). In the case of system dynamics models, the focus is on the development of conceptual and computer-based models for understanding and solving complex problems (Richardson and Pugh, 1981) using behavioural decision theory to understand a model’s information flows and decision-making processes (Morecroft, 1985; Sterman 1987). These models are particularly useful, at a strategic decision-making level, in the development of better-informed policies to address complex problems and in the analysis of the long-term dynamic patterns of alternative development options.

The most widespread example of a system dynamics application to sustainability issues is the work of Meadows et al. (1972; 1992; 2004) on the “Limits to Growth” in a finite world. The 30-year update of the original World3 model has been used for analysing the implications of different scenarios in restructuring the global system toward sustainability. This work highlights the potential of dynamic modelling for supporting the assessment of sustainability scenarios, the development of sustainability criteria and the simulation of sustainability indicators (e.g. the ecological footprint and the human welfare index) (Meadows et al., 2004). In another study, Bockermann et al. (2005) developed a SD model for supporting integrated assessment of sustainability scenarios for the EU 15 economy. Hinterberger et al. (2004) developed a modelling framework for ISA in Austria, whereas Ronchi et al. (2005) proposed an integrated indicator for sustainability in Italy based on a dynamic model that allowed for managing quantitative indicators together with non-numeric evaluations of the citizens’ quality of life.

Along with “traditional” expert modelling studies, participatory modelling approaches based on the system dynamics methodology, such as Group Model-building (Vennix, 1996) and Mediated Modelling (van den Belt, 2004) have evolved to engage interested parties in the modelling process and facilitate team learning and consensus-building, while dealing with “messy” and complex dynamic problems.

The conceptual framework proposed in this paper (Figure 1) aims at progressing the state-of-the-art in ISA methods by presenting an innovative methodology, which facilitates the dynamic analysis and long-term impact assessment of policies, frames the assessment within extended peer reviewed sustainability criteria, promotes the active participation of social actors in the assessment, and fosters integration of assessment methods and tools such as system dynamics modelling, visioning workshops and sustainability indicators.

The paper describes in detail each of the stages of this conceptual model, compares it with other assessment frameworks and discusses the contribution of the proposed tools in supporting ISA tasks.

Considering Figure 1, the process starts with “scoping and abstraction” of the structure underlying unsustainable trends of a persistent problem or set of issues (*e.g.* climate change and biodiversity loss). This aims at the development of broad and low resolution conceptual models depicting the inter-relationships between the socio-economic and natural systems wherein policies interplay and new interventions unfold.

“Envisioning and goal-setting” aspires at developing a shared vision of sustainable futures and sustainability criteria, with the collaboration of the interested parties involved. This will translate into the “model building and validation” stage where a series of participatory modelling workshops are planned to engage actors in a mediated modelling process aiming at the construction of a simulation model upon which alternative “solutions” may be explored and evaluated.

The “simulation and assessment” stage is concerned with appraising the sustainability impact of policy initiatives. We propose to test model-based assessment tools linked with other assessment methods (*e.g.* cost-benefit and multi-criteria analyses) to support the analysis of the long-term implications of alternative development policies. “Monitoring and measuring” the impacts of implemented measures is supported by the use of sustainability indicators and accounting systems, which leads to a new iteration of the ISA cycle through adaptation to an evolving context and governance structures.

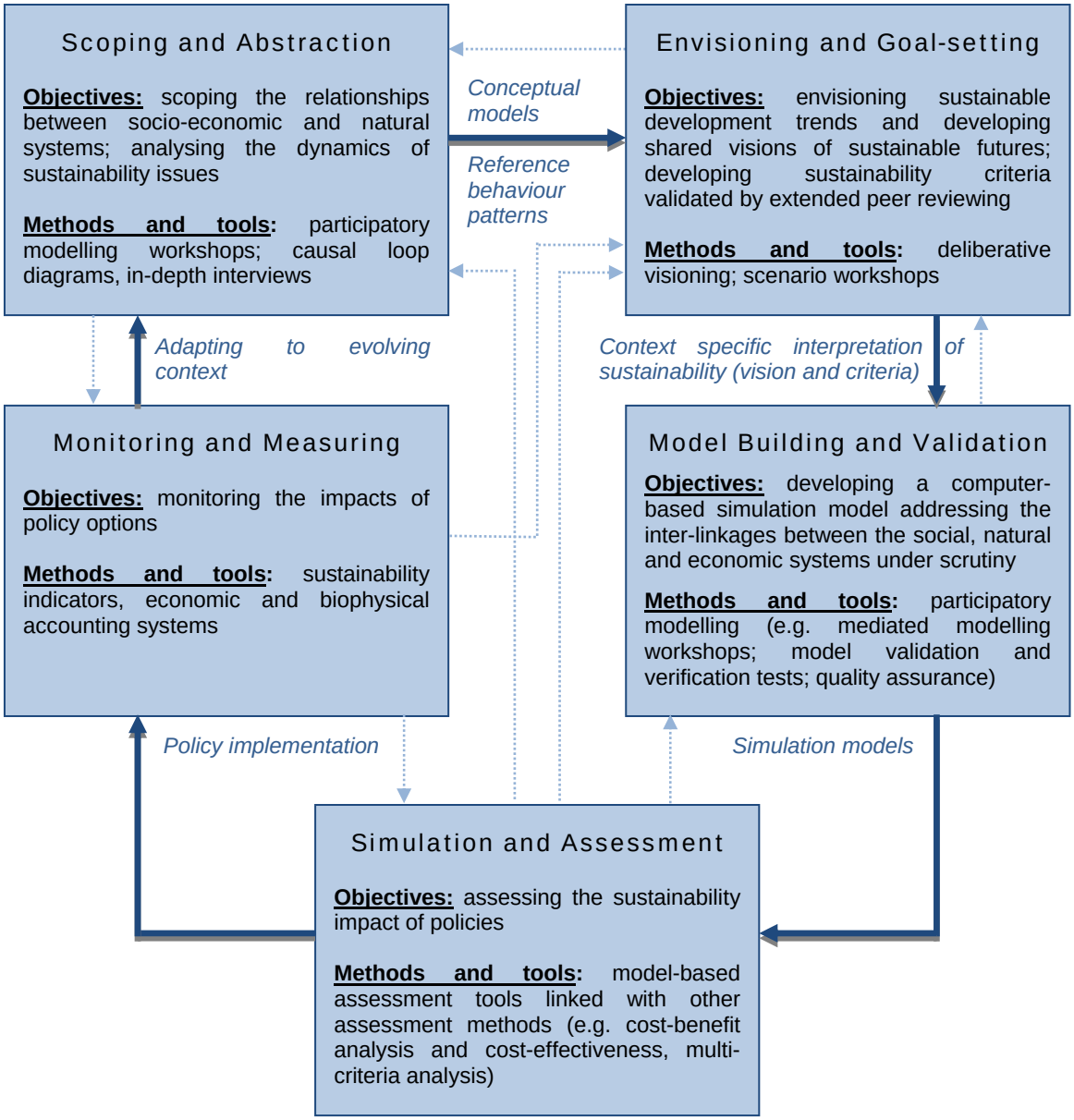

Figure 1 – Conceptual participatory modelling framework for ISA.

The feedback loops drawn inside the main cycle indicate that iteration and learning opportunities are encouraged throughout the several stages of the ISA framework.

In implementing the proposed framework we will take into account a set of principles of best practice in participation and deliberation processes (Antunes et al. 2009; Reed, 2008):

- Participatory modelling workshops will be conducted with a philosophy that emphasises transparency, equity, trust and learning;
- Participation will be embedded in the ISA process from the very early stages of the problem scoping kick-off phase;

- The participatory modelling process will strive to systematically identify and include all the relevant stakeholders;
- Clear objectives for participation will be stated and communicated to the stakeholders early in the process, and formal procedures will be deployed for its evaluation;
- Participatory modelling and the other methods foreseen by the framework will be integrated in a deliberative decision-making process, tailored to the decision-making context, and accounting for the objectives, type of participants and appropriate level of engagement.

Hence, this conceptual framework is expected to provide a coherent approach to sustainability assessment and policy development, which is different from a "one-off" participatory assessment tradition.

3. Conclusions

In this paper we present a participatory modelling framework for supporting integrated sustainability assessment processes, developed within the scope of the SUSTAINAMICS research project.

According to our review, the available body of integrated assessment concepts and tools does not fully respond yet to the challenges posed by the multi-dimensional complexity of sustainability issues. The proposed framework is expected to advance ISA processes by exploring distinctive features such as dynamic modelling and analysis of long-term sustainability impacts, the development of extended peer reviewed sustainability principles and criteria, a strong emphasis on the involvement of social actors in the assessment process, and the integration of assessment methods in a coherent platform.

We also conclude that, in line with recent findings from participatory modelling experiences (cf. Stave, 2002; Stave, 2003; Videira et al., 2008) such framework is potentially well suited for promoting the integration and co-production of knowledge, transparency, appreciation of different values, and increasing commitment towards implementation of more sustainable policies.

The application and testing of the proposed framework is currently underway. The selected case study is related with the sustainability assessment of integrated maritime policies in Portugal, which is expected to reveal additional insights on the usefulness of this approach.

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