Supporting sustainable development: Using the SMILE toolkit with stakeholders in Scotland

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Introduction

This paper reflects on using the SMILE toolkit with stakeholders, namely staff members from the Cairngorms National Park Authority (CNPA). The paper considers applying these tools and the response of potential end-users, in the context of literature on evaluating the use of such tools. Therefore, the paper explains the rationale for undertaking a utility evaluation; provides the context for our application; presents the findings to date; and illustrates what lessons have been learnt. This paper follows the tradition of stakeholder participation in generating, refining and using tools and describes the challenges that arise. The paper focuses on the role of the researcher(s) as a process manager, constantly facilitating this process of evaluation, refinement and application; and the relationships within the case study (Sterk et al., 2006). Models play a heuristic role to help multiple stakeholders understand complex systems; a symbolic role in making issues visible to politicians and a relational role by creating a boundary object around which a social network can be developed. It is interactive learning that facilitates these roles; and the practice of working with models can be improved (Sterk et al., 2009).

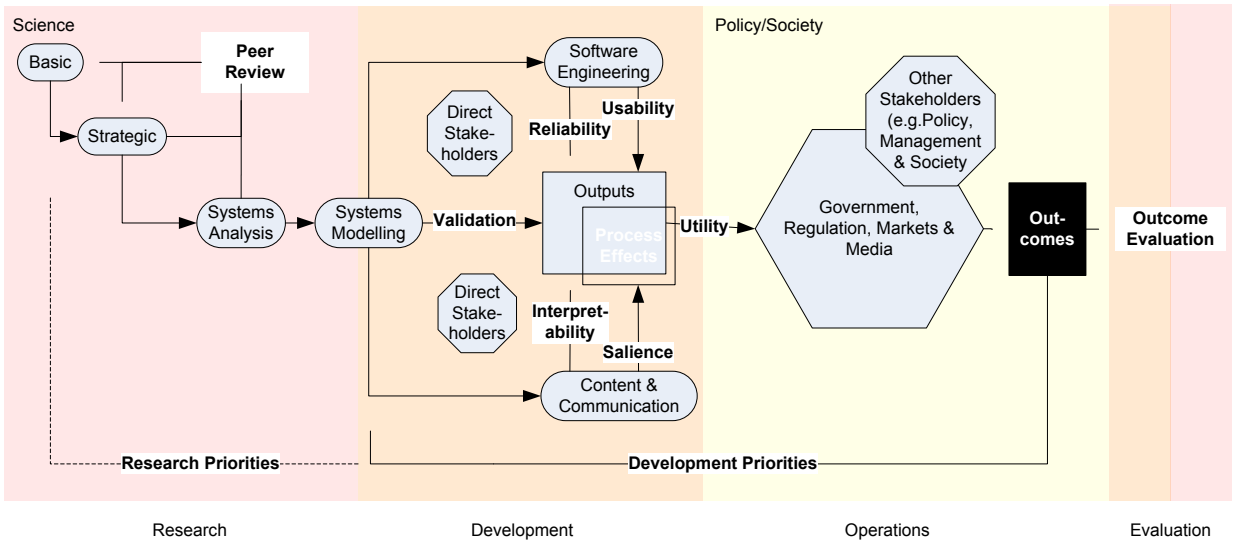
Understanding Utility

There are a series of interdependent problems to be overcome if research based tools are to be useful for, and used by, policy makers and managers. Utility links the outputs of research (knowledge embodied in peer reviewed articles, software or datasets) to outcomes (changes in values, attitudes and behaviour in the world beyond the research institute). Evaluation literature has increasingly focused on understanding how and under what conditions outputs from processes are interpreted and can result in outcomes (Blackstock et al. 2007; Patton 1998). Tools follow three loosely coupled adaptive cycles – research, development and operations (Figure 1, after McCown, 2002a). The Research phase (the left column in Figure 1) is concerned with developing new theories, methods and tools e.g. the DECOIN project. In the Development phase, activities undertaken may resemble those of the Research phase but are differentiated by being action oriented, having a primary concern for outcomes rather than academic innovation (Argyris et al. 1985) e.g. our SMILE case study. The Operations phase is where the knowledge is used within the social processes of government, regulation, markets and media by a wider range of stakeholders (this lays beyond the scope of SMILE).

It is possible to identify five preconditions for utility: validation, salience, interpretability, reliability and usability. **Validation** defines the criteria used in the choice of an "acceptable" model, and then testing the model performance according to those criteria (Bellocchi et al. 2010). Validation can significantly enhance the credibility of model outputs (Carberry et al. 2002) but is hard to achieve if data cannot be directly measured, where the systems are very large and/or very complex or where validation would raise ethical concerns (Giampietro 2004). **Salience** means that a tool should address the issues of most interest to the stakeholders. Deciding on the scope and focus of an

application requires an ongoing partnership between developers and the stakeholders (Van Ittersum et al. 2008). However, these choices may change between phases (research, development, operations)- reconciling the supply from the Research phase with the demand from the Operational phase is a serious challenge (McNie 2007). **Interpretability** is the degree to which the outputs of the tools can be understood by the relevant stakeholders. Interpretability requires clarifying the assumptions being made and how the compromises in translating reality into formalism affect the outputs. Generally, the developer acts as an intermediary to help explain the outputs within the social processes of decision making and policy (Carberry et al. 2002). **Reliability** is assessed through software quality control from simple debugging to larger structured processes of software testing (Britton & Doake 1996) and can be automated to benchmark systems (Hutchins et al. 2006). Such evaluations typically focus on the quality assurance of outputs rather than assessing the outcomes of tool use. **Usability** is the ease (and thus efficiency) with which a tool can be applied to a new problem. However, overly simplified user interfaces may detract from the credibility since they may reduce the transparency of complex analyses (McCown et al. 2006). **Utility** is relates to how useful the outputs are for achieving Operational phase outcomes, in the view of stakeholders. It has been argued that the stakeholder perceptions of utility are more influential in determining the outcomes of than later verifications of utility (Diez & McIntosh 2009). The implementation gap between development and operational use phases is widely recognised (McIntosh et al. 2008). Both stakeholders and developers of tools need to be realistic in agreeing what can be achieved for the resources being invested.

Figure 1: Conceptual framework for assessing the utility of software tools

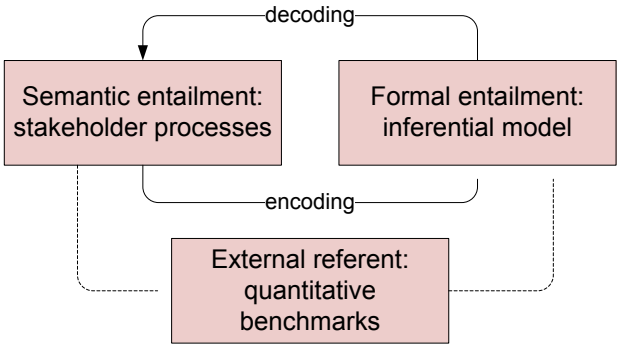


Overview of the SMILE toolkit

The Synergies of Multi-Level Integrated Linkages in Eco-social Systems (SMILE) project seeks to implement a set of models from the ongoing DECOIN project. The DECOIN tool kit (http://www.smile-fp7.eu/deliverables/SMILE%20D3.pdf) consists of three bio-economic accounting methods that work at multiple levels over time, to illustrate trajectories of development. It focuses on the concept of social metabolism that draws attention to how energy, material, money and ideas are utilised by society. The first, ASA (Advanced Sustainability Analysis); will not be discussed as it is not being applied in our case study. The other two are MUSIASEM (Multi-Scale

Integrated Analysis Societal Ecosystem Metabolism) and SUMMA (Sustainability Multi-criteria Multi-scale Assessment). MUSIASEM calculates relationships between extensive variables (stocks) of land and human labour, which create flows of money, energy and materials expressed in intensity ratios (Giampietro & Mayumi, 2000). SUMMA is an empirically based set of co-efficients that also consider how stocks create, and are created by, flows of money, energy and materials through the system. These flows are expressed as emergy to illustrate the embodied energy and materials being utilised by the system (Brown & Ulgiati, 2004). SUMMA and MUSIASEM were applied at the Scotland (N+1), Cairngorms (N) and within-Cairngorms (N-1) level. SUMMA was specifically applied to the agricultural sector, whilst MUSIASEM was applied to the whole system. For more information on results regarding growth; trade-offs; and policy implications see reports D28 – 30 (available http://www.smile-fp7.eu/?id=deliverables).

Figure 2: Interpretation of Rosen's Modelling Theory



Although there was detailed information on how to apply SUMMA, there was no information provided for using the tool with stakeholders within specific institutional contexts. The MUSIASEM developers did not provide explicit guidance on the procedures for implementing the tool. Using Rosen's (1978) principles of modelling, we constructed a procedural diagram (Figure 2), that illustrates the need to close the loop between the outputs of the formal model and the perceptions of the system expressed by stakeholders. Whilst both tools advise carrying out this step, there is little explanation of how to do this stage compared to the detailed guidance on the formal modelling procedures.

Case study application

The Cairngorms National Park is the largest national park in the UK and was created as a result of the National Park (Scotland) Act in 2003. It covers approximately 3,800 km^2 and is home to approximately 16,000 human residents as well as significant protected habitats and species. National Parks in Scotland are explicitly required to achieve 'sustainable development', as illustrated by the four statutory duties set out in the Park Act: to conserve and enhance the natural and cultural heritage of the area; to promote sustainable use of the natural resources of the area; to promote understanding and enjoyment of the special qualities of the area by the public; and to promote sustainable economic and social development of the area's communities. Therefore, they are not 'wilderness reserves' but fit the IUCN category V (protected landscape). The Park has a statutory management authority – Cairngorms National Park Authority (CNPA) but unusually, the CNPA are not land owners, regulators or service providers per se, but instead seek to coordinate the multiple private, public and voluntary/NGO sector land owners at the local, regional and national (Scottish) level.

Methodology

The results are based on 4 phases of data collection and analyses: introducing the study (3 sets of field notes/transcripts from interviews and two letters); systems diagramming workshop (2 sets of field notes, one transcript); follow up discussions (5 sets of field notes/transcripts from interviews) and the utility workshop (2 sets of field notes, one transcript, 3 evaluation forms). The SMILE

project works in parallel with a longitudinal research project funded by the Scottish Government from 2006 – 2011, which aims to collaboratively evaluate the development and implementation of the Cairngorms National Park Plan. The approach is focussed on ongoing social learning through collecting, analysing and sharing findings. The semi-structured interviews were held with individuals or groups of CNPA staff for the longitudinal research project. Where possible, the interviews were taped, providing a combination of field notes and verbatim transcript. These were loaded into NVIVO[1] for data management and analysis. The data coded to the node 'SMILE project', covering all comments about the project were then analysed by the first author.

The project was originally presented to the CNPA during a group interview in December 2007, followed up by correspondence in April and August 2008; and the project was then discussed at a group interview in August 2008. A system diagramming workshop was held in November 2008, involving five participants from the CNPA and four from the MLURI in a deliberative group process. The methodology is described in D16 (see http://www.smile-fp7.eu/?id=deliverables) and results in Blackstock et al., (2009). The SMILE project's progress was discussed in five interviews (2009-2010), involving two of the key informants who took part in the workshops. The utility workshop was held in December 2010, at the CNPA offices and involved three participants from the CNPA and two from MLURI. All the participants had between a little and a fair amount of knowledge about sustainability assessment. We do not claim generalisability from the evaluation metrics, given the size and purposive nature of the sample.

The utility workshop was a round table, interactive process; therefore the information was presented in workbooks, which were annotated by participants with ideas, questions and comments. The content balanced explanation of the methodology with a sufficient range of results to illustrate what the tools can do. The workbook had four sections. First, the project was (re)introduced and the aims of the workshop were presented. This took approximately 20 minutes, with little discussion. Then the SUMMA tool and results were presented. This section took about an hour and three quarters, and generated considerable discussion. The participants filled in the SUMMA evaluation sheet during the coffee break. The MUSIASEM tool and results was presented, lasting about an hour and there was also much discussion. The final section on overall evaluation of the tools and the next steps for the project was a group based discussion. The participants then filled in the MUSIASEM and overall evaluation form. The results are tentative as the application of SUMMA to wider land use and more detailed analyses using MuSIASEM are being finalised and running a workshop during unseasonably cold weather affected the number of participants. We will run a workshop in June 2011, with more participants and a wider set of results, leading to final conclusions.

Results

This section reports on all four sources of data, although it mostly focuses on the utility workshop. Participants felt the work book had provided new information on sustainability assessment. However, only one felt they had changed their views on sustainability assessment and neither changed their views on the sustainability of the CNP after the workshop.

[1] A computer assisted qualitative data analysis software, we used NVIVO 8.

Views on the SMILE project expressed prior to utility workshop

The SMILE project was promoted as an opportunity to "bring these models to the Cairngorms National Park Authority to see if they actually help you make some of your decisions" (Dec, 2007). We agreed to look at the economic profitability of the land use sector, its environmental impact particularly with relation to climate change and aspects of social justice. Further aspects of sustainable development were raised 2009 – 2010 - how SMILE tools could complement their baseline economic state of the park report and how the SMILE tools could relate economic and social well-being to the Park's natural assets. However, it was also important to focus on the national perspective and legitimacy of decision making processes. The need to interest and engage the Scottish Government in the research was raised during both workshops. However, the difficulties in using tools with policy makers were also raised: "I'm very keen on this multivariate analysis, but policy is very…. uni-variate … it usually focuses on one particular issue" (Nov, 2008).

The concerns for the CNPA were staff time commitment; availability of, and access to, data; and whether the CNP was a suitable case study. These comments highlighted that any tool has to be both practical and require relatively little staff time to be attractive. Furthermore, staff members noted that they had reservations over whether the results of the tool would be reliable as they thought it was unlikely that we could get sufficient data to make the tool work. At a feedback discussion in February 2009, CNPA staff members teased the MLURI team for being 'far too enthusiastic' as we were using two new tools for a new spatial domain for the first time whilst trying to apply the tools with stakeholders. The language and terminology used by the SMILE project team has proved somewhat of a barrier - whenever the SMILE project and the tools were mentioned, there would always be a smile or joke about the complex terminology.

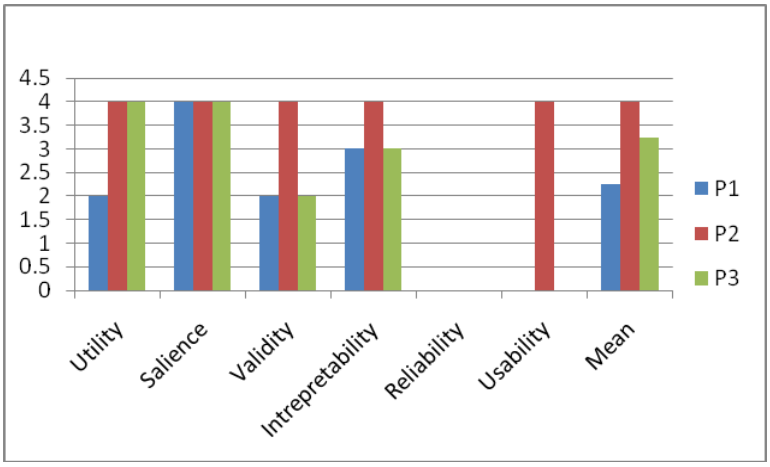
Specific feedback on SUMMA from utility workshop

Once the participants had been given an extended introduction to the tool itself, including the concept of emergy and the indexes used, the following issues were discussed. The participants were 'excited' by some material, such as workbook page 22, which illustrated that the CNP has low emissions from the agricultural sector per hectare compared to Scotland's agricultural sector's average, but the situation is reversed when it comes to units of dry matter, energy and money. The participants offered and evaluated various explanations for why this might be so including the energy mix, high transport costs, fixed infrastructure costs, etc (see D23 for more information).

However, there were queries about the inputs to SUMMA and how these might affect the results as presented. For example, one participant queried the land cover figure used as they believe that IACS returning land parcels comprised 70-80% of the Park, not 47% as the workbook suggested[2]. One participant was uncomfortable with the system diagram as it did not fit with how he conceptualises the system. The MLURI facilitator also noted that we are yet to calculate uncertainties for the data input; that fuel use doesn't yet include solid fuel and that the methane results have not included the direct emissions from livestock, which may explain why one participant noted that "there are too many caveats and gaps in the input data to give me confidence that the outputs are a reliable basis on which to shape or monitor policy" (Dec, 2010).

[2] 47% was the coverage in 2007 with ~75% in 2009. IACS stands for Integrated Administration and Control System that collates information on agricultural business holdings.

Figure 2: Evaluation results for SUMMA, December 2010

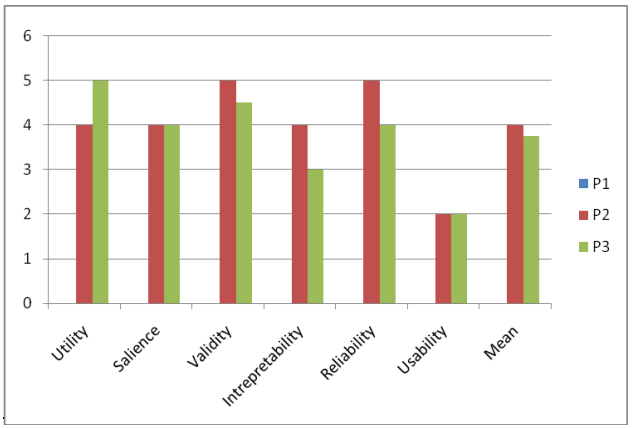


These queries about the quality of data inputs can also be related to the need to avoid averaging across the Park. For example, emissions from peat are an important issue in the CNP, but SUMMA uses emissions from an average agricultural soil. Participants also questioned the treating all grassland management the same, when the 'agricultural' area is highly heterogeneous and differentiated. Some grazing results in meat production, but other areas are actively managed for field sports or nature conservation. As shown by the Figure 2, views on the overall utility of SUMMA varied. The lower scores for the utility of the tool and the validity of the tool are explained by the lack of confidence in the input data. None of the three participants thought they would try to run SUMMA themselves, which explains the missing data for reliability and usability.

Specific feedback from MUSIASEM from utility workshop

As with SUMMA above, the participants were interested in the results, and immediately began to try to interpret and explain the trends. For example, the participants tried to guess why the CNP result (for ELP pw by EMR pw by region[3]) was clustered with Edinburgh, Glasgow and Aberdeen City, Shire and Moray. The reasons given included the influence of distilleries and the number of wealthy people living in the Park. The participants felt the results might illustrate the average hours worked – the CNP has 12% of human activity in paid work compared to 9% for Scotland as a whole. The participants were intrigued that Gross Value Added (GVA) for the CNP seemed to be the same as the Scottish average but the average income for the CNP is below the national average (the latter statistic was provided by the participants). This led into a discussion about the ability to capture the social benefits of high yield industries in the Park.

Figure 3: Evaluation results for MUSIASEM, December 2010



The major issue regarding inputs to MUSIASEM was whether GVA was the most appropriate metric. Participants were unsure if the GVA includes changes in house values, as this is likely to have increased the figures given the rise in values for the period. There was also a question about whether GVA included pensions and incomes earned elsewhere. Participants felt GVA may not be a good indicator of the flow of

[3] ELP = Economic Labour productivity (calculated by dividing Gross Value Added by Total Human Activity). EMR = Exo-somatic metabolic rate (calculated by dividing total energy throughput by Total human activity). PW = paid work sector. Scotland is divided into NUTS3 regions.

money within and between the park and Scotland or the best measure for a small region where people commute across its boundary. However, there was less discussion about the quality and appropriateness of the inputs, beyond the focus on GVA. This may be because there are fewer inputs to the tool, and those inputs are more generic, so are less contentious. As shown by the Figure 3[4]; views on the overall utility of MUSIASEM were less varied than for SUMMA. Again, the answers on validity were qualified with respect to the availability of data. One participant qualified their answer on interpretability by noting 'with guidance only'. Although participants wouldn't try to run MUSIASEM themselves, they did score for on reliability and usability.

Overall views on utility of tools

Table 1 shows the results of the ranking for criteria when evaluating utility of SUMMA and MUSIASEM. This demonstrates the diversity of preferences, but confirms the primacy of utility, salience and validity. A free choice for additional criteria was offered, but none were mentioned.

Table 1: Individual rankings for utility criteria

Ranking	P1 - SUMMA	P2 - SUMMA	P3 - SUMMA	P2 - MUSIASEM	P3 - MUSIASEM
1	Utility Salience	Utility Salience Interpretability	Validity	Utility Salience Interpretability Reliability Usability	Validity
2	Validity	Validity Reliability Usability	Utility	Validity	Salience
3	Interpretability		Salience		Usability
4	Usability		Reliability		Utility
5	Reliability		Interpretability		Interpretability
6			Usability		Reliability

The workshop discussions, combined with the evaluation results, suggest that MuSIASEM was seen as a more useful tool than SUMMA. When asked to compare the utility of the tools, the participants felt that the SUMMA application at Park level was inappropriate. The national scale did not illustrate the important regional differences in Scottish agriculture; and the Park level also overlooked important differences in agricultural systems between areas. They felt the 'blanket' coverage of MuSIASEM was more relevant and more attractive. SUMMA was perceived to be less transparent, although it raises some useful questions and the presentation of both the trend and the degree of the results was appreciated. Participants wanted to understand more about the 'black box'; as they noted that if they can't explain how the results are produced, then they are wary of using them in their work "it's hard to defend a trend if you can't understand how it is was generated". SUMMA was perceived to be data hungry, and the participants talked about the need to trade off the cost of accessing and preparing the data to the benefit gained from the information. One pointed out that it is not just the one off cost of accessing the data but "if the analysis can't be replicated, then it loses its value". Another participant then wanted to know what would happen to

[4] P1 did not fill in an evaluation form for MUSIASEM or the overall workshop due to leaving before the end.

the tools when the project ended, "would they just sit on a shelf?[5]" This is important given the evaluation returns that suggest that none of the participants intend to use the tools themselves.

The participants feel the results were salient to the Scottish Land Use Strategy, the CNPA's landscape strategy and the Low Carbon Cairngorms project. During this discussion, the notion of decision-making scale was reintroduced. One participant pointed out that many of the questions raised by the tools are not able to be solved by the CNPA. For example, the Park provides an administrative boundary but agricultural decisions are made at Scottish Government or the farm level. Therefore, it will easier to interest CNP-level stakeholders if Scottish Government uses these tools to make policy decisions. The CNPA participants were willing to "make an investment" to try to understand the material, due to their personal interest and their role at work. However, they did not think other stakeholders, with less interest in research, would be willing to invest the time required to understand the tools. Furthermore, one felt there is 'no natural constituency' and whilst stakeholders might be interested in some results, but few would be interested in all of them.

Concluding Discussion

As the tools are unlikely to be used by anyone other than researchers, this discussion focuses on validation, salience and interpretability. The lead author expected that the participants would score the validity of SUMMA lower than MuSIASEM because the SUMMA tool appears to have more complex inputs, co-efficients and outputs, which would be more sensitive to uncertainty. She expected the participants to rate the interpretability, reliability and usability of MuSIASEM lower. Validity was closely linked with whether the participants felt the outputs from the SUMMA tool were credible and reflected their perspectives of the system, reflecting the literature. The more interesting question therefore is why the validity of MuSIASEM was not raised, given the complexity and value-laden issues of economic and social performance, although if the socio-economists had attended, they may have been more questioning.

The salience of both the tools was ranked relatively high. This partly reflects the fact that we had tried to focus on issues with policy traction. However, the results resonate with McNie's comments about feedback loops, whereby there are path-dependencies between the Research and Development phases, which may not suit the needs for the Operational phase. Policy priorities are dynamic and shift more quickly than the pace of tool development and application. We were broadly correct in our requirements analysis but our ability to service the changing policy requirements was limited. The issues of interpretability relate to the ability to use the results, not the tools themselves. Our findings show that there was a problem with terminology, a diversity of ability to interpret the outputs, and preferences for the different presentations. Outputs from both tools needed to be explained before they could be interpreted. One participant noted he has discussed the SMILE outputs a number of times but it took until Dec 2010 for him to start to understand the implications.

Our findings illustrate that relationships and social capital are important at the Development phase. Our participants may have been frank with us when talking about the drawbacks of the tools given we were not the tool developers. We have worked with these participants for the past five years – as they have found previous analysis to be useful and to be credible, we have some reputational capital

[5] The social metabolism approach is written into the next five year Scottish Government funding programme, so the capacity will be maintained by the authors.

on which to draw. Data from the longitudinal research project also suggest that these participants are willing to use outputs from other modelling projects, when they find the results credible, and they have a history of working with those modellers.

Finally, reflecting on Sterk et al.'s typology of tool use, our findings suggest that the participants are unconvinced about SUMMA's role as a heuristic or using either tool as a boundary object, due to problems with interpretability. They are unwilling to place much faith in the trends that SUMMA produces, until the inputs are contextualised for the different land use subsystems within the Park. However, the fact that they were comfortable with the 'blanket' approach of MUSIASEM and the flow/fund ratios may suggest that this tool could play a heuristic (or early warning) role. Therefore, the tools are most useful as symbolic objects, to communicate key trends to policy makers. The issues of interpretability are important; given the findings suggest that it would be difficult to present these complex ideas to the Scottish Government, who want 'uni-variate answers'. The findings resonate with the difficulties of engaging policy makers with long term, complex and intractable problems requiring adaptive management (Verweij and Thompson, 2006). However, it is these conditions when (a) more meaningful sustainability assessments and (b) when social learning processes of knowledge exchange are needed.

The SMILE tools are extremely powerful at illuminating the parameters of the existing system and the trade-offs that have to be considered when pursuing normative goals of sustainable development. Our results illustrate the importance of having a shared semantic understanding before implementing formal representations of a system using tools and how to 'decode' the model outputs with the stakeholders. These steps are essential if the tools are to be seen as credible, salient and legitimate (Matthews et al. 2008). However, in addition, the utility of the tools will be affected by the practical issues of access to data and staff time, making the CNPA dependent on an intermediary between the tool developers and themselves.

Mainstreaming these tools requires us to move beyond working with the CNPA to those who might use the tool outputs to alter real world outcomes, but the participants' questioned who the "natural constituency" for these tools are. This illustrates the difficulty with sustainability assessments, when sustainability is relevant to everyone, yet few stakeholders are explicitly responsible for 'sustainability'. For the CNPA to enact sustainability, they must maintain the good will and support of Scottish Government and local landowners and communities (Dinnie et al., in press). Therefore, when using tools and their outputs, the CNPA staff must consider how the tool use will impact on their relationships with others, their personal and organisation reputations and their credibility in order to protect their claims to legitimacy. Our bonds of reciprocity with the CNPA are weak when set against their day-to-day relationships and the current political climate, where budget cuts are forcing all staff to prioritise and demonstrate delivery of Scottish Government policy. Within this context, salience of tools remains vital, but must be complemented by the ability to provide timely and credible evidence that sure up the legitimacy of the policy maker using them.

ACKNOWLEDGMENTS

The research is funded through the European Commission FP7 SMILE project, with match funding from the Scottish Government's Environment: Land Use and Rural Stewardship Programme. We would like to thank Gillian McCrum, Alana Gilbert, Hamish Trench, Murray Fergusson, Chris Bremner, and Gavin Miles for their contribution to the diagrams and ongoing support to the project. We could not have written this paper without Mario Giampietro, and Sergio Ulgiati and their teams, who coached through the use of their tools.

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