DOING POLICY IN THE LAB! OPTIONS FOR THE FUTURE USE OF MODEL-BASED POLICY ANALYSIS FOR COMPLEX DECISION-MAKING

Kathrin Happe and Alfons Balmann

Leibniz Institute of Agricultural Development in Central and Eastern Europe,
Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany
Contact: happe@iamo.de

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Abstract

For models to have an impact on policy-making, they need to be used. Exploring the relationships between policy models, model uptake and policy dynamics is the core of this article. What particular role can policy models play in the analysis and design of policies? Which factors facilitate (inhibit) the uptake of models by policy-makers? What are possible pathways to further develop modelling approaches to better meet the challenges facing agriculture today? In this paper, we address these issues from three different points of view, each of which should shed some light on the subject. The first point of view discusses models in the framework of complex adaptive systems and uncertainty. The second point of view looks at the dynamic interplay between policies and models using the example of modelling in agricultural economics. The third point of view addresses conditions for a successful application of models in policy analysis.

Key words: modelling, complexity, participatory modelling, policy analysis, model use

1. Introduction

Model-based quantitative policy support has a long tradition in agricultural economics. An impressive number of models have been developed and applied over the past decades, many of them with the objective to support agricultural policy making at different levels of scale. In many respects the attention to model-based policy support, the kind of models used and the policy questions of interest, seem to be interrelated (Balmann and Happe 2001; Happe and Balmann 2006). For models to have an impact on policy-making, they need to be used. Among the many contributions on policy analyses at agricultural economics conferences presenting a great variety of models, the issue of model uptake and use has hardly been addressed. An exception are Devarajan and Robinson (2002), who study the influence of CGE models on policy, and Rausser and Just (1981) who provide principles of policy modelling that may be interpreted as rules or a code of conduct which will allow the potential of policy models to be realised. The ability to represent and integrate observed policy-relevant phenomena in models does not automatically imply a shared understanding of the modelled processes. Hence, using a computer model does not imply an effective transfer of the understanding intended by the model or model developers (McIntosh *et al.* 2007).

Exploring the relationships between policy models, model uptake and policy dynamics is the core of this article. What particular role can policy models play in the analysis and design of policies? Which factors facilitate (inhibit) the uptake of models by policy-makers? What are possible pathways to further develop modelling approaches to better meet the challenges facing agriculture today? In this paper, we address these issues from three different points of view, each of which should shed some light on the subject. The first point of view discusses models in the framework of complex adaptive systems and uncertainty. The second point of view looks at the dynamic interplay between policies and models using the example of modelling in agricultural economics. The third point of view addresses conditions for a successful application of models in policy analysis.

Our overall starting point is that we view models not as a final product but as a virtual laboratory which can be used to test experiment with policies in different environments. Unlike real-world experimentations, models provide a safe environment for experimentation, which allows developers and users possibilities to explore phenomena or to implement features (e.g. extreme behaviours, or policies) which would not be feasibly in reality. In view of models as laboratories, this article is about possible conditions and prerequisites that make the laboratory to generate effective results.

Given the great variety of models produced over the years, there have been ongoing discussions about which models are most appropriately used and what are conditions for an effective use. Although it may be of some interest to provide an account of these questions, we do not aim to discuss the appropriateness of any specific models in this paper. Moreover, we will NOT provide a review of applications in agricultural economics, but tackle the above questions from different directions. The thoughts and ideas presented in this paper are preliminary and incomplete. But they may be of interest to agricultural economists and stimulate some discussion about future uses of models.

2. View 1: Implications of complexity and uncertainty for policy analysis and modelling

For about 10 years, policies shaping the agricultural sector are in the process of major changes. Two developments can be observed. First, there is no longer a clear-cut definition between agricultural policies and other policy areas such as environmental, structural policies or industrial policy. Hence, agricultural policy making is moving from a pure sector-orientation towards cross-sector and cross-scale policies. Rural development, for example, views agriculture as part of a larger rural social-ecological system. In addition to changes in the way and working of policies, forces or disruption from outside the agricultural sector as identified and discussed by the SCAR-group (climate change, energy, food security, social and knowledge drivers) exert change in the agri-food system. Second, in view of the theoretical progress in terms of systems analysis and complexity, also the agricultural sector can be understood as a complex system (Balmann and Happe 2001; Happe 2004). The agri-food system combines characteristics of economic, environmental, social, and technical systems. The increased awareness of the complexity of systems has been recognised in some fields such as economics (Colander 2000; Colander 2003; Colander 2005; Tesfatsion 2006; Oxley and George 2007), social-ecological systems (Berkes *et al.* 2002; Janssen and Ostrom 2006), integrated resource management (Pahl-Wostl 2007). In the literature, there are a range of definitions and characteristics of complexity originating from different sources such as physics, computer sciences, economics, social sciences, or psychology (Oxley and George 2007).

It is hence likely, and reasonable, to also describe the agricultural system as a adaptive complex system. Following Tesfatsion (2006), a system is typically defined to be complex adaptive if it exhibits the following properties. The system consists of many (probably heterogeneous) interacting agents. Moreover, there is no central control institution, but properties arising at the macro-level (e.g. prices, total income) are the result of the interactions of agents at the individual level. These micro-macro relationships are typically found to be non-linear and mutual. Agents within these systems continually adapt by learning or evolving parallel to other agents or their environment. If these characteristics apply, there will not be a unique equilibrium, but a multitude of possible equilibria. Hence, change in the sector is driven by a multitude of social, economic, and environmental factors and interactions between them. Structural breaks may arise in addition to higher uncertainty with respect to the pace of change. To summarise, complex adaptive systems can generate unexpected, surprising behaviour simple because different individuals act with a changing environment. If this is the case, the development of the system can hardly be predicted.

These developments have important consequences for the analysis of policies using models. Given the complex nature of the system, the direction and dynamic impacts of policies are not that clear any longer. Because of this, complexity may require some changes in the way how we understand the role of models in the process of policy making (Pahl-Wostl *et al.* 2007). Borrowing from the definition of integrated environmental resource management, policy making is a purposeful activity with the objective to guide, maintain, or improve the state of a particular system (Pahl-Wostl 2007). It can be defined as the process of formulating, developing, implementing and evaluating policies. Policy analysis is then concerned with producing relevant information so that it may be of use in political decisions to solve policy problems (Dunn 1994).

For many years it has been the domain of model-based policy analysis to predict the outcomes of sector-specific policies such as price reductions or direct payments in quantitative terms. Conventionally economic problems are expressed in terms of an optimization problem, which is solved using differential calculus and which results in an analytical solution with either a unique equilibrium or multiple equilibria (Colander 2000). The applicability of mathematics to economic problems is what Shackle (1988 , p. 214) calls the “toolbox conception of economic theory.” As for economic theory, Colander (2003) compares policy making based on neoclassical economic theory with its known assumptions with a house that is built exactly according to the blueprint. That is, the blueprint (economic theory) was there before the house (economy). Policy in this house is based entirely on the underlying architectural plans and can be fully controlled. What, however, if the blueprints are only vaguely known, if the house looks similar but not exactly the same than the blueprint, if the blueprint got lost and one can only observe the house? In this case both the developers or re-producers of the blueprint (economists), and the people governing the house (policy-makers) have only limited information and no full knowledge of the general laws of the economy. Under such conditions, governing the system is a process of muddling through (Colander 2003; Colander 2005). Differences between what the economic model can address and the actual dimensions of a policy maker’s problem appear (Bonnen and Schweikhardt 1998). Accordingly, the rational governance of a system based on optimality and efficiency concerns becomes governance based on muddling through, trial and error, taking into account differences between actors. Similar arguments regarding policy making in complex adaptive systems are made in the field of environmental management and policy (Geurts and Joldersma 2001; Janssen and Ostrom 2006; McIntosh, Seaton et al. 2007; Pahl-Wostl 2007).

3. View 2: Policy dynamics and models in agricultural economics

Model-based policy analysis has a long tradition in agricultural economics. Many models have been constructed. Some have been constructed for different purposes (Rausser and Just 1981): explanatory or causal purposes, forecasting purposes, causal purposes, or for the purpose of decision analysis.

From an economic point of view this can be understood in the way that there has been for a long time demand for as well as supply of model-based analyses. On the demand side, the main drivers can be seen in scientific curiosity, the need of policy makers for advice and guidance and last but not least from a political economy perspective the need of politicians for convincing arguments. Considering that agricultural policies and protection also have a very long tradition – for instance, agricultural protection started in Germany already in 1879 with the introduction of specific tariffs for grain – it can be also be assumed that there has been a potential demand for a long time – at least if one presumes that there was and is at least some trust in the outcome of the models.

On the supply side, the drivers can be seen in the available tools for modelling as well as scientists' curiosity in developing models and the potential results of these models. In this regard, critical drivers can be seen in the development of computers and parallel to it in theoretical and methodological progress. The two main historical strands in agricultural economics are on the one hand programming models and on the other hand equilibrium models. Particularly, the use of linear programming models started already in the 1950s and 1960s by e.g. Earl O. Heady and Richard Day and probably already earlier in socialist Eastern European countries. Model adaptations as well as the models' outcome are traditionally closely related to farm level implications of policies. Main reasons can be seen on the one hand in the crucial role of farm level production coefficients within these models and on the other hand in their ability to illustrate how farms or regions are concerned by policy changes. On the other hand, general as well as partial equilibrium models found particular interest on the macro-level, particularly with regard to trade issues in general and WTO negotiations in particular. This can be explained similarly: the necessary econometric calibration is easier on the macro level and the models are better suited to consider equilibrium conditions among sectors and countries.

Looking at the outcome of the Common Agricultural Policy (CAP) reforms of the EU as well as of the WTO negotiations provokes the hypothesis that particularly such policies were reduced or even banned which can relatively easy be analyzed with equilibrium models. For instance, quantitative figures on the negative effects of export subsidies and import tariffs have been used for negotiations as guidance and powerful political arguments. The facts that the models are theoretically well understood and available for the negotiating parties make them trustworthy. Discrepancies in results of different studies have been widely reduced by developing standardized data bases like within the Global Trade Analysis Project (GTAP). Opposite to the applicability of equilibrium models on product oriented market and price policies is their limitedness regarding more recent policies, such as the production oriented direct payments introduced in the MacSharry reform of the CAP. Different to tariffs or export subsidies these succeeding policies are no longer directly linked to price and quantity variables used within equilibrium models – even though the payments were directly linked to the acreage on which certain products were produced. Looking at actual support within the first axis for modernizing farms, these are even less analyzable though they could be understood as coupled input support. Following these developments, one may argue that the WTO categories of red, blue and green box policies are not only driven by theoretical arguments or model-based results but rather by whether or not the trade distorting impacts of certain policies can be convincingly analyzed at all.

May this be true or not, it seems that there is a tendency away from agricultural policies which are directly accessible by the traditional modelling tools. Moreover, there are new requirements for the agricultural sector to fulfil such as the expectation that the agricultural sector should less rely on governmental support but rather become more entrepreneurial and be part of the rural economy, specific societal demands regarding externalities – including environmental, sanitary and health issues – as well as the verticalization and internationalization of the food chains with increasing food safety demands. Related to these developments seems to be an increasing insight that structural issues of the sector become increasingly important (Balmann *et al.* 2006).

These developments create new demands and challenges for scientific support. Particularly the increasing complexity and nonlinearity of policy changes and sectoral adaptations as well as an increasing speed of change imply that there are new modelling requirements and the question is how to fulfil these demands.

4. View 3: Conditions and pathways for successful applications of models

In view of the previous discussion of the implications of complexity for policy modelling and the models in agricultural economic policy-making, there appears to be a positive perception of models and support tools in general. This is reflected not only in the high demand for scientific policy support, but also in a large number of projects explicitly involving the use of models and the amount of financial resources going into model development and applications. Despite of this, the question remains, what impact models have made in policy making. As discussed above, in agricultural economics, it is likely that models have indeed had an impact, at least with regard to certain questions. Starting out from the mentioned experiences in agricultural economics it may be worthwhile to ask in more general terms about the role of modelling and quantitative support tools in general for political decision making. This means going back one step, and asks which factors may have contributed to, but also created barriers to model adoption and use.

In this section, we hence review some literature addressing this issue. We use the term model and support tool interchangeably. Much research and thoughts regarding model use and adoption have been developed in environmental sciences, but less in agricultural economics. As regards environmental concerns and policies in many respects are often closely related to agricultural policy, environmental management may serve as a good and suitable example from which to draw conclusions for agricultural policy.

4.1 The role of models in the policy process

Policy making is not a static issue, but a process accompanied by trial and error. The process of policy making has been considered to follow a set of stages (John 1998; van Daalen *et al.* 2002). The following four stages can be distinguished

1. recognition of the policy problem;
2. selection of options; policy formulation;
3. agreement;
4. policy implementation; control and evaluation.

This linear model of policy making has been criticised because it does not include feedbacks. In reality, many policy problems are considered to be much messier than suggested by this model. Messy policy problems arise because some stages of the policy model are intertwined, include feedbacks, and are not clearly separable (Geurts and Joldersma 2001; Pahl-Wostl 2007). Despite of these criticisms, dividing the policy process into consecutive stages can be useful when studying the role of models in policy-making. The first three of the stages in the policy process described above appear to be most important in the context of this paper and are addressed in the following.

In the *recognition* phase of the policy process, models are useful as *eye-openers*. Here, models can raise awareness for certain previously unexplored problems. They can help to put new issues on the political agenda. If models have a graphical user interface or a graphical representation of results, they can provide an easier connection to the problem by way of visualisation. In some cases, models can function as eye-openers if they address questions which are perceived as relevant, but which are not necessarily reality. In this case, a model is an "as-if" playground for situation which are not (yet) reality. The underlying reasoning is that a better understanding of a system's dynamics, interactions, and uncertainty allows for better management decisions when the problem becomes reality. So to say, models at this stage can serve as a playground for reality. For example, models dealing with the effect of a full reduction of subsidies to agriculture can be placed here. A necessary condition is, however, a shared representation of the system by the model developers and the model users which are often not trained in a specific field. This issue will be addressed below. Often, however, models themselves do not function as eye-openers. It is, for example, catastrophes, financial pressures, or societal demand which lead to policy pressures and initiate the policy process. In this case, models can be built to support the thinking about new pressures, challenges, and about ways to react to them. Here, action is often taken after an event has taken place to prevent the situation from getting worse.

In the *selection* and *formulation* phase, models can serve to support *arguments in dissent*. This means, different opposing groups use models and results to support their arguments. In this case, different perceptions of one problem exit which are implemented into models. One example for such opposing views may be rural development policy. Depending on the point of view, economical, environmental, or social aspects are perceived as more important. Models being built in either one of these domains or integrating different domains can be of use here to stimulate discussion and to identify possible trade-offs. Moreover, by using models to support their points of view, opposing parties have to make their assumptions and conclusions explicit. The use of several approaches is often even desirable and supportive in developing, evaluating and elaborating alternative solutions (Rausser and Just 1981). It can stimulate discussion and initialise a process of understanding by delivering insights instead of just answers. In recent years, there have been many attempts to either combine existing but different models or to integrate different domains into one modelling approach. Many activities have been taking place as part of EU-funded research projects (e.g. SEAMLESS, SENSOR, MEA-Scope). These approaches allow analysing a set of policies with regard to different points of view.

In the *agreement* phase, models can serve as *vehicles to reach decisions or even consensus* as well as to *manage* a particular problem. Reaching a solution is not a straightforward problem, particularly when the policy problem involves many actors with different perceptions, mental representations, and interests. Not all policy problems require consensus. Yet, more stakeholders and hence more interests make it increasingly difficult to reach an agreement. Even if not all policy problems require consensus, it is generally desirable to reach a high degree of identification and a shared representation of the policy problem between model developers, models, and users. The goal is to improve as well as to integrating different mental representations of the policy problem of different actors (McIntosh, Seaton et al. 2007).

4.2 Interactive policy making

In this respect, an effective means of facilitating the effective use of models is to involve the model users or policy-makers in the development process (Rausser and Just 1981). Model users and policy-makers are assumed to be the same here. We assume that most model users are non-scientists and less able to build models by themselves. There is, however, a discrepancy between what scientists consider a precondition of effective model use and what many model users demand (either directly or by way of project calls leading to a specific output). As noted by (Rausser and Just 1981), *"...development of policy models must be treated as a process, as opposed to just the creation of a product."* This means that the creation of a model is an important step along the way toward using the model to affect policy making. It equally involves model developers and model users. Parker et al. (2002) distinguish three groups of stakeholder participation: (a) where stakeholders are involved in all stages of developing a model; (b) where stakeholders are not involved in model-building, but are involved in running the model; (c) where models are presented to policy-makers and stakeholders as final products with the ability for users to change parameters or to view results only.

If one looks at modelling reality in many agricultural economic or environmental models, the situation is often different: it is the scientists, who develop a model, use the model, document it for peers, produce results and only then communicate ready-made results to decision-makers. Hence, they fall into category (c) mentioned above. Understandably, this often creates discontent with users and the impression that important aspect of the policy problem have not been included (McIntosh, Seaton et al. 2007).

There are different ways of sharing the model building process between model developers (scientists) and model users (non-scientists, decision-makers, policy-makers). In general, involving users during the development phase facilitates understanding, it increases confidence by incorporating individual knowledge and perceptions, and decreases communication and educational efforts required after the model is constructed. Interactive policy-making has been an issue in environmental management for some time (Forssén and Haho 2001; Geurts and Joldersma 2001; Moss 2002; Duijn *et al.* 2003; Ridder and Pahl-Wostl 2005; Janssen and Ostrom 2006; Pahl-Wostl 2007).

In the case of interactive policy-making, the role of the analyst changes compared to "traditional" modelling techniques. As regards the latter, the policy analyst is an expert developing and supplying a product. She acts as an external and neutral person who avoids interference with the policy process as such (Geurts and Joldersma 2001). From a scientific view, the role of the expert policy model underlines the distance and neutrality associated with many researchers and which may have a value in itself. With interactive policy making the clear distinction between neutral policy modellers and decision-makers vanishes as the policy analyst takes the role of a facilitator enabling and moderating the process towards a policy decision.

There have been many different examples of using models in interactive policy making and management problems. In recent years, approaches starting from the concept of agent-based modelling have become a popular means and widely applied (Ramanath and Gilbert 2004). Agent-based models are suitable because of their ability to connect heterogeneous microbehaviour to different patterns of the macrobehaviour, as was described above (Lempert 2002). Agent-based models are able to capture the main characteristics of complex adaptive systems (section 1) in a modelling framework. In addition, agent-based models are similar to the ways in which stakeholders generally think about actions of and interactions between decision-makers(Matthews *et al.* 2007). Moreover, agent-based models are flexible with respect to the way they are implemented. In principle, the modeller is free to base individual agents' behaviour on theory, empirical observations, or ad-hoc assumptions. Matthews et al. (2007) provide a recent review of agent-based models in the domain of land-use. An example of applying agent-based models in an interactive ways is the CORMAS group at CIRAD in France. The so-called Companion Modelling Approach (Commod) links role-playing games with the development of agent-based simulation models (Barreteau 2003; Barreteau *et al.* 2003; Gurung *et al.* 2006; Bousquet *et al.* 2007). The main principle behind this approach is *"...to develop simulation models for integrating different stakeholders' points of view and to use them in the context of the stakeholder's platform for collective learning."* (Gurung, Bousquet et al. 2006). With regard to representing stakeholders' subjective perceptions and a shared representation, actors may in fact hold erroneous representations (Pahl-Wostl 2007). These should be corrected in the modelling process by combining hard facts (when available and proven), but stakeholders need to be willing to accept factual knowledge.

4.3 Conditions for successful use and application of models

In the field of environmental science, McIntosh *et al.*(2007) compare the adoption and use of models to the innovation process or knowledge transfer from one group to another. Accordingly, they identify three areas in the model development process, where knowledge transfer can take place: the conceptual model, the mathematical/computational formalisation, and the software implementation. Each area contributes to the way in which models are used.

The *conceptual model* is a pre-requisite for any further formal modelling activities. In this phase, different conceptualisations and representations are made explicit and articulated. They are assessed with regard to their suitability for the final model. At this stage interaction with users can be fruitful because concepts can be communicated more easily with non-scientists, e.g. by way of cards, flipcharts or conceptualisation computer tools. Moreover, user wishes, representations, and expectations can be made explicit. In the second phase, the conceptual model transferred into a *mathematical/ computational formalisation*. This, however, requires specialised knowledge and abilities (e.g. calculus, theoretical knowledge) which users often do not possess. Because of this, model developers can hold power over potential users. On the opposite trust in models can be negatively affected if users cannot follow the formalisation. Barriers to effective model communication can arise, and interaction with users is limited. In the third phase, the *software implementation*, there is again more interaction with users, yet usually in one direction. A good example for this stage is the provision of web-based support tools as part of some EU-projects. In these tools, model results are displayed in an easily accessible way, or the user can directly run simulation models developed in a project. At this stage, knowledge is usually transferred by way of a final product. Knowledge transfer is probably highest, if users are involved in all three stages.

To answer the question how different user groups respond to models, McIntosh *et al.*(2007) employ the concept of receptivity (Seaton and Cordey-Hayes 1993; Trott *et al.* 1995). Receptivity is the ability of an individual or group to be aware of, to identify, and to take effective advantage of a technology. The receptivity of an innovation is variable and generally low. Failure rates are high because of inadequate design and limitations of users' adaptability to the new technology. The adoption of technologies is more successful if it is translated into the users' pre-existing knowledge structure.

Transferred to the world of modelling, there seem to be a number of barriers to the use of support tools which are related to the persons of the users and the conditions in which they apply models on the one hand. On the other, it is related to the different stages in the modelling process and differing interests between scientists and users. More specifically, the following issues are important:

1. The ability to represent and integrate observed phenomena in computer-based models does not automatically imply a shared understanding of the modelled processes. This applies to modellers combining existing models, e.g. of different domains, as well as to end-users, such as policy-makers, or decision-makers. The use of models by decision-makers does not imply an effective transfer of the understanding intended by the model or model developers.
2. The conditions in which end-user carry out their work may be adverse with respect to a successful uptake of models, and particularly of interactive approaches. Influence of different working practices, e.g. in the EU commission or national ministries (rotation principle, work overload, focus on managerial tasks, time restrictions) and scientific backgrounds are adverse to the mentioned conditions for successful model uptake.
3. Effective communication is costly. This aspect is relevant on the side of researchers as well as on the side of users. For example, the development of an integrated model with scientists from different disciplines and host institutions requires much communication and effort. Modelling in interdisciplinary teams allows addressing more complex questions, but it makes an effective collaboration also more difficult (Scholten *et al.* 2007).
4. There is an emphasis on documenting model development instead of model use. If models are developed with only a vague idea of potential users (if there are users at all), documentation is produced to serve the needs of fellow colleagues rather than both colleagues and users.
5. Most models are used by the developers and not by users. This puts the developers in a special situation as they have learned to understand the functioning of the model whilst developing it. On the downside, it may be leading to the development of models which serve the researchers but do take less account of the actual problems and demands by end-users.

5. Conclusion

This paper has addressed some issues which appear to be relevant for future directions of policy modelling in agricultural economics. Models and their uses as support tools in policy making have been discussed from three different points of view. The first point of view identified some challenges to modelling arising from interpreting the agricultural system as a complex adaptive system. Moreover, challenges provided by new policy directions have been identified. Implications for the future use of models were drawn. The second point of view took a look at the parallel evolution of models and policies in agricultural economics. The core issue here is that certain models seem to generate specific policy dynamics and vice versa. This was supported using the example of trade policies. The third point of view addressed models with respect to their uptake and use in the policy process. The main point here is that model use cannot be seen independent of the characteristics and perceptions of modellers and users. With regard to this point, many authors stressed that models are used effectively if they are accepted by users and if users are involved in different stages of model development. There is, however, a downside as with interactive approaches. The researcher is merely involved in the process and steps down from the position of a neutral external observer. Moreover, many models developed with some policy interest are not developed for the purpose of policy analysis and support. Here, a clear distinction should be made with regard to the intention of the approach. However, given the previous arguments there appears to be some difficulty in developing models which are equally recognised and trusted in the scientific and the user communities. This can only be reached if scientists and users have developed a shared understanding. With the thoughts in this paper we hope to stimulate and to motivate researchers as well as policy-makers to actively engage in a mutual learning process. In this process, models have and should have the role to support the thinking of highly informed and knowledgeable individuals. In order to govern the agri-food system effectively and to adapt to changing framework conditions, it is essential to develop a thorough understanding of and knowledge about the system. Hence, one may assert that the role of model-based policy analysis, for it to be of value and use, is likely to change from pure quantitative prediction using large-scale integrated models towards qualitative analysis using smaller scale tools. The objective of these is to better understand and learn about the systems than to quantify impacts under the restriction of abstraction of the system's complexity and dynamics. In this sense models are and should be used as virtual laboratories and tools to think with; but they should not replace human decision-making.

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