Chapter 26
Operationalizing Climate Proofing in Decision/Policy Making

Carlo Giupponi

Abstract The purpose of this work is to present an operational approach to include consideration of global change drivers (climatic, economic, social, etc.) in support to the design of local policies or investment plans. In both cases decision/policy makers typically have sets of plausible solutions and decisions to be taken in terms of choices among sets of plausible solutions with the best knowledge about the future dynamics of endogenous and exogenous system variables. The ambition is to identify the preferable solution(s) (in terms of technical performances, acceptance by stakeholders, cost–benefit ratio, etc.) in a medium term perspective, (e.g., 10–40 years), with current knowledge about the problem and under the effect of important sources of uncertainty (both aleatory and epistemic). Common to most decision contexts in a medium term perspective typical of both investment decisions and adaptation policies is the prevalence of economic signals in the shorter term and of climatic signals in the longer term. Models play a fundamental role in both cases, but they rarely cover the whole set of variables needed for decision making and the outcomes usually require integration of qualitative expert knowledge or simply subjective judgements. Multi-criteria analysis coupled with uncertainty analysis can contribute with methodologically sound and operational solutions. This paper elaborates on a series of recent cases with the ambition to extract common elements for a general methodological framework.

Keywords Decision support · Uncertainty · Modelling · Regional scenarios · expert-based assessment

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Introduction

It has become clear that climate changes resulting from the combination of anthropogenic sources (greenhouse gases) and natural dynamics are already affecting social and ecological systems, to which adequate responses must be identified and implemented. The European Union approached the problem through the EU Adaptation Strategy (EU 2013a), with a series of documents and instruments, including the "Guidelines on developing adaptation strategies" (EU 2013b), identifying six main steps of an adaptation process. The three central steps are strongly related to modelling activities (see Fig. 26.1); for example, the assessment of risks and vulnerabilities requires the support of climate change modelling, but also, very importantly, it is only trough integrated modelling that the expected performances of alternative adaptation options can be assessed and thus final decisions about strategies can be taken.

Altered frequencies and magnitude of climate related phenomena (e.g., droughts, storms, floods) affect socio-ecosystems and decision makers have become aware of the importance to include climate risks in medium to long term decisions, both in the policy sector in general and in the financial and economic activities in particular. However, signs of climate change effects always appear in combination with other signals, particularly those deriving from the evolution of markets and policies on different scales (see, e.g., Arnell et al. 2011).

Therefore, entrepreneurs and public decision makers have to define effective development strategies, necessarily taking into account the combined effects of all

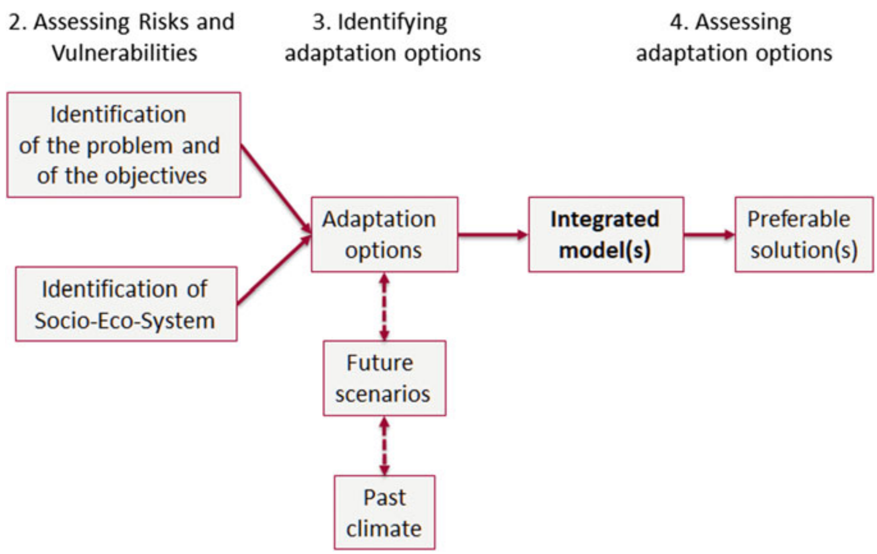

Fig. 26.1 Block diagram showing the contribution of integrated modelling to the identification of adaptation options, following three steps of the EU Guidelines on developing adaptation strategies

the drivers and their dynamics and interrelationships. What they often ask climate change experts is to provide solutions for climate proofing of plans and projects, i.e., to operationalize the available knowledge deriving from climate change integrated modelling and bring it to the decision making process to improve it. In practice, this means to include sources of uncertainty related to the future trajectories of socio-economic development and climate change.

The high level of uncertainty about future evolutions of multiple drivers makes the assessment of risk and resilience a challenging task for analysts and decision-makers. The level of unpredictability of these drivers is known to be deep, since changes have yet to be experienced and knowledge is limited both in terms of modelling (from conceptual to mathematical ones) and in the quantification of these uncertainties. In existing literature, such premises are generally referred to as a situation of deep uncertainty (Lempert and Collins 2007; Lempert and Kalra 2013). Therefore, the need emerges to assist decision-makers not by providing them with an optimal solution based on past trends or a few plausible scenarios, but rather with an analysis able to provide ranges of possible future outcomes under wide sets of plausible scenarios in order to identify robust solutions. As compared to optimal ones, robust solutions are those that show relatively limited cases of failure in a high number of possible future conditions.

A decision-making approach based on the identification of robust solutions (Robust Decision-Making or RDM) has been implemented in several different contexts, such as agriculture, resource management and strategic infrastructure. Public and private investments in maintenance, in protection and in the development of critical infrastructures, i.e., electric power plants, telecommunication and transportation networks, are essential to the functioning of society as a whole. Similarly, effective adaptation policies typically require substantial investment of financial resources, impose chances to consolidated behaviour, and may introduce distributive effects so that in both cases one could say that they should be considered “too important to fail”.

A series of recent decision support experiences (private infrastructural and industrial developments, regional policies, etc.) allowed us to extract common needs and solutions and to propose here a methodological framework that could be used to integrate modelling efforts into operational decision making for climate proofing (see, for example, Bernhofer et al. 2019).

The purpose of this work is to present an operational approach to include consideration of global change drivers (climatic, economic, social, etc.) in support to the design of local policies or investment plans. In both cases decision/policy makers typically have sets of plausible solutions and decisions to be taken in terms of choices among sets of plausible solutions with the best knowledge about the future dynamics of endogenous and exogenous system variables. The ambition is to identify the preferable solution(s) (in terms of technical performances, acceptance by stakeholders, cost–benefit ratio, etc.) in a medium term perspective (e.g., 10–40 years), with current knowledge about the problem and under the effect of important sources of uncertainty (both aleatory and epistemic). In both cases decision/policy makes typically have sets of plausible solutions and decisions to be taken in terms of choices. Common to most decision contexts in a medium term perspective typical of both investment decisions and adaptation policies is the prevalence of economic signals in the shorter term and of climatic signals in the longer term. Models play a fundamental role in both cases, but they rarely cover the whole set of variables needed for decision making and the outcomes usually require integration of qualitative expert knowledge or simply subjective judgements. Therefore, both sources of uncertainty should be integrated in the process.

Methods

The proposed approach is aimed in general at analysing alternative options (plans, policies, projects) affected by climate risks or related to climate change adaptation. Such investments are usually characterized by considerable initial and maintenance costs and must therefore be carefully chosen by assessing potential benefits, trade-offs and interactions with the existing settings.

Six main steps are foreseen—developed upon the framework of the EU Guidelines shown in Fig. 26.1—with possible iterations and are depicted in the block diagram of Fig. 26.2.

The first step consist in the identification of the objectives of the actions to be implemented and of the socio-ecosystem (SES) involved, in order to, e.g., identify the boundaries of the system, exogenous and endogenous variable, and the main interacting elements.

In the second step, stakeholders are involved to develop a shared conceptual model of the SES and the main cause-effect relationships between its social, economic and environmental elements, to define the needs for simulation models and other data processing tools, such as spatial analysis ones, together with the required inputs in terms of information to be acquired.

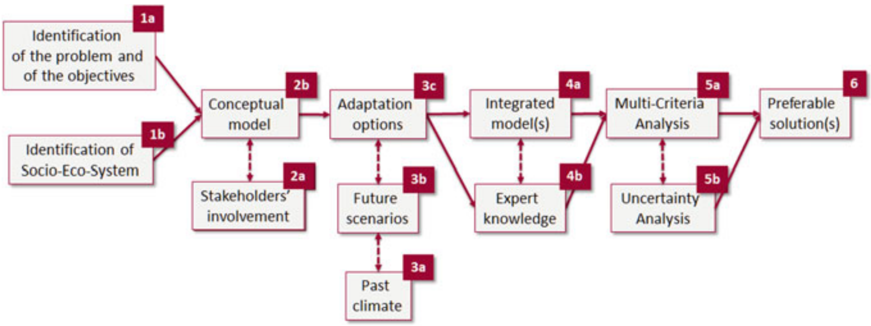

Fig. 26.2 Block diagram for the proposed approach integrating modelling, expert knowledge, scenario analysis, multi-criteria analysis and uncertainty analysis for climate change adaptation

The definition of the conceptual model allows—in a third step—to identify a set of plausible solutions to the given problem and in the specific SES in question. In parallel to that, scenarios to explore how the future may unfold are defined. Exploratory scenarios typically describe plausible trajectories of variables related to different aspects of the future and are used to analyse the possible consequences of predefined assumptions on the evolution of the most important driving forces. In climate change applications, scenarios try to represent the main driving forces deemed relevant so as to bring the correct information into the selection of policies in response to climate changes (Swart et al. 2004; van Vuuren et al. 2012). Scenario development should be done by referring to the most important exogenous variables identified in the first step of the approach, as distinct future situations (e.g., 5 SSP's or N combination of SSP's and RCP's) or, better, as sets of intervals of possible manifestations of the variables. Obviously, the goal in scenario analysis is not to predict the future but to gain a better understanding of possible future alternatives to be able to assess how robust the different decisions or options can be within a wide range of plausible futures. The development of participatory scenarios is increasingly used to stimulate local actors to consider changes that had not been contemplated previously, create integrated images of a future that must be considered in continuous evolution and ensure that multiple skills and subjective interpretations are taken into account, hence strengthening their legitimacy and relevance.

In the following—forth—step, models are utilised, together with expert knowledge. Global models have low resolution as they describe the processes on a continental or a regional scale. In the transition from the global to the local analysis phase (downscaling), many quantitative methods based on mathematical models have been proposed (for an example of integrated models, see Popp et al. 2017). However, the international literature (Lempert et al. 2004; Swart et al. 2004; Alcamo 2008; Van Vuuren et al. 2012) recognises the limits of purely quantitative tools and therefore generally opts for approaches that integrate quantitative analyses with those that use expert judgement (for recent examples, see Palazzo et al. 2017; Kebede et al. 2018). Participatory qualitative scenarios are used to create new ideas and strategies, clarify the options and identify future problems and opportunities, thus incorporating more points of view (Maier et al. 2016).

In the fifth step a classical multi-criteria analysis (MCA) is combined with uncertainty analysis (UA), with which the multiple dimensions of the problem are assessed through decision-relevant indicators (e.g., investment costs, resilience enhancement, environmental impact). In order to offer involved actors methodological solutions with interfaces that could be understood by all, a DSS software was used in our experiences (mDSS; Giupponi 2014). The traditional deterministic MCA is here evolved into a multi-scenario sensitivity analysis by introducing the consideration of various sources of uncertainty (e.g., scenario variables, subjectivity, risk attitude of the decision makers). Numerous MCA matrices are generated to approximate the performance of each alternative and create a range of possible outlooks. The deficiencies of each option under different sets of scenarios are determined; and, based on the above assessment, the robustness of each solution is defined, following the methodology of Rosenhead (1980a, b). In order to provide an effective interface for decision makers, data mining techniques are applied to the multitude of results obtained. The CART (Classification and Regression Trees) algorithm here allows for an identification of critical score values able to overturn the final ranking (step 6) to be shared with the involved actors.

The combination of the various components of the proposed methodology results in a comprehensive and intuitive decision support system that helps the decision-maker to mitigate the impacts of uncertainty and to increase the system's adaptation and resilience to scenario changes, by identifying the most robust solution, which is to be interpreted as the option that ranks best under most of the simulated alternative scenarios.

Applications

Variants of the approach presented above have been applied in various contexts. As applications in support to planning, the Outlook 2030 project and the CORASVE projects financed by the Veneto Region administration can be mentioned. In the first case, sets of measures in consideration for the future Rural Development Plan were analysed through a sequence of expert workshops, vis a vis the alternative scenarios deriving from downscaling of IPCC SSP's at regional level. Similarly, in the CORASVE Project the approach was applied in support of the analysis of measures proposed for a general conference on agriculture, still in support to the RDP. Among projects in support of private investments and planning, applications were in the field of climate proofing of hydraulic safeguarding of infrastructures, decarbonisation and renewable energies, and other economic activities, such as tourism and electric power distribution, all with the involvement of the main local stakeholders (local administration, SMEs, big farm, port authority) in the assessment of strategies under the effect of future climatic scenarios of normative and market evolutions.

Conclusions

Decision making for climate change adaptation is affected by deep uncertainty, i.e., by the lack of agreement about how the future will look like, about probability distributions and about parameter values. This has serious consequences for modelling exercises that can only partially dealt with by running model ensemble simulations. Moreover, climate change drivers must be considered jointly with others and in particular with socio-economic ones.

Outputs of modelling exercises cannot be immediately used by decision/policy makers; instead, they have to be integrated with other sources of knowledge (local, collective, subjective, qualitative,…) and jointly implemented within an integrated platform for decision support.

A combination of qualitative and quantitative modelling, with multi-criteria analysis and data mining techniques, can significantly improve the potentials of modelling techniques alone.

Hence, instead of following the traditional path of assessing discrete and deterministic, or in some cases probabilistic, values and searching for optimal solutions, decision-making for climate change adaptation requires lying out all the conditions under which plausible solutions may emerge and search for more robust options. Decision-makers are thus informed about how far unknown future events led by various related or isolated factors may influence their ability to adapt and cope with the negative consequences and the positive opportunities that may arise.

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