ECONADAPT

The Economics of Adaptation

Funded by the European Union

Policy recommendations, lessons learned and guidance: Case study on Policy Impact Assessment

Authors: Anne Biewald[1], Tatiana Ermolieva[2], Esther Boere[2], Ekko van Ierland[3], Alistair Hunt[4]

Deliverable number	D7.4
Work Package Number	WP7
Submission date	2.9.2016
Type of Activity	RTD
Nature	R = Report
Dissemination level	Public

[1] Potsdam Institute for Climate Impact Research (PIK).
[2] International Institute for Applied Systems Analysis (IIASA).
[3] Wageningen University
[4] Bath University

Document information

Title:	Policy recommendations, lessons learned and guidance: Case study on Policy Impact Assessment
Authors:	Anne Biewald (PIK), Tatiana Ermolieva (IIASA), Esther Boere (IIASA), Ekko C. van Ierland (Wageningen), Alistair Hunt (Bath)
Other Contributors	-
Date:	29.08.2016
Contact details	biewald@pik-potsdam.de
Work Package Number	WP7
Deliverable number	D7.4
Filename:	ECONADAPT_ D7.4.docx
Document history:	Final version 2
Type of Activity	RTD
Nature	R = Report
Dissemination / distribution level	PU = Public
Citation:	Biewald, A., Ermolieva, T., Boere, E., van Ierland, E. C., and Hunt, A. 2016, Policy recommendations, lessons learned and guidance: Case study on Policy Impact Assessment ECONADAPT Deliverable 7.4.
Copyright:	ECONADAPT Project

The ECONADAPT project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 603906.

To find out more about the ECONADAPT project, please visit the web-site: www.econadapt.eu

For further information on the ECONADAPT project contact Alistair Hunt at: ecsasph@bath.ac.uk

Summary

Policy impact assessment is an essential part of policy making. With a changing climate and the resulting increased risk of climate-change induced negative impacts in all policy areas, policy appraisals taking into account the potential of a policy to enhance adaptive capacity are essential. We identify in this report six key elements that can support appraising complex policies that aim to increase adaptation towards climate change: 1. Interdependence of policies, 2. Monetary and non-monetary costs and benefits 3. Intergenerational justice and multi-time levels, 4. Risk and uncertainty, 5. Simultaneously assessing different objectives, 6. Interlinkages between sectors. Conventionally used tools, such as cost-benefit analysis, cost-effectiveness analysis, multi-criteria analysis, as well as standard integrated assessment modeling do not cover these four aspects sufficiently. Using an alternative approach, we show how a stochastic integrated modeling framework can appraise different policies of the Common Agricultural Policy, resulting in an optimal mix of policies that maximizes both monetary and non-monetary benefits.

Policy impact assessment guidelines of the European Commission support the procedure of policy appraisal. As (Stochastic) Integrated Assessment Models are not yet part of these guidelines, we have developed suggestions on how these could be integrated. Specifically, we propose the following additions to the policy impact assessment guidelines of the EC:

1. To include in section 7 of the guidelines, on the definition of policy options, an additional paragraph with the following header: How will the proposed policy interact with already existing and newly developed policies?
2. To add in section 8 of the guidelines a remark, referring to the possibility of using stochastic IAMs to evaluate monetary and non-monetary costs and benefits.
3. To include the wellbeing of future generations in section 8 of the guidelines, refining the existing sentence to: "*Identify who is affected by these impacts (including those outside of the EU* ***and future generations****) and in what way".*
4. To expand the description of risk assessment in section 5.3 of the guidelines by the proposition of using different scenarios based on IPCC's Shared Socioeconomic Pathways.
5. To name (Stochastic) Integrated Assessment Models additionally as one of the tools for policy appraisal listed in section 9 of the guidelines in order to be able to assess simultaneously different objectives,
6. and to be able to understand interlinkages between sectors

Mainstreaming adaptation to climate change in the to-be appraised policies is already considered in the guidelines in Table 3, Section 8 with the question: "Does the option affect our ability to adapt to climate change?" We, therefore, consider that the appraisal of adaptive capacity of policies is in principle sufficiently integrated in the guidelines.

Table of Contents

1. Introduction

The costs of taking action to address climate change will be much lower than the costs of inaction over the long and medium term (European Commission, 2009a). Therefore it is essential to design policies that consider climate change and ensure that these policies are designed in a way such that adaptive capacity of the corresponding sector can be enhanced (mainstreaming adaptation).

In Work Package 7 of the ECONADAPT project, we used the Common Agricultural Policy (CAP) as a case study to investigate how different policy strands within CAP combine to promote adaptation. This has comprised several strands. The first strand is a review of the EU CAP reform that uses a variety of means to scope out the problems and needs that decision-makers are faced with when developing adaptation policies in the context of the CAP reform in order to make the European agricultural sectors more climate resilient. This review is based on a literature study and stakeholder consultation and the findings are presented in detail in Deliverable 7.1. These included the following:

1. Although the current CAP already has several mechanisms to enhance adaptation and to pay more attention to sustainability and climate resilience, further strengthening of these mechanisms should be considered, informed by more substantial monitoring systems.
2. The set of options for mainstreaming climate adaption in the CAP ranges from simple provision of information on climate change and adaptation options in the context of the CAP policies, at one extreme, to a fundamental revision of the CAP mechanisms, at the other extreme. This leads to much larger shares of the CAP payments that are directly related to environmental targets and investments in adaptation.
3. Although the rural development and CAP policies aim at fostering a climate resilient agricultural sector in Europe, currently there still is a high risk that despite the large amount of CAP subsidies, or even as a result of these, the agricultural sector is developing in a direction that makes it more vulnerable to weather extremes that may occur under climate change.
4. The 2014 CAP reform pays limited attention to practical mechanisms that deal with the behavioural barriers related to adaptation decisions under long time horizons and uncertainty. While adaptation to climate change often requires a long-term perspective that enables investments in irrigation, water supply security, and changes in crops and cropping patterns over Europe, high discount rates that many farmers hold prevent these measures from being implemented. They are only likely to become viable if public-private partnerships are established.
5. A variety of alternative mechanisms are identified in the CAP that can be used to stimulate and facilitate adaptation including insurance, capacity building, networks, and partnerships. However, currently, it is not clear how the proposed measures will be implemented in practice and whether the speed and intensity of the actions are sufficient to provide the required resilience in the agricultural sector.

6. In the context of water quality management, the CAP support may currently lead to developments in manure management, nitrogen leakage, and eutrophication that aggravate existing problems. For this reason, it is important to harmonize the CAP system further with policy areas such as biodiversity conservation, landscape, and water and air quality.
7. Although private actors, farmers in the agricultural sector clearly have responsibility for adaptation to climate change, many farmers have imperfect information on climate change impacts and the adaptation options that are available and suitable. This implies that it is important to consider whether the financial means incorporated in current CAP arrangements can be used to provide stronger incentives to farmers to adapt to climate change and therefore to make the agricultural sectors in Europe more climate resilient and less greenhouse gas intensive.

Given these findings, and within a broad aim of adding support for further agricultural policy initiatives to promote climate adaptation, the second research strand reviews the evidence that exists on the modelling of climate risks and agriculture in the EU. To this end, 16 relevant papers following the so-called structural approach (the impacts of climate change on agricultural yields are modeled using crop models, and this output is fed into economic models) were screened.

The modeling set-ups in these studies are substantially different, the differences including: basic setups (time horizon, spatial resolution, regional setup, sectoral resolution for general equilibrium models); different reported variables, different definitions of these variables (e.g. prices), different baselines; choice of socio-economic scenarios; derivation of biophysical crop yield changes; inclusion of global trade relations and inter-regionally consistent climate change effects on crop yields, and adaptation assumptions.

The papers in the assessment found that while aggregate effects are relatively small, this masks large regional differences, in particular, more positive effects in Northern and negative effects in Southern Europe are found. Furthermore, effects in the agricultural sector are large compared to other sectors for Northern and Southern Europe. However, the inclusion of international trade effects - as well as explicitly excluding or including adaptation - is decisive for results and can potentially reverse signs.

In terms of recommendations for generating a consolidated and comprehensive picture of climate change effects on agriculture in Europe, the following were given: transparent and efficient communication between scientists and stakeholders on uncertainties; the need for a structured assessment of agro-economic impacts of climate change in Europe based on a suit of climate, crop and economic models, and including related sectors like water and energy; the agricultural products (crop types, grasslands, livestock) included in these studies needs to be extended, as well as the occurrence of weeds, pests and diseases; the need to include global trade effects, consistent climate change effects and adaptation in all regions, and; the policy relevance of the studies needs to be ensured, through close interaction with stakeholders, e.g. in the design phase of studies.

The third research strand undertakes an analysis of specific agriculture policy initiatives within the framework of the new CAP reforms. It uses an advanced policy appraisal method based on integrated modeling that combines socio-economic and biophysical complexities and integrates relevant uncertainties.

Within this approach, it is possible to model synergies and trade-offs on adaptation between policies with different objectives. By analyzing direct payments to farmers per ha as defined under Pillar I; and subsidization of physical investments and infrastructures such as storage, as defined under Pillar II, complementarities between policies are identified. The analysis shows that in some regions of the EU the introduction of grain storage increases not only the adaptive capacity towards climatic shocks, but also decreases water use, avoids investments in irrigation expansion, and stabilizes profits. When, for example, optimal per area payments to farmers are combined with storage facilities, the irrigated area in the EU will decrease by about 20% compared to the current implementation of the CAP (Ermolieva et al., 2016a).

In the next section, a number of important issues to be considered in the integration of adaptation in policy impact assessment are highlighted, together with discussion of the methodological requirements needed to address them. Following this, we outline how the EC policy impact guidelines can be adjusted to incorporate these factors.

2. Preconditions for policy appraisal integrating adaptation

To appraise a policy under the twin goals of evaluating its objective and its potential to enhance adaptive capacity in the face of climate change, a number of questions have to be considered. These include: (1) Is the policy measure inter-dependent with other policies? (2) Are there several benefits, including monetary and non-monetary? (3) Does the implementation of the policy have a positive long-term effect and avoid inflicting harm on future generations? (4) Is the fulfillment of the objective of the measure subject to uncertainty? (5) Are different objectives assessed? (6) Does the appraisal take the interlinkages between several sectors into account. The methodological challenges raised by attempting to respond to these questions are outlined in the following paragraphs.

Inter-dependent policies

Policy appraisals often concentrate on single measures (e.g. hard measures such as building dykes) and single objectives, insufficiently addressing the fact that each single policy can fulfill several objectives, and that different policies can enhance or impede each other's objectives. Therefore it is necessary to employ an appraisal methodology which can consider several policies at the same time and deduce an optimal mix of different policies to reach an anticipated objective. Clearly, a sophisticated integrated modelling framework is more likely to be able to undertake such an analysis.

Monetary vs. non-monetary benefits

Costs and benefits of policies can be monetary or non-monetary, but they are often evaluated in the context of a financial assessment. Such a financial assessment has a limited scope and ignores the costs and benefits that cannot be reflected in monetary terms and is therefore often seen as unsuitable to deal with issues where no distinct price or loss/cost can be associated, e.g. risk to human wellbeing or environmental impacts that are not expressed in monetary terms. An appraisal method which aims to integrate non-monetary benefits must therefore carefully consider which non-monetary costs and benefits could potentially accrue from a policy and how they can be measured. Increasingly, cost-benefit and cost-effectiveness analysis incorporate non-financial impacts in monetary or physical terms, respectively, though such efforts are still far from being comprehensive. Multi-criteria approaches explicitly highlight non-financial elements also, and these can be incorporated in integrated modelling approaches.

Multi-time horizon, intergenerational justice

The trade-off between different policy measures is highly dependent on the time horizon at which it is analyzed. Under a short time-horizon, low initial costs are essential. Under a long time-horizon, high initial costs can be acceptable if the resulting benefits can be reaped for a large number of years. Also, long-term policies targeting - for example - infrastructure investments will have an impact on future generations, and are therefore subject to intergenerational justice.

Discount rates are used in traditional appraisal approaches to represent the extent to which today's society values costs and benefits in future time periods. However, to the extent that future benefits are weighted less than near-term benefits, these rates can also lead to a low incentive to invest in policies which are beneficial to future generations. An appropriate discount rate is especially difficult to define when decisions involve a time span beyond the planning horizon of the current generation, since market interest rates do not reflect the preferences of future generations (Arrow, 1996).

As a potential way to avoid the pitfalls of high current discount rates, appraisal methods should integrate the timing and phasing of policies. This means that appraisal methods need to focus both on low-regret actions today as well as include the capability for continuous evaluation and learning processes in considering policies with long lifetimes. This is the key principle addressed by the real options analysis (ROA) appraisal method (Linquiti and Vonortas (2012)). It is also likely to be advantageous to consider longer time horizons than are currently incorporated in policy appraisals.

Risk and Uncertainty

Appraising policies using only a single scenario can result in the risk of irreversibility and sunk costs if a different scenario materializes. The trade-off is therefore between how much to act now and how much to act when more information relating to specific uncertainties is revealed (Chichilnisky and Heal 1993). This links strongly with the discussion of the role of learning highlighted above, and the potential use of real option analysis approaches to appraisal.

For an effective policy appraisal under uncertainty, it is also necessary to investigate a mix of a number of potential measures under a range of different climate and socio-economic scenarios. Only when accounting for various climate risks and multiple adaptation measures under different degrees of uncertainty, is it possible to deal with issues of interdependent (systemic) risks, sunk costs of maladaptation, and the costs of reversing decisions (e.g. if a different than expected scenario occurs). These concerns are beginning to be addressed in the project appraisal literature through the testing of portfolio and robust decision analyses (e.g. Van der Pol et al. 2016).

Assessing different objectives at the same time - Mainstreaming adaptation

Adaptation is more and more recognized to be an important part of any policy, as unavoidable climate change will affect every part of our society. To integrate the ability of policies to enhance adaptive capacity, as well as contributing to prior development objectives is, therefore, essential. The use and evaluation of multiple objectives, therefore, needs to be a part of policy impact assessment (PIA).

Interlinkages between systems

Related to the discussion of multiple objectives and non-financial costs, the impact of a policy on other activities outside the focus of policy concern should be recognized. Traditional PIAs tend not to integrate the interconnected natural and anthropogenic systems, and other interdependencies. They do not take interlinkages between sectors into account and thereby cannot analyze the result of a policy scenario on the stability of systems. Therefore, they do not reflect the actual costs and benefits to society, because they focus on only one sector, not including externalities or other impacts that occur in other sectors. An appraisal, especially of complex policies, should take such interlinkages into account. These inter-linkages are not always captured in traditional economic analytical tools such as CBA and CEA that are based in partial-equilibrium analytical principles. The use of extended partial equilibrium and general equilibrium modelling approaches are likely to be useful to explore in this regard.

Stochastic integrated assessment modeling as an advanced form of policy appraisal

In the context of agricultural policy in the EU, our third research strand has highlighted that a sophisticated, but also substantially more resource consuming, way of assessing the economic dimensions of adaptation options in policy impact appraisal is the utilization of integrated assessment models (IAMs). IAMs have become a common tool for addressing the strategies to cope with the negative effects of climate change. There have been several ways to include adaptation in IAMs (a more detailed description can be found in Patt et al., 2010). The first is implicit adaptation where e.g. farmers react to changes in yield by shifting to more profitable crops to maximize profits. This approach has come under criticism for two main reasons: (1) Applied in a partial equilibrium approach it does not consider changes in prices of different commodities, which affect resource allocation e.g. the greater need for irrigation water, (2) It does not take into account the additional costs from changing from one production system to another.

In ECONADAPT, we have used the stochastic partial equilibrium price-endogenous land use model Global Biosphere Management Model (GLOBIOM) as an example of designing robust policy decisions under uncertainties, maladaptation, and irreversibility (Havlík et al., 2011). Stochastic GLOBIOM is based on the principles of a two-stage (two types of solutions) stochastic optimization framework (Ermolieva et al., 2016b). This approach enables coherent analysis of both ex-ante measures (taken in front of uncertainties) and ex-post measures (to adjust initially taken decisions when additional information becomes available). The approach minimizes total costs of the decisions providing policy makers with flexibility for revising the measures in light of newly acquired knowledge about uncertainties (O'Neill et al. 2006).

Stochastic GLOBIOM is applied for the analysis of different CAP measures intended to support EU farmers in dealing with climate change and production risks. The model explicitly accounts for various types of uncertainties, (systemic) risks and climate variability. The set of ex-ante (strategic) measures comprises production allocation, storage capacities for staples, where the ex-post operational decisions concern the level of demand, trading, and storage control. In Ermolieva et al. (2016b) the model is applied to the case of increased food storage facilities, which can be viewed as catastrophe pools to buffer production shortfalls and fulfill regional and global Food-Energy-Water-Environment Security requirements when extreme events occur. The effects of storage capacities on expected shortfalls can be measured using the Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) risk measures. Our analysis is an IAM analysis as it focuses on both biophysical and economic processes, but it is still partial as it simulates only the agricultural and forestry sectors. However, GLOBIOM can be efficiently linked with other sectoral models such as e.g. the energy sector model MESSAGE. Although not exhaustive, reversible "low regret" adaptation measures are modelled that are short-term and address current climate variability, such as different direct payment measures, and autonomous adaptation of switching to less impacted and more profitable crops. More structural, long-term measures may relate to the construction of irrigation schemes or storage facilities. All these measures can be part of the CAP, meaning that estimating their costs and benefits are an important part of the policy appraisal and do not require additional public expenditures. Finding the optimal mix and level of these measures means also finding the maximal synergies between existing agricultural policies which aim at supporting farmers and providing ecosystem services and the optimal level of adaptation and reduction of negative climate change impacts, and finally understanding how a given public money flow can be transformed in the most efficient way. Mainstreaming adaptation options into existing policies is an important step in advancing the economics of adaptation and has rarely been done yet on a larger than national level (Watkiss et al. 2015).

GLOBIOM also covers the complexities of the economic interaction between different agricultural sectors, countries, and continents. All modeled measures and impacts are influenced by production and demand in other regions through trade policies. In the model, climate change-related shocks and systemic risks of various kinds are explicitly covered and can be analyzed and mitigated in all their interactions.

Our analysis assumes that the goals of the CAP such as secure food provision, sustainable management of natural resources and balanced territorial development are in harmony with the goal of adaptation to reduce the negative impact of climate change on agricultural production. But this is not necessarily the case under existing technologies. A sustainable management of natural resources might require new (not yet implemented or/and existing) technologies for sustainable land use management and food-energy-water-environment security. The stochastic GLOBIOM, as it has been discussed with the example of storage facilities, estimates the "deficit" (shortfall) of such technologies.

The systemic interconnectedness between regions (e.g., through markets or food chains or producers of a certain commodity) is often considered beneficial. However, as we can show, it can increase the vulnerability to shocks when interconnectedness is too strong as the damage of one component can have severe impacts on other components or even destroy the entire system.

Stochastic GLOBIOM includes systemic risks and security (safety) criteria enabling to buffer various shortfalls and meet Food-Energy-Water-Environment Security requirements at regional and global levels, which is important for planning agricultural development policies. The criteria also include targets and norms on the emission of greenhouse gases, water, and fertilizer utilization norms. Instead of using scenarios and investigating several possible futures, stochastic GLOBIOM employs all relevant uncertainty scenarios on yields to account simultaneously for different policies and derive measures that are optimal (robust) with respect to a range of possible scenarios. This provides policy makers with one integrated perspective on policy making instead of a multitude of suggestions on which they can base their decision.

3. Suggestions for improving PIA guidelines of the EC

Recognizing that a well-performed policy appraisal is a key part of good policy making, the EC provides Policy Impact Assessment Guidelines (PIA) for preparing policy proposals (European Commission, 2009b). In the light of the issues highlighted above, we make concrete recommendations as to how the current PIA guidelines can be enriched by taking into account additional evaluation criteria and evaluation tools. In combination, this could improve the assessment of complex policies in the face of climate change.

Interdependence of policies

In the PIA guidelines interdependence of policies is not mentioned, although interactions between existing and new policies can in the worst case lead to counterproductive results and in the best case to the generation of synergies. Designing balanced and complementary policies can, therefore, create win-win situations. To integrate the impact of interdependent policies in the document, we would, therefore, propose in section 7 on the definition of policy options an additional paragraph with the following header: How will the proposed policy interact with already existing and newly developed policies? Answering this question in the context of the PIA would entail identifying policies that might in one or the other way interact with the proposal measure and evaluate if this interaction is fruitful or harmful. The latter can be done when using the stochastic IAM method as described above. Section 7 should, therefore, refer to section 9 where such an IAM methodology could be described.

Monetary vs. non-monetary evaluation

In section 8 of the PIA guidelines it is specifically stated that impacts should be assessed in qualitative, quantitative and monetary terms, meaning that non-monetary costs and benefits are explicitly included. In tables 1, 2 and 3 economic, social and environmental impacts are listed. This is a reasonably comprehensive list, including greenhouse gas emissions as well adaptive capacity. What is not mentioned however is how non-monetary costs and benefits such as, for example, the impact of cultural and biological diversity, or animal welfare should be measured. Although defining such non-monetary measures in the PIA guidelines would go beyond the scope of the document, one suggestion would be to highlight the necessity of evaluating the widest variety of impacts in different areas at the same time.

Intergenerational justice and geographical scope

A key part of the PIA guidelines is dedicated to the analysis of the impact of the different options (section 8). Persons who are affected have to be identified in and outside of the EU. However, impact assessment over long time horizons, potentially impacting also future generations, is not mentioned. We, therefore, suggest that in section 8 also the well-being of future generations should be included, for example by adding to the blue box on page 31 the term "future generations". A proposition for that would be: Identify who is affected by these impacts (including those outside of the EU ***and future generations***) and in what way.

Inclusion of risk and uncertainty

The way to approach risk assessments is described in section 5.5 of the PIA document through the following three steps: 1. Identifying relevant risks, 2. determining their probability, 3. and describing alternative ways to reduce identified risk. Although very important, from our perspective two decisive steps are missing:

(a) The risk assessment is based on only one baseline scenario (defined in section 5.3 of the document), but as explained above problems can occur when a different scenario than projected materializes. We therefore suggest that the entire appraisal and specifically the risk assessment should be carried out based on at least three scenarios. These baseline scenarios could be based on the Shared Socioeconomic Pathways (SSPs) defined in the IPCC process (O'Neill et al., 2014). We also stress that the choice of the scenarios is not trivial and has consequences for the proposed policies.

(b) In section 9 of the PIA guidance document, three ways in which the different options can be appraised are described. These are cost-benefit analysis, cost-effectiveness analysis, and multi-criteria analysis. None of these include a rigorous assessment of policies under uncertainty. We, therefore, suggest combining risk assessment with the three appraisal tools that are described in section 9 by, for example, integrating into this text descriptions of other appraisal tools, such as ROA, Portfolio Analysis (PA) and Robust Decision Making (RDM) that are being used in the project appraisal of adaptation options. The stochastic IAM we use in the agricultural policy context incorporates a number of the principles incorporated in these tools and could also be mentioned. Although still underdeveloped, not available for all sectors and only usable when run by those with expertise in these models, it can serve well as an assessment tool for complex policies under different scenarios and uncertainty. This would be an improvement compared to traditional risk assessment and predictions that analyze policy impacts on a scenario-by-scenario basis.

Assessing different objectives at the same time - Mainstreaming adaptation

"Integrating adaptation into EU key policy areas" (European Commission 2009a) as identified by the EC as one of the four pillars of the EU adaptation framework is important for guaranteeing that the different economic sectors can carry on with their tasks even within the circumstances of a changing climate (Altvater et al., 2011). Adaptation to climate change is therefore included in the PIA guidelines as one of the questions in Table 3 by asking: "Does the option affect our ability to adapt to climate change?" The impact assessment guidelines are therefore seen as an important instrument to ensure mainstreaming adaptation. Addressing this question could be made compulsory and it could be required that an example is given as to how this has been done for a specific domain of policy analysis, e.g. agricultural policy analysis.

Interlinked effects on different systems and sectors

Given the very detailed and comprehensive list in the tables 1-3 of the PIA guidance, on economic, social and environmental impacts, all relevant sectors of society appear to be covered. But as conventional tools may fall short of being able to incorporate the effect of a policy on different sectors, it may again be worthwhile to refer to the possibility of using, e.g. stochastic IAMs to integrate a multi-sector assessment where competing objectives need to be made explicit.

It lies in the nature of the PIA guidelines, which have to be applicable to each policy developed and implemented by the EU, to be very general. The PIA guidelines therefore concentrate on well-established tools that can be applied to a broad range of policies. But as shown above, the conventional ways to assess complex policies under uncertainty can be insufficient. In D7.3 we have shown that in the specific case of mainstreaming adaptation into the CAP, using a stochastic integrated assessment model has clear advantages over the usages of conventional assessment tools such as CBA. We therefore suggest that developing and using such models may be helpful for the appraisal of other complex policies in the face of climate change.

References

Altvater, S., Görlach, B., Osberghaus, D., McCallum, S., Dworak, T., Klostermann, J., van de Sandt, K., Tröltsch, J., and Frelih Larsen, A. (2011). Recommendations on priority measures for EU policy mainstreaming on adaptation (Berlin: Ecologic Institute).

Arrow, K.J. (1996). The theory of risk-bearing: Small and great risks. J. Risk Uncertain. 12, 103–111.

De Bruin, K., and Ansink, E. (2011). INVESTMENT IN FLOOD PROTECTION MEASURES UNDER CLIMATE CHANGE UNCERTAINTY. Clim. Change Econ. 02, 321–339.

Chichilnisky, G., and Heal, G. (1993). Global Environmental Risks (Columbia University, Department of Economics).

Dixit, A.K. (1994). Investment under uncertainty (Princeton, N.J.: Princeton University Press).

Ermolieva, T., Biewald, A., Boere, E., and Havlik, P. (2016a). Report on major uncertainties related to climate impacts and socio-economic costs, and policy recommendations related to the effectiveness of adaptation options.

Ermolieva, T., Havlík, P., Ermoliev, Y., Mosnier, A., Obersteiner, M., Leclère, D., Khabarov, N., Valin, H., and Reuter, W. (2016b). Integrated Management of Land Use Systems under Systemic Risks and Security Targets: A Stochastic Global Biosphere Management Model. Journal of Agricultural Economics, 67, 584–601

European Commission (2009a). White paper - Adapting to climate change: towards a European framework for action — European Environment Agency.

European Commission (2009b). Impact Assessment Guidelines. At: http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/iag_2009_en.pdf

Füssel, H.-M., and Klein, R.J.T. (2006). Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. Clim. Change 75, 301–329.

Havlík, P., Schneider, U.A., Schmid, E., Böttcher, H., Fritz, S., Skalský, R., Aoki, K., Cara, S.D., Kindermann, G., Kraxner, F., et al. (2011). Global land-use implications of first and second generation biofuel targets. Energy Policy 39, 5690–5702.

Kip Viscusi, W., and Zeckhauser, R. (1976). Environmental policy choice under uncertainty. J. Environ. Econ. Manag. 3, 97–112.

Linquiti, P. and N. Vonortas (2012) The Value of Flexibility in Adapting to Climate Change: a Real Options Analysis of Investments in Coastal Defense. Climate Change Economics, May 2012, Vol. 03, No. 02

O'Neill, B., Ermoliev, Y., and Ermolieva, T. (2006). Endogenous Risks and Learning in Climate Change Decision Analysis. In Coping with Uncertainty, (Springer Berlin Heidelberg), pp. 283–300.

O'Neill, B.C., Kriegler, E., Riahi, K., Ebi, K.L., Hallegatte, S., Carter, T.R., Mathur, R., and Vuuren, D.P. van (2014). A new scenario framework for climate change research: the concept of shared socioeconomic pathways. Clim. Change 122, 387–400.

Patt, A.G., van Vuuren, D.P., Berkhout, F., Aaheim, A., Hof, A.F., Isaac, M., and Mechler, R. (2010). Adaptation in integrated assessment modeling: where do we stand? Clim. Change 99, 383–402.

Pindyck, R.S. (2000). Irreversibilities and the timing of environmental policy. Resour. Energy Econ. 22, 233–259.

Ranger, N., Millner, A., Dietz, S., Fankhauser, S., Lopez, A., and Ruta, G. (2010). Adaptation in the UK: a decision-making process | Grantham Research Institute on climate change and the environment.

Ulph, A., and Ulph, D. (1997). Global Warming, Irreversability and Learning. Econ. J. 107, 636–650.

van der Pol, T.D., Gabbert, S. ,Weikard, H.-P. , van Ierland, E.C. , and Hendrix, E.M.T. (2016). A Minimax Regret Analysis of Flood Risk Management Strategies Under Climate Change Uncertainty and Emerging Information. Environmental and Resource Economics, 20 August 2016, Pages 1-23.

Watkiss, P., Hunt, A., Blyth, W., and Dyszynski, J. (2015). The use of new economic decision support tools for adaptation assessment: A review of methods and applications, towards guidance on applicability. Clim. Change 132, 401–416.

Webster, M. (2002). The Curious Role of Learning in Climate Policy: Should We Wait for More Data? Energy J. 0, 97–119.

Wright, E., and Erickson, J. (2003). Incorporating Catastrophes into Integrated Assessment: Science, Impacts, and Adaptation. Clim. Change 57, 265–286.