Socio-Economic Research in Support of Climate Policy Development: Mistra's Research Program Clipore

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Abstract Mistra's Climate Policy Research Program, Clipore, is one of the largest research programs directed to support international climate policy development, involving research groups in Sweden, Norway, United States and India. It has been running from 2004 to 2011 with a budget of more than 100 MSEK (15 M USD). The paper briefly describes the program and its outcomes in relation to climate policy development. Discussion focuses on how the program has been able to be in the front of and include the development of emissions trading systems in Europe and the United States and how the program has been able to follow and produce inputs to the agenda of the United Nations Framework Convention on Climate Change (UNFCCC). The paper also discusses how the program has managed to present its outcomes and maintain an active dialogue with the various stakeholders. The paper emphasises options and obstacles in the communication between science and policy.

Keywords Climate policy · Science-policy interactions · Climate policy research

INTRODUCTION

The main objective of Mistra's¹ climate policy research program Clipore has been to support international policy development through scientific research on social and economic issues. The program differs from many other climate change research programs due to its ambition to develop and maintain a direct dialogue with policymakers and other stakeholders. Its long duration (more than seven years) and the involvement of research organisations from three continents also set it apart from most other research initiatives.

In this introductory paper to the Special Report of Ambio assigned to the Clipore research program, we will

discuss some of the characteristics and experiences of the program. We will also elaborate some general aspects of the relation between science and policy in connection with international environmental conventions.

Natural science has been in the centre of climate policy development over the last two decades. Scientific assessments have formed the basis for a general acceptance of the climate change problem and an imperative for actions, not the least for commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and through decisions at other levels. International climate research and the preparation of assessments are, however, not part of the Convention. Instead, research and assessments are mainly organised by actors who do not participate in the climate negotiations. For support to policy development, the UN has instead established a separate organisation, the Intergovernmental Panel on Climate Change (IPCC), under which new scientific results continuously are evaluated and integrated into reports with thoroughly prepared summaries.

Climate science has also been in the centre of climate policy with respect to its credibility and legitimacy. Some of the original research, and in particular, the way scientific results have been compiled and evaluated by IPCC, have been questioned. Even when criticism has been given considerable attention in the media, the main conclusions in the assessment reports have not been questioned in the negotiations, and climate change is today accepted by practically all countries as one of the most serious environmental and societal problems. Through the UNFCCC, all parties have agreed upon the needs for taking immediate

¹ Mistra, The Foundation for Strategic Environmental Research, Sweden, www.mistra.org.

and far reaching action to protect the earth from devastating temperature rise and climate change.

Science has thus set a frame for the international negotiations and objectives, but as the amount of findings and data increase and as negotiations become more complex, science is expected to be increasingly looked upon for policy support (Raes and Swart 2007). Experiences from other international environmental problems such as the protection of the stratospheric ozone layer under the Montreal Protocol and the protocols under the Convention on Long-Range Transboundary Air Pollution have shown the importance of advanced scientific support and a continuous dialogue between researchers and practitioners.

It is in this perspective the Mistra Climate Policy Research program Clipore was set up in 2004. The idea behind the program was that international climate change negotiations and agreements involve a large number of complicated issues related to social science and that social science research could support the climate negotiations system. Clipore was also set up in order to develop social science competence on climate change. It has been one of the largest international research programs on climate

policy, with an overall budget of more than 100 MSEK (15 M USD) involving eight research groups on three continents. The program has been running for two periods; Phase 1 between 2004 and 2007, and Phase 2 from 2007 to 2011 (Table 1).

SETTING PRIORITIES

The Clipore program had from the beginning two foci. The first was on the possibility of using financial and other instruments as tools for cost-effective emission control of greenhouse gases, with particular emphasis on the European Union and the United States. The second focus was on the development of the global political agenda with respect to the role of knowledge in international climate negotiations, leadership, relations between domestic and international policies and the possibilities and constraints of instruments involving developing countries. As the program progressed, it was extended, and in particular during Phase 2, broader aspects of international climate policy were included.

Table 1 Facts about the Mistra Climate Policy Research Program Clipore

Duration 2004–2011

Overall budget 107 M SEK (approx. 11 M Euro, 17 M USD)

Participating organisations and contact persons

Centre for Climate Policy Research (CSPR), Linköping University

Cicero, Oslo, Norway,

Department of Governance, Uppsala University.

Environmental Economics, Gothenburg University, Gothenburg, Sweden

IVL Swedish Environmental Research Institute, Stockholm and Gothenburg, Sweden

Resources For the Future (RFF), Washington, United States,

Stockholm Environmental Institute, Stockholm, Sweden

The Energy Research Institute (TERI), New Delhi, India

Program Host: IVL

Program managers: Phase 1: Deborah Cornland (2004–2007); Phase 2: Peringe Grennfelt (2007–2011)

Program Board chairs: Anders Turesson, Head of the Swedish Delegation at UNFCCC negotiations (2004–2006); Lars-Erik Liljelund, Special Advisor on Climate Change to Sweden's Prime Minister (2007–2010); Inge Horkeby, Director Environmental Affairs, AB Volvo (2010–2011).

Program Components:

Phase 1 2004–2007: The role of Emission Trading in Climate Policy (ETIC). Climate Science and Policy Beyond 2012 (CSP2012+).

Phase 2 2007–2011: Five work packages:

- Critical elements in the design and implementation of emissions trading
- Further developing the EU ETS
- A broader climate policy palette
- Interplay between climate change and development
- Legitimacy and Linkages: Institutional dimensions of effective international climate policy

Clipore Scholars: Assistant professors at University of Gothenburg and Uppsala University.

European Climate Platform: Joint seminar program together with Centre for European Policy Studies, Brussels. Under the ECP umbrella, 12 seminars have been organised.

www.clipore.org

Financial instruments were a central part of the political agenda after the final agreements on the Kyoto Protocol in Marrakech in 2001. The European Union decided in 2003 to use a cap and trade program to as an element in achieving its targets under the Protocol. Issues related to the design of such a program therefore became a key topic for Clipore; the collaboration between research groups in Europe and the United States, which had the experience of a similar program for sulphur dioxide, formed a strong basis for this research.

At the start of the program, issues related to long-term agreements—the situation after 2012—began to emerge and the design of such agreements also became an important part of the program. Initially, one strand of Clipore research addressed the role of science for building trust and legitimacy for policy proposals. The first decade of the climate convention saw several controversies around policy proposals revolved around scientific credibility. Scholars pointed at the “knowledge divide” between rich and poor countries as a challenge for the legitimacy of the negotiation process (cf. Linnér and Jacob 2005). Since then some developing countries have put considerable efforts into underpinning their proposals with scientific reports, such as the modelled attribution of historical emissions. Four country case studies were in focus: Sweden, China, the US and Brazil (Lahsen and Nobre 2007; Ye and Sun 2006). Clipore was also fairly early in giving attention to the co-production of science and policy on adaptation (Storbjörk 2007).

Phase 2 of the program, starting in 2007, became broader with the inclusion of other aspects of high relevance for future international climate policy. The research on financial instruments turned from mainly looking at the design of instruments to also take into account the experiences of the established systems in Europe and United States.

For the more global issues, the research program supported a long-term international agreement. Much of the research was directed to the so-called Bali Action Plan decided at COP 13 and the support for an expected agreement at COP 15 in Copenhagen 2009. The research included various aspects of all the four elements in the Bali plan: mitigation, adaptation, technology and financial issues. After Copenhagen, the program has focused on issues related to new mechanisms, i.e. the proposed Nationally Appropriate Mitigation Actions by developing countries (NAMAs), the meaning of the so-called Copenhagen Accord and the new policy landscape emerging with new coalitions and a larger involvement of the private sector. The program also became more integrated during Phase 2 and mutual benefits of the different activities appeared within several areas, which were presented at

high-level science–policy seminars held in Washington 2009, New Delhi 2010 and Brussels 2011.

CLIMATE POLICY SCIENCE IN RELATION TO EXTERNAL FACTORS

When setting up a research program to be run over long time (Mistra research programs normally run for 6–8 years) and which should interactively support policy processes, it is important to balance high-level research, which mostly has a long-term perspective, with the short-term and immediate needs appearing within the policy processes. As over the period since the program proposal was written in 2003, there have been dramatic changes in international society’s perception of climate policy and the needs for social science support.

When Clipore began, the United States was quite passive in the negotiations after George W. Bush decided in 2001 not to seek US ratification of the Kyoto Protocol; but in 2009, the Obama administration took an active line; and even if the situation in the US continues to be uncertain, American delegates now participate more constructively. At the same time, the full potential of China and India is becoming much clearer, putting the climate negotiations in a broader foreign policy and geopolitical framework.

Similarly, the deep economic and financial crisis has had a heavy impact on the climate negotiations, making financial support to developing countries much more difficult to realise and more generally taking a heavy toll on world leaders’ capacity to spend time on issues like climate change. The deep reduction in high-level political attention to climate change after Copenhagen is an example.

A number of other events impact climate politics and climate negotiations, making them more or less difficult, and influencing public opinion. New climate research influences the climate agenda, as do events such as the 2011 nuclear disaster in Japan. And there is no doubt that the recent decision by Germany on dismantling nuclear by 2022 could have a significant impact on new research and new investments in solar and wind.

Of course, research is by its very nature a long-term endeavour. A programme on policy research running over a period of 7–10 years should consider best ways to facilitate adaptation of the research process to meet the changes in policy priorities and processes.

SOME KEY FINDINGS AND THEIR LINKAGES TO POLICY

In this section, we highlight some of the key findings and indicate how these findings have found ways into policy.

Economic Instruments

Setting a price on carbon dioxide is considered a key factor for a successful climate policy. A high, stable and to some extent predictable price on carbon dioxide is expected to drive investments towards low carbon economies. Instruments such as taxes and cap and trade programs are therefore considered as being cost-effective ways to meet climate mitigation targets. Clipore already from its start in 2004 was strongly committed to study various problems associated with existing and proposed introductions of such instruments. Of particular importance was the development of a cap and trade program for the European Union, the so-called Emissions Trading System (EU ETS), which was launched in 2005, and became the main instrument for the EU to meet its obligations relating to the power sector and heavy industry in the first commitment period of the Kyoto Protocol 2008–2012 (European Commission 2003).

Cap and trade programs are strongly dependent on how they are designed and implemented. In several studies, Clipore investigated how efficiency is affected by allocation methodology. Key results from the multitude of studies produced under Clipore are presented in two other papers in this Special Report (Wråke et al. 2012 [this issue] and Zetterberg et al. 2012 [this issue]). There are several examples when results from Clipore research have been used for the design of the cap and trade programs in the European Union, the Regional Greenhouse Gas Initiative in the NE US, the proposals for US-wide cap and trade programs and the proposal for a cap and trade program in California.

Ground transportation is a rapidly increasing source of GHG emissions. Within Clipore, the effect of fuel taxes was studied. Even if fuel taxes (mainly in Europe and Japan) were not always introduced for environmental reasons, they have reduced carbon emissions at such a scale that the carbon dioxide content of the atmosphere would have been several parts per million higher in their absence. Had the US and other countries also had high fuel taxes, the effect would obviously have been still more significant. The acceptance of fuel taxes appears to be determined by consumption patterns: it is simply more difficult to raise fuel taxes in countries with large per capita consumption due to lobbying from affected parties (Sterner 2007).

Other Policy Instruments

Financial instruments are not enough for reaching long-term targets. Other strategies are necessary. Clipore has studied some of these possibilities from their social science perspective. One issue involves technological development and implementation of new technology. Our results show the importance of building technological capabilities at

national levels and the necessity that government support the development of emerging climate-friendly technologies (Fischer et al. 2012 [this issue]). Technology policies and their combination with market-based mechanisms are important in reducing long-term mitigation costs and reaching more ambitious emission cuts. Even if carbon pricing is the single most effective instrument for reducing emissions, targeted support for technologies is an important complement.

Carbon Capture and Storage (CCS) is considered as one of the tools for reducing the long-term emissions of carbon dioxide. The introduction of such policies is, however, not uncontroversial and the perception of this new technology has been a topic for Clipore research. Firms make regular media statements on CCS either to foster legitimacy or respond to criticism of CCS; interpretations of the technology take different forms depending on whether the related activity occurs in domestic or foreign markets. Media framings depend on domestic energy situations and politics. Corporations attempt to shape people's perceptions of CCS through the media, using specific language and reasoning by associating the technology with existing emerging systems (Buhr and Hansson 2010).

Clipore has also investigated pathways towards a long-term low carbon economy in Sweden, and how close to a zero emission target it is possible to come with sustained economic growth. We have identified the main potentials and barriers, implications for energy supply and discussed these findings with Swedish authorities and industry (Gode 2010).

Financing Adaptation

One of the key issues for global agreements is financing of adaptation. There is an agreement under UNFCCC that parts of the costs for adaptation in developing countries should be covered by the industrial world, which to the largest extent is the cause of the climate change adaptation problem. Various funds have been set up in order to support this process. Clipore has provided useful results on complexity of institutional structure and governance of adaptation finance (Persson et al. 2009). Results also indicate that the private sector must play a much greater role in generating adaptation finance if adaptation investment needs in developing countries are to be met. Further, mainstreaming adaptation into development is viewed with suspicion by developing countries, because it is seen as a way of avoiding the commitment to provide new and additional finance (Klein 2010).

Climate Change and Development

Clipore has included extensive work regarding the tension between climate change and development. The program

has contributed to the communication and substantiation of a conceptual framework for burden-sharing, i.e. Greenhouse Development Rights, plus disaggregated analyses of its implications for various countries and regions (Baer et al. 2009; Kartha et al. 2009).

The concrete policy suggestions for developing country commitments under the UNFCCC have also been an area of research. As an input to the Cancún negotiations, Clipore researchers suggested a registry for the Nationally Appropriate Mitigation Actions, which would differentiate between domestic, supported and allowance NAMAs. The registry includes details for linking actions and support and ensuring minimum sustainable development criteria (Linér and Pahuja 2012 [this issue]).

A particular emphasis has also been directed towards climate change policy development in India and its relation to international climate policies (Atteridge et al. 2012 [this issue]). This research has led to further development of collaboration on the reduction of greenhouse gases in India using financial mechanisms and other incentives.

Adaptation has received increasing attention as the program has progressed. One key product was the development and launch of the Adaptation Atlas as an online tool for bringing together scientific information on the impacts of climate change and on-going adaptation activities (www.adaptationatlas.org; Morris and Krishnan 2012 [this issue]). This project has now been fully implemented through support from other financial sources.

Governance and Leadership

Clipore researchers have analysed EU climate policies to examine the modes of international leadership, which EU has employed in pursuing its climate protection objectives (Karlsson et al. 2012 [this issue]). They conclude that the EU's own performance is crucial for its aspirations to be an influential leader in forging global solutions to address the climate change challenge (Parker and Karlsson 2010). The lack of empirical data and research about factors explaining how people identify national leaders in international climate policy-making became clear while doing this work and provided the spark for Clipore to fill these knowledge gaps by using survey data from the climate negotiations collected within Clipore since 2007. These analyses concluded that the structural position and the aggregate power held by different actors are not the most important explanatory factors with regard to the leadership perceptions of prospective followers. For example, the US has the greatest combined power resources and its position as one of the two largest GHG emitters makes it a key player in the field of climate change. Nevertheless, at COP 14 (Poznan), the US was only recognised as leader by roughly a quarter of all respondents (Karlsson et al. 2011).

When breaking down the data, important dimensions of leadership recognition were identified: There was a strong geographical component, as the various leadership contenders are more widely recognised as leaders in their "home constituencies" than among respondents in general. The survey also reveals that rather than looking to G-77 for leadership, developing country participants increasingly identify either the so-called large emerging economies within the BASIC group (Brazil, South Africa, India and China) or Small Island Developing States as leaders.

There is also some evidence of issue-specific climate change leadership; the pattern observed reflects the various elements of the Bali–Copenhagen process. China and the EU clearly emerge as leaders when it comes to mitigation and the issue of future agreements. However, among those respondents who report an interest in adaptation and equity issues, China is the strongest leadership candidate whereas the EU's position as a leader is substantially weaker. On energy and CCS, leadership is again shared between the EU and China, but on these issues a substantial proportion of respondents also see the US as a leader.

DELIVERING SCIENCE-BASED ADVICE

The idea behind Clipore was that science should interact more closely with policymakers and negotiators than what is normal in international climate negotiations and that the research should give appropriate views and advice of importance for policy. Clipore should thus form a direct and continuous dialogue with stakeholders, which would benefit both scientists and stakeholders. In this respect, the Clipore differs from many other research programs.

The Clipore communication strategy identifies three main arenas: (a) the UNFCCC process and its work towards long-term agreements, (b) the European Union with directions towards common European policies and (c) national needs including governmental organisations but in particular industry.

The Global Arena

The UNFCCC formal negotiation meetings, such as the Conference of Parties (COP), seldom offer possibilities for science to communicate directly at plenary sessions. Instead, the Convention high-level meetings have a well-established structure of smaller communication arenas in the form of so-called Side Events. These events are organised in parallel with the ordinary negotiations and form an opportunity for research organisations, NGOs and industries to present messages and forming fruitful dialogues. Clipore has to a large extent used the side events as a communication platform and was involved in more than

10 such events at COP 15 (Copenhagen). Clipore has also investigated the role of side events per se, through enquiries and interviews with both side event organisers and participants. These investigations show that side events have a value in particular for many developing countries (Hjerpe and Linnér 2010).

The European Perspective

One of the most important and fruitful initiatives within Clipore was the establishment of the European Climate Platform (ECP). The platform was set up as a joint venture between Clipore and the Centre for European Policy Studies (CEPS) in order to form a European science-based forum for a dialogue between negotiators and other stakeholders (industry, NGOs, scientists and other experts) in climate policy and science.² The starting point was that there is a need for science–policy interactions that go beyond reading reports and listening to presentations at various events.

Most of the interactions were set up as 1-day seminars. The model for these seminars was that for each topic there would be a background paper, a broad presentation and then a discussion through which the issue and its conclusions were more deeply penetrated. The topics were chosen after discussions within a steering group made up of the main stakeholders. Over the entire Clipore period, twelve such seminars have been held. Examples of issues that have been handled are the progress of the climate negotiations; EU relations with other parties in the negotiations, particularly the US and developing countries; the EU ETS; technology and investments; issues related to governance of climate funds within the UNFCCC; and various topics related to adaptation to climate change. The outcome of several of these seminars was then taken further and formed side events at UNFCCC meetings.

National Initiatives

Industry has throughout the entire Clipore program been a main stakeholder and industrial representatives are always invited to the ECP events. In Sweden, a number of industry-oriented seminars have been held, highlighting issues of particular concern as, for example, the consequences of cap and trade programs for competitiveness of industry.

² The European Climate Platform was led by a board co-chaired by Frank Convery, Heritage Trust Professor of Environmental Policy at University College Dublin and Bo Kjellén, Former Chief Climate Negotiator for Sweden. It involved several heads of delegations from EU countries, representatives from various industrial stakeholder groups etc. For more information see <http://www.ceps.eu/content/european-climate-platform>.

Our intercontinental participation also formed the basis for some larger communication events; in New York City in 2005, one in Washington DC in April 2009 directed towards the US–EU interrelations and one in New Delhi in November 2010 directed towards climate policies in developing countries and how these policies are linked to industrial countries. The timings of these events were carefully chosen and they attracted the participation of leading actors in the climate negotiations and high-level officials.

In addition, Clipore's scientific results and expertise have been frequently used by governments, industries and others, in particular in those countries involved in the program. There are several examples of activities where Clipore funded research directly supported policy development, e.g. with respect to the Waxman-Markey bill (US Congress 2009) within the US Congress and the shape of climate change policy in California. Another example is the numerous presentations of Greenhouse Development Rights to various stakeholders, including invited presentations to the IMF, The World Bank, and the International Development Bank.

The Clipore program also benefitted from a program board involving the climate policy advisor to the Swedish Prime Minister, the head of the Swedish delegation at UNFCCC negotiations, key stakeholders from both industry and the Swedish Energy Agency.

Clipore scholars have several times been invited as experts to workshops delivering testimonies that have fed directly into the EU and Swedish climate policy process. This is a result of the policy-driven research agenda that Clipore has pursued.

LESSONS FOR THE FUTURE

The possible role of social science has often been neglected in international environmental negotiations. Social science may, however, make contributions, in particular as negotiators are facing crucial questions such as how to share the burdens of emission reductions between countries or the burdens of costs for adaptation. In these and other fields, which are strongly politicised already before they are discussed at the negotiation tables, science can contribute through analysing not only obstacles but also possible ways forward. Research has to try to define the enabling national conditions, which are the foundation for negotiation instructions and for the capacity to implement international agreements. Much of the research in Clipore looked forward to the possibilities rather than just making retrospective studies of what has been done.

Clipore had a very broad agenda. The programme covered issues from economic instruments such as the

technical design of cap and trade programs to issues related to justice and effort sharing within the climate negotiation system. The breadth of the program had large advantages. It made it possible to discuss and study issues in a broad context. It also made it possible to pick up questions from stakeholders that were broader than the (often) narrow aspects that scientific research has to face. The breadth also caused some problems. It was sometimes difficult to define the core issue in the program and also to generate real interdisciplinary research. The issues were often not as unifying as one had hoped.

The program also included research activities on three continents. This made the program unique and made it possible to compare policies between different actors. It also made it possible to maintain a distance from national preferences and priorities.

The long duration of the program had several advantages. Linking different competences and establishing true interdisciplinary research take time. The same is also obvious for the science–policy relations. Credibility of research and scientists is formed over time and it is often

only through long-term relationships that it is possible to get messages through the general media noise. The length of the program also posed some challenges. It made it sometimes difficult to foresee which questions would be of crucial importance several years ahead. The program needed therefore to be interactive and keep an open agenda. The ways Mistra programs are organised are in this respect beneficial. The program plans are not set up with deliverables for the whole program. Instead the program works with annual plans, which had to be approved by the program board. It also reserves a substantial part of the budget to be used for emerging new issues, but also for additional activities in order to strengthen the science–policy relationships.

At the onset of Clipore, connecting science and decision-making spheres and to make research useful to decision-makers were increasingly called for by leading actors in sustainable development research (e.g. Clark and Dickson 2003; ICSU 2002; Kates et al. 2001). This call for research that is accountable for knowledge needs in society at large and policy makers in particular has come to

Fig. 1 Long-term policy development. A question yet to be solved. Photo by Lukáš Patkaň (Stock.xchng)

dominate sustainable development research (e.g. Sarewitz and Pielke 2007; Möbjörk and Linnér 2005). The use of knowledge in decision-making has proven to be a complex web of interactions. The traditional image of “truth speaks to power” has been rebuked by views that emphasise the mutual interplay or co-production of science (e.g. Lidskog and Sundqvist 2002).

Clipore had an outspoken core ambition to be useful for climate policy makers, negotiators and industry, not only through active science communication, but also through deliberative dialogues. Knowledge co-produced between researchers, policy makers and other stakeholders is expected to provide new perspectives, contextualise findings as well as “open up questions, provoke debate, expose differences and interrogate assumptions” (Wilsdon and Willis 2004). Inevitably it also involves ethical, business and political considerations (e.g. Jasanoff and Wynne 1998). Ideally the co-production of knowledge evolving from the close encounter of researchers and policy makers in the research process could lead to a re-examination of policy research and innovative outcomes. A key challenge for Clipore researchers has been to balance the call for usefulness with the risks of becoming biased towards the political and business interests of those stakeholders who had a chance of influencing the programmes’ research strategies.

In another major research program on climate policy, the EU funded Adaptation and Mitigation a: Supporting European Climate Policy (ADAM) also mirrored the call for useful research from climate researchers. In her analysis of the EU funded ADAM project, Löfbrand (2011) concludes that high pressure for science that was useful for the EU policy makers “‘closed down’ rather than ‘opened up’ the interpretations of feasible and desirable climate policy goals in the post-Kyoto era”. In comparison with ADAM, Clipore appears to have been less directed by high politics. Clipore’s primary strategy for reflecting upon biased influence on research focus and conclusions has been the heterogeneous composition of research groups. Different interests and social science background have allowed for a critical reflection on how usefulness might influence research focus and practice and vice versa.

However, judging from evaluations, the establishment of dialogues with the stakeholders have worked out well, and the evaluations of the program have confirmed the success and that Clipore has been important for policy. In particular, the European Climate Platform was a success and key stakeholders continuously showed up at these meetings. But in the long run we see a need for the establishment of new and more efficient pathways for social science to interact with stakeholders, in particular on the global arena. For the very difficult issues such as burden-sharing and forming fair and stable agreements, social science will certainly be of importance. However, social

science has so far been largely invisible. Researchers must continue to strive to make social science more relevant to policy makers and to promote the integration of social science into climate policy development. The Clipore program has provided a strong example of the benefits and challenges ahead (Fig. 1).

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