RESEARCH PAPER

Incorporating Co-Impacts into Climate Mitigation Planning
Experiences from Latin America

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Incorporating Co-Impacts into Climate Mitigation Planning
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1 INTRODUCTION

Countries are increasingly being faced with national and international pressure to reduce greenhouse gas (GHG) emissions. At the same time, developing countries in particular are faced with a variety of other developmental challenges, including preservation of degrading natural environments and a host of social issues, many of which relate to poverty alleviation. However, the two considerations are not independent: implementation of GHG mitigation interventions has a potential range of other positive and negative impacts (collectively referred to in this paper as “co-impacts”) while development action may be associated with changes to greenhouse gas emissions. Both mitigation and development actions may either be complementary (where mitigation action has positive development benefits or vice versa) or work in opposite directions. Arguments could also be made that the distinction between mitigation and development action is artificial, and in many cases they are one and the same thing.

Understanding the relationship between GHG mitigation and development has been an important theme in the work that has been conducted under the MAPS Programme (www.mapsprogramme.org) and in related work being conducted in India. The MAPS Programme supports developing countries in long-term planning towards reducing GHG emissions. The Programme combines an extensive stakeholder consultation process with deep quantitative research to provide defensible results that have buy-in from a wide range of stakeholders, including those in high levels of government. The latter is demonstrated by the fact that the Programme is always supported by a high-level government mandate. These results are used to inform long-term greenhouse mitigation planning and policy setting. The Programme is nearing completion in Peru, Brazil, Colombia and Chile (although follow-on activities are underway in these countries), with preliminary planning activities already having been conducted in a number of African countries.

This paper has been developed with the aim of documenting some of the key learnings that have come out of the MAPS Programme. In meeting this overall aim, the paper begins by presenting a brief overview of the emerging literature on co-impacts thinking and quantification, along with a description of a selection of approaches that have been used for quantification and/or qualitative description of co-impacts of climate mitigation. It then goes on to document in detail the approaches that were used in the different MAPS countries for assessing co-impacts of GHG mitigation, as well as those used in a linked project in India. In the concluding section, a set of high-level common observations is presented.

Three complementary papers are also being produced under the MAPS Programme which could be read in conjunction with this paper. The first of these is a paper that describes the use of Multi-Criteria Decision Analysis (MCDA) in guiding the generation, interpretation and use of the results of the co-impacts assessments. The second paper provides a deeper reflective piece on the discussions presented here, providing the key insights that have been

\(^1\) Other terms that have been used to describe the knock-on effects of mitigation actions and policies include trade-offs, externalities, adverse side effects and/or ancillary benefits.
gathered and learnings that can be taken forward into future similar processes. The third paper explores the evolution of knowledge networks on co-impacts.

This paper was developed based on a review of the academic literature and a variety of MAPS publications, as well as a number of semi-structured interviews with key stakeholders in the participating countries. The information gathered in this way was complemented with the authors’ own observations and experiences gathered from working with the MAPS country and Indian colleague teams on this topic.

2 OVERVIEW OF THE CO-IMPACTS LITERATURE

The literature on the co-impacts of climate action has grown substantially over the last decade. Here a brief review of this literature is presented, to demonstrate the breadth of publications on this topic. It is noted that the review only focuses on co-impacts of climate mitigation policy, rather than assessing the literature on co-impacts assessment in decision making and policy development more broadly. For example, in South Africa the Energy White Paper of 1998 was developed with due cognisance being given to the co-impacts on energy poverty, water and economic development. In Chile consideration is given to the co-benefits of individual infrastructure investments, although there is no mechanism for doing so as part of policy development.

2.1 Why the focus on co-impacts of climate action?

Addressing climate change mitigation and adaptation is only one of many priorities in developing countries. Typically, development agendas outweigh climate objectives (Ürge-Vorsatz et al., 2014), despite the fact that the positive co-impacts of GHG and adaptation can be substantial. Co-impacts analysis thus serves two primary purposes; the first being to support the case for implementing climate action and the second being to allow for modifying the design of GHG mitigation and adaptation actions to maximise other development benefits. Conversely, development and other policies may have significant mitigation and adaptation benefits and thus need to be considered in the climate action conversation (IPCC, 2014). Ultimately, therefore, climate action cannot be seen as entirely separate from development action. While recognising the links between mitigation and adaptation and co-impacts, the remainder of this paper focuses primarily on co-impacts related GHG mitigation – due to the focus of the MAPS Programme. One interesting additional consideration related to GHG mitigation action and co-impacts is that of temporal impacts. The benefits of mitigation policies occur over a long time-scale, but the impacts of development policies can be felt in the short to medium term.

On the basis of these observations, it is suggested that the analysis of co-impacts of climate mitigation as an integral part of climate mitigation planning is critical, helping to provide justification for mitigation action and increase the willingness of decision makers to implement mitigation strategies. This assertion is supported by a number of previous studies (Longo and Markandya, 2012, Crawford-Brown et al., 2012, Haines et al., 2010, Ürge-Vorsatz et al., 2009, Mrkajic et al., 2015, Dirghayani, 2013, IPCC, 2014). It is also observed that various countries are starting to include analysis of such multiple objectives into their climate planning towards making more informed decisions and increasing the robustness of policy making. For example, India’s National Action Plan on Climate Change (NAPCC) intends to simultaneously reduce CO₂ emissions and address other environmental and developmental challenges (Dhar and Shukla, 2015).
2.2 What types of co-impacts of climate mitigation are considered?

The co-impacts of climate mitigation can broadly be grouped along the three pillars of sustainable development: social, environmental and economic. Figure 1 presents an overview of the potential sustainable development-related impacts of climate mitigation. This classification developed by the United Nations Framework Convention on Climate Change (UNFCCC) as part of an online tool to assist projects to (voluntarily) declare potential benefits relating to their Clean Development Mechanism (CDM) projects or Programmes of Activities. The Figure provides a basis from which to frame the remainder of this paper. Clearly the co-impacts that will result from a specific climate mitigation action will vary widely depending on the nature of the action, the location and the extent of adoption.

![Figure 1. Sustainable Development Taxonomy based on UNFCCC, 2012](image)

The co-impacts presented in Figure 1 address the co-impacts that are typically associated with mitigation actions applied at the sector or sub-sector level. As an example, if a country has to build a rapid transport system or introduce sustainable agricultural practices, the analysis would demonstrate what the direct effects thereof would be. What became clear through the MAPS experience is that there is also a need to understand the macro-economic impacts of climate mitigation action. These impacts relate to both the impacts of cross-sectoral actions such as the introduction of a carbon tax or cap-and-trade system, and the implications of following particular mitigation scenarios, where an extensive basket of sectoral level mitigation actions is combined to provide a substantial reduction in overall emissions for a country. Undertaking scenario-level assessments is relevant, not only because mitigation actions have the potential to have knock on implications for the remainder of the economy beyond their direct impact area, but also because one mitigation action may amplify or diminish the impact of another. The co-impacts that are considered in this context include, but are not limited to, positive and negative impacts on:

- Gross Domestic Product (GDP)
- Household income and income distribution

### 2.3 Approaches to quantitative and qualitative analysis of co-impacts

Three broad categories of approaches can be used for the analysis of co-impacts, being:

- **Fully quantitative approaches:** Certain co-impacts lend themselves readily to quantitative assessment, such as absolute volumes of air pollutant emissions reductions, water consumption or number of jobs created.
- **Proxy approaches:** where one indicator category is used to provide an indication of the co-impact in another. A common example here is where reduction in local air pollutant emissions is used as a proxy for health benefits of a mitigation action.
- **Qualitative approaches:** These may be used for impacts that are not readily quantifiable (such as impact on quality of life); in situations where quantitative data is not available; and/or where collection of data is too time and resource intensive.

The range of approaches to quantification includes cost benefit analysis (CBA), cost effectiveness assessments (CEA), robust decision-making approaches (RDMA) and multi-criteria decision analysis (MCDA). Different modelling tools also feed into these approaches, such as computational general equilibrium models (CGE), partial equilibrium models (PEM), system dynamic models (SDM), integrated assessment models (IAM), and other optimisation and simulation models (Scrieciu et al 2014). Pros and cons of such approaches are discussed extensively in the literature (Scrieciu et al 2014, Ürge-Vorsatz et al 2014). Ürge-Vorsatz et al (2014) present a comprehensive review of the experiences of co-impact quantification and how this information may be used in climate policy development and decision making. Dubash et al (2013) propose a comprehensive methodology for the operationalisation of developmental and environmental co-impacts. There are also a number of studies that focus on quantifying a small selection of co-impacts of individual mitigation actions in particular sectors, using a range of these tools. The use of case studies is also a popular approach to assessing co-impacts. Numerous papers analyse the public policy impacts in transport, cement, commercial buildings and waste on city pollution in Asia, drawing mainly on secondary literature and modelling results (Jiang et al., 2013b, Jiang et al., 2013a, Puppim de Oliveria, 2013, Creutzig and He, 2009, Yang et al., 2013).

Table 1 provides the outcomes of a review of a wide range of literature studies on the subject, linking the co-impacts considered, the mitigation actions which achieve these co-impacts, indicators used to represent the co-impacts, assessment methods and the references to the relevant studies. For the latter a distinction is made between studies that undertake quantitative assessments and studies that provide qualitative assessments.
### Economic Impact Analysis

#### Distance to public transport

- Lower oil demand (Mtoe)
- Energy Security
- Water quality change
- Air pollution
- Greenhouse gas emissions
- Population size
- Number of species
- No. PM2.5

### Spatial Data

- Improved comfort in homes
- Energy efficiency in homes
- Difference in air quality

### Comparative Risk Assessment

- Mortality
- Years of life lost (YLL)
- Disability-adjusted life years (DALYs)
- Years lived with disability

### Table: Studies which consider co-benefits (adapted from Levy-Vonlan et al., 2014)

<table>
<thead>
<tr>
<th>Method</th>
<th>Indicator</th>
<th>Example of Mitigation</th>
<th>Co-MAPTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARKAL model</td>
<td>Improved comfort in homes</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
</tr>
<tr>
<td>MARKAL model</td>
<td>Difference in air quality</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
</tr>
<tr>
<td>MARKAL model</td>
<td>Improvement in comfort</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
</tr>
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<td>MARKAL model</td>
<td>Mortality</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
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<tr>
<td>MARKAL model</td>
<td>Years of life lost (YLL)</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
</tr>
<tr>
<td>MARKAL model</td>
<td>Disability-adjusted life years (DALYs)</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
</tr>
<tr>
<td>MARKAL model</td>
<td>Years lived with disability</td>
<td>Energy efficiency in homes</td>
<td>Co-MAPTS</td>
</tr>
<tr>
<td>Indicator</td>
<td>Method</td>
<td>Example of mitigation</td>
<td>Action</td>
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<tr>
<td>Change in GDP</td>
<td>CGE model</td>
<td>(Bye et al., 2002, Melo et al., 2013)</td>
<td>(Bysticky et al., 2010)</td>
</tr>
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</table>
Further details on some of the approaches to co-impacts analysis that were considered in the early stages of the MAPS Programme are presented in the remainder of this section, while the actual approaches that were ultimately used are discussed in Section 3. In this section, consideration is given to participatory processes; economic valuation approaches; and economy wide modelling. It is noted that further discussion is not given in this section to approaches that can be used for the direct quantification of the co-impacts of individual mitigation actions (such as particulate emissions associated with reduced vehicle usage) as the approach to such analyses is considered to be self-evident.

### 2.3.1 Participatory processes

A number of different participatory processes are relevant here. The simplest of these is expert ranking, where experts are asked to score the performance of mitigation actions against a number of co-impacts. This approach was trialled in Colombia and Peru, as discussed below. Multi-criteria Decision Analysis (MCDA), discussed briefly in Section 3.5, provides guidance on problem structuring, quantification of co-impacts and ways to engage with trade-offs. The Action Impact Matrix (AIM) is a multi-criteria analysis approach that helps to structure complex decision-making and to understand conflicts and trade-offs. The AIM can be applied with a variety of different purposes to identify challenges in climate change adaptation and mitigation in overall development planning (e.g. Munasinghe 1994). In South Africa, the AIM methodology was tested to inform the work on co-impacts in MAPS (ERC, 2012).

Other examples of participatory approaches are available from The Gold Standard Foundation, which has developed a comprehensive way of assessing (carbon) projects for socio-economic benefits and potential harm. Under the umbrella of co-impacts assessment, four methods applied by the foundation are relevant (Gold Standard 2008). These include: a stakeholder engagement; do-no-harm assessment following certain safeguarding principles; the participatory process of populating a sustainable development matrix; and the monitoring, reporting and verification of co-impacts.

### 2.3.2 Economic valuation

The presentation of co-impacts in financial or monetary terms allows for relatively easy comparison of different types of co-impacts. This approach, however, relies on the availability of methodologies for quantification of the biophysical or social impact, and thereafter methodologies for the valuation thereof. Converting co-impacts to a monetary value can help to simplify the issue for decision-makers. For example, economic value can be linked to the investment required or to the maintenance costs of a particular initiative. The drawbacks are generally recognised as being the fact that some co-impacts are easier to monetise than others and that, for a number of co-impacts, a monetary value will not adequately capture the complexity or adequately represent the true value of the impact.

Cost-benefit analysis (CBA) is one commonly applied method of economic valuation (Preval et al., 2010, Tirado Herrero et al., 2013). Preval et al (2010), for example, has utilised CBA to investigate the projected health benefits and energy savings from improved space heating implemented as a mitigation measure.

Another approach to economic valuation is the benefit transfer methodology (BTM), where economic values of co-impacts are estimated by transferring available information from studies already completed in another location and/or context. This approach is used when the cost of gathering primary, site-specific data is prohibitive, and a rapid and efficient assessment of the same co-impact is needed in a different location. Another option, usually building on the findings from a BTM, is to assess positive change resulting from the provision of economic, environmental and social goods and services through a cost-benefit assessment (e.g. Plummer 2009, Ecosystem Valuation 2013).
2.3.3 Economy wide modelling

Macro-economic assessments evaluate the economy wide impacts of climate policies (impacts on GDP and other macro-economic indicators, sectoral costs, labour market, income distribution, trade, etc). These approaches are based on financial flows through the economy as a whole. The models generate a consistent set of values for levels of economic activity and prices of capital, labour and primary materials. Where economy wide models are sufficiently disaggregated, by including different industries and household types in their database, they can provide information on employment, income distribution, and relative advantages for different industry sectors. These features allow researchers to carry out cost/benefit analyses on a set of mitigation actions and quantify the socio-economic benefits. While sectoral models only provide the direct impacts on, for example, employment in the sector, economy wide models account for the total job losses or gains, including indirect impacts elsewhere in the economy. Computational general equilibrium (CGE) models and social accounting matrices (SAMs) allow for a one-way flow of data from the sectoral models, while hybrid and linked models (such as IMACLIM, described for Brazil later on in this paper), allow for dynamic flow of data between the physical and monetary values.

2.3.4 Challenges and limitations in co-impacts assessments

Several challenges and limitations associated with the methodologies used to analyse and quantify co-impacts are identified. The primary challenge relates to finding reliable and comprehensive data at the correct scale. Not only is data not always available, but its collation can be an expensive and time-consuming exercise (Puppim de Oliveira, 2013, Lee and van de Meene, 2013, Moreno and Lopez, 2008). Secondly, accurately quantifying impacts can be difficult and is further complicated by taxation, subsidies, regulations and infrastructure development utilized during implementation (Haines et al., 2010, Puppim de Oliveira, 2013). In many cases, there is a compromise between precisely quantifying a co-impact and a generalisation of the method to assess co-impacts (Puppim de Oliveira, 2013). Assumptions regarding trends can affect the estimates of the impacts (Haines et al., 2010) and certain valuation methods, particularly revealed preference, contingent valuation and other survey methods, are subject to bias (IEA, 2011). Consequently, several potential benefits may be excluded from the analysis due to cost concerns or calculation difficulties that arise from methodological complications (Preval et al., 2010). In addition, it is difficult to combine and compare results generated using different approaches and methods.

Other evaluation challenges include avoiding double counting, difficulties in developing credible scenarios and determining whether co-impacts are temporary or long-lasting (Haines et al., 2010, IEA, 2011, Dhar and Shukla, 2015).

3 COUNTRY EXPERIENCES IN CO-IMPACT ASSESSMENT

Under the MAPS Programme, researchers and policy makers in Chile, Colombia, Peru and Brazil have been developing and testing different approaches for assessing co-impacts and using them to inform decision making. Here a summary is provided of the evolution of co-impact thinking, describing the motivation for including a co-impacts analysis in the individual countries, what was initially trialled, and what approaches were ultimately used in the analysis. For completeness and contrast, a summary of related work being conducted in conjunction with colleagues in India is also presented.

3.1 Peru
The Peruvian process, known locally as PlanCC, included the development of a business as usual and required-by-science trajectory, cataloguing of the mitigation actions available to Peru and the combination of these into a set of discrete scenarios. These scenarios were assessed using a macro-economic model to determine what the overall impacts of following these trajectories would be on the economy.

The need for analysing co-impacts in PlanCC was identified from the outset of the project, having been identified explicitly in the project description (pro-doc). Some examples of statements in the pro-doc where reference is made to co-impacts include:

- … Peru is a land of entrepreneurs, looking to new global trends with which to align and also after new ways of doing things differently; it is also a country rich in forests and with a high potential for renewable energies. Lastly, we have an adequate environment for investment coupled with the liquidity of the financial system. In the case of Peru, these opportunities might consist of taking advantage of our abundant natural resources, reduce environmental pollution, generate inclusive businesses, reduce socio-environmental conflicts, improve energy efficiency, and promote technological innovation, among others. All of these are globally regarded as “co-benefits” from the implementation of mitigation measures. In the case of Peru, these are associated with sustainable development objectives and prevail over the goal to reduce GHG gases…”

- …Furthermore, the benefits and impacts to be derived from “decoupling” economic growth from emissions growth and environmental degradation are not fully understood. This is primarily due to the lack of information on environmental degradation costs and socio-environmental conflicts, and the lack of national studies proving the feasibility of a low-carbon economy...

- …To reduce risks and take advantage of opportunities, attract “low carbon” investments and reduce the risk a climate change context, it is proposed to develop – under the leadership of relevant institutions - scenarios that should enable one to understand costs and the economic, social and environmental benefits stemming from different development models and, in a next phase, to plan out a “climate-compatible” model...

The pro-doc also mentioned two activities (out of the seven activities in the project) that related to co-impacts analysis, being:

- **Formulate and assess mitigation options:** … each team shall model the reduction of emissions created by each option towards years 2021 and 2050; shall perform a quantitative and qualitative analysis to value the proposed mitigation options (which should include the cost and the economic, social and environmental benefits created)...

- **Model and assess scenarios to identify economic, financial, social and cultural implications and environmental externalities of the various “packages” of actions:** … Finally, the impacts of mitigation options shall be determined through the general equilibrium model and the multi-criteria analysis...

The potential for realising positive co-impacts of climate mitigation was used as a lever for engaging the stakeholder team (known in the MAPS processes as the scenario building team or SBT). When initially presenting the project to
the SBT team, co-impacts were identified as the principal reason for mitigating emissions. This was an important consideration given that the country represents less than 0.5% of global emissions and hence it would have been difficult to engage stakeholders through using mitigation as a sole motivator for the project.

Although co-impacts featured in the pro-doc, it is highlighted that the mandate from government for the project did not identify co-impacts explicitly; rather it made reference to a need for the analysis of the feasibility of a low carbon economy.

Initially the intention was to include co-impacts at two stages of the analysis. The first included an analysis of the co-impacts of individual mitigation options before modelling of emission reduction scenarios, while the second consisted of evaluating what the implications of following a particular mitigation trajectory would be on the economy. During the second SBT meeting, participants were asked to identify a list of variables and indicators that could be used to measure the performance aspects of a low carbon economy, apart from a reduction in emissions. This information was to be used for obtaining an initial list of the potential co-impacts of mitigation measures, and for the purposes of engaging with the macro-economic modelling team to determine which of these would be possible to quantify with the macro-economic model.

The first trials of inclusion of co-impacts into the process related to the analysis of the impacts of individual mitigation options. In preparation for the third SBT workshop, each of the sectoral analysis teams was asked to complete a spreadsheet template that included generic quantitative or qualitative information on the co-impacts of every mitigation action. This data was based on information contained in the literature. There was no prescription on the kinds of information to be collected, with examples of the environmental, social and economic impacts that could be considered including a reduction in the costs of production, a reduction in negative health impacts, impacts on employment etc. This information was presented at the SBT and used to prioritise those mitigation options for which more co-impacts information should be gathered. For the prioritised mitigation actions a more detailed template for gathering information was developed, specifying which information should be obtained. This template included detailed descriptions of indicators, units and assumptions or sources of information.

However, as a result of time limitations, the researchers were unable to compile all of this information. In each sector it was found that it was only possible to find information to populate these indicators for a small selection of the mitigation actions. It was thus decided to develop a qualitative list of all possible co-impacts identified for each measure and then consult with the SBT to complement and validate this list. This approach proved to be effective.

One of the challenges, however, was that there was not complete clarity between the different sectoral teams as to what information was to be collected, and hence the type of information collected varied between sectors. This challenge was compounded by the fact that there were large differences in the level of information that was available in the literature for the different sectors, with limited information being available for quantitative estimations of co-impacts. The teams found gathering information to be very time consuming, particularly given the other demands of the project related to calculating emissions reduction potential and costs.

Ultimately, a list of co-impacts was developed for each sector, based on the previous work that had been done. At the fourth SBT, the participants were broken up into sectoral working groups and were presented with a matrix for the sector containing the mitigation actions and the principal co-impacts. The groups were asked the question “What is
the relationship that exists between each mitigation action and the co-impacts included in the matrix?” and were asked to give this a score of -2 to +2. The scores provided by the individuals were then averaged to provide an overall contribution of the mitigation action in terms of co-impacts.

The score for each mitigation action was used for two purposes. The first of these was to identify mitigation actions with the largest negative impacts (and potentially exclude these from the analysis) and to highlight those with the greatest potential positive co-impacts for packaging purposes (see below). The second use of the scores was to select two mitigation measures for which further, more detailed quantification of co-impacts would be conducted by the research teams.

At this same SBT, mitigation actions were packaged into five different scenarios, using co-impacts, costs and emissions savings potential as criteria. The resulting scenarios were (PlanCC, 2013):

- A “savings” scenario, which looked purely at emissions savings. Here 47 mitigation actions were included.
- A “sustainable” scenario, which included mitigation actions that achieved a minimum of 40 million tonnes of CO₂e savings, and at the same time offered social and environmental positive co-impacts (this was the scenario analysed further in the final reports).
- A “fast” scenario, which included 14 mitigation actions that could be implemented quickly.
- An “all actions” scenario.
- A “sustainable” scenario + carbon tax. This scenario was based on the “sustainable” scenario to which a transversal carbon tax was added. The tax was applied on 2026 at a rate of US$15 per tCO₂e and gradually increased to reach US$50 per tCO₂eq in 2050. It was applied to all productive activities that generated emissions; activities that did not generate or otherwise capture emissions such as the land use, land-use change and forestry (LULUCF) sector were not affected by the tax.

Once the mitigation actions had been compiled into scenarios using these criteria, a CGE model was run which provided co-impacts of the mitigation scenarios. These included impacts on GDP, capital accumulation, public investment, private investment, exchange rate, salaries, total household income, income in the lowest income and less impoverished households and the GINI coefficient. The CGE model did not estimate variations in employment due to a key assumption that the economy has full employment and adjustments to the economy occur as a result of adjustments to salaries.

The outputs from PlanCC are all available at http://www.planccperu.org/. One of these outputs is a library of mitigation actions which includes a qualitative overview of the co-impacts for each of the actions.

3.2 Chile

The MAPS Programme in Chile consisted of three phases. The first phase included developing a 2007 GHG emissions baseline for the period 2007 to 2030 and a ‘required by science’ projection for Chile. The baseline was built to provide evidence for the government to use to draft its formal communication to the UNFCCC Cancun voluntary commitment. This phase finished in 2012. In 2013 Phase 2 began which included the development of a 2013 to 2050 baseline trajectory that reflected the current climate policy at the time (although results were only published until 2030 due to high level of uncertainty in the 2030-2050 period); identification of mitigation actions and packaging these into
mitigation scenarios, analysing the macro-economic impacts on the economy, and exploring of a methodology for performing a qualitative assessment of co-impacts, as described below. The third phase, which was underway at the time of writing, is focussing on the 2030 to 2050 period and co-impacts assessment. Co-impacts were considered in both the second and third phase, as detailed below.

At the time of writing of the pro-doc for the MAPS-Chile process in 2011, the authors identified the opportunity for the project exploring the impacts of GHG mitigation beyond only emissions reductions and costs. As such, consideration was given to the idea of conducting a “strategic assessment”, borrowing from the language of Strategic Environmental Assessment. At the time of writing the pro-doc, however, there was no common understanding of what this might involve in practice, and whether the analysis would be of individual mitigation actions or of scenarios. The plan was to conduct the strategic assessment by the end of Phase 2 of the Chilean process. It is noted, however, that unlike in Peru the inclusion of co-impacts in the analysis was not key to obtaining the mandate to do this project.

When the time came to start exploring the ‘strategic assessment’ as per the pro-doc, a number of meetings were held to try and ascertain what such an assessment might look like in practice. It was ascertained that there were a number of different perspectives on this topic, and some of the sectoral modellers in particular were uncomfortable with analysis of parameters that were not readily quantified by their models. As such, a study was commissioned to develop a methodological approach for exploring what such a strategic assessment might look like. It is noted that the team recognised that such a strategic assessment would cover similar issues to the concept of co-impacts as was being thought about in other MAPS countries.

The methodological approach study was conducted through a review of literature and consultation with the seven ministries who were on the project steering committee. It was found that initially these ministries had reservations about thinking outside of their mandated spheres of influence, but later came to realise that there was value in determining the alignment of mitigation measures with sectoral priorities, with an important realisation from this process being that ministries would not be inclined to undertake mitigation unless they achieved sector-relevant co-impacts.

As part of this process the interviewees were asked to identify the critical issues that were important to them. These issues were presented to a special SBT meeting, where participants were asked to identify any issues that had been missed, and were asked to prioritise the most important issues in terms of understanding the impacts of following different scenarios on the country. The report concluded with identifying what issues should be assessed, and gave some indication of how they should be assessed. Consideration was given to options such as monetisation of impact, and how quantitative and qualitative issues could be addressed in parallel.

On reflection of the outcomes of the methodological study, it was recognised that the approach presented considered ‘top down’ impacts of mitigation. However, in MAPS Chile there was a desire to look at co-impacts from the ‘bottom up’ perspective.

During Phase 2 of the MAPS Chile study, the importance of considering co-impacts of individual mitigation actions was recognised as providing valuable information for policy makers, although the Chilean team did not have the time to conduct more than an initial review. For each of the 96 mitigation actions, a spreadsheet was developed that had provision for recording qualitative and descriptive information on impacts including environmental, social,
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institutional and health impacts, based on the views of the sectoral consultants. Although this information sits in a publically available library on their mitigation actions and is being used to inform Phase 3 of the project as discussed below, it was not formally published in the Phase 2 project outputs.

Also in Phase 2, the project team packaged mitigation actions into scenarios, with considerations relating to the technical, political and financing feasibility of mitigation actions being used to inform the scenario combinations (although with mitigation potential and cost). Two groups of scenarios were developed (although co-impacts did not feature as packaging criteria). These were:

- Thematic mitigation scenarios: This included different combinations of technologies.
- Level of efforts scenarios: Constructed using differing effort levels which in turn related to abatement costs, mitigation potential and feasibility to develop the action, although the latter was the key driver when classifying each action into a scenario.

The team then employed a Dynamic Stochastic General Equilibrium (DSGE) model to determine the macro-economic implications of following particular emissions trajectories or scenarios. This model provided an indication of costs to the economy/macro-economic implications, emissions reductions and some indication of social impact through implications for employment. However, the models were unable to provide an indication of distributional effects of money flows through the economy. The income distribution analysis was undertaken later on under Phase 3.

At the end of 2014 it was agreed that co-impacts analysis was to form part of Phase 3 of the MAPS Chile process. The design of the third phase had at its core a visioning exercise to look at the period from 2030 to 2050. Initially there were a number of discussions as to whether this analysis should be quantitative or qualitative, although the value of quantitative work was acknowledged. Gradually three main distinct work streams emerged: one focusing on the long term, the other one on the co-impacts assessment and the third one directly informing policy development, and in particular the development of the Intended Nationally Determined Contribution (INDC).

A specialist technical team was then put together to assess co-impacts, which included more than 50 experts on issues like health, pollution, water, congestion and social analysis. Although this work was in progress at the time of writing, it is indicated that the co-impacts of a small number of mitigation actions are being identified and qualitatively described in terms of a description of the co-impacts and interrelations between the interventions and the impacts, key conditions that are required to optimise co-impacts when implementing a mitigation action, potential indicators that may be used for measurement and the information required to calculate it and international experience in the quantification or consideration of the co-impact. This information will be provided to decision makers to help support the development of mitigation actions’ implementation roadmaps.

Outputs from this project can be found at [http://mapschile.cl/](http://mapschile.cl/).

### 3.3 Colombia

The MAPS Programme in Colombia formed part of the Colombian Low Carbon Development Strategy (CLCDS). Phase I of the CLCDS was completed in mid-2013 and included the modelling of sectoral reference scenarios until 2040; the identification and formulation of mitigation actions; the assessment of costs and abatement potential of mitigation...
actions; and the assessment of feasibility and co-impacts of the identified mitigation actions. Phase II included the design of Sectoral Mitigation Action Plans (SMAPs) for the mitigation actions prioritised in Phase I. Phase II also included specific feasibility studies and additional co-impacts studies, as well as implementation considerations for the SMAPs and development of the INDC.

The pro-doc of the Colombian process made explicit the intention to deal with the issue of co-impacts as part of the process through including it in one of the questions it sought to address:

Which are the options and alternatives with the greatest potential for reduction of emissions in each sector; what are their costs, co-impacts and expected effects regarding economical growth, employment, competitiveness, wellbeing of the Colombian people and poverty reduction?

The importance of including co-impacts considerations was further highlighted during the inception meeting of Phase 1 in 2011, where a number of objectives and components of the study beyond just costs and mitigation potential were identified. These related to similar considerations to the other MAPS countries, including economic growth and increasing productivity, reduction in poverty, rural development, employment, competitiveness and others. It is noted that the term “co-benefits” was introduced at this first meeting.

During Phase I of the CLCDS, researchers at Universidad de los Andes, together with sectoral experts, attempted to conduct a Multi-criteria Analysis of the co-impacts of the mitigation actions using an expert ranking approach. Co-impact indicators were developed by the research team and discussed with sectoral experts during the second SBT meeting, with the expert ranking being conducted in the third expert’s workshop (SBT3).

The expert ranking approach was chosen for three reasons: firstly, the wide range of experts present at the SBT meetings presented a potentially favourable opportunity to create legitimacy for the proposed co-impacts assessment analysis. Secondly, plans to contract consultants to develop a full economic valuation method were delayed and hence there was a desire to include some form of analysis in Phase 1. Thirdly, the project management team realised that with so many actions identified by experts, it would be economically impossible to value them all and have those results made part of the prioritisation process.

A basic evaluation matrix was designed prior to the workshop that included a list of the mitigation actions proposed in previous experts’ workshops and the assessment criteria. In some sectors additional criteria were included, or the understanding of the criteria was adapted to the sector context. Workshop participants were asked to respond to the question: “The impact that the mitigation action has on (criteria) is?” The response options were: very positive, positive, neutral, negative and very negative. For the assessment of the implementation criteria, experts were asked two questions:

- To what level are the requirements for an action (financial, regulatory change, cultural practices etc.) a barrier to its implementation?
- To what level is the mitigation action aligned with sectoral priorities?

The response options for the implementation were: very high, high, moderate, low, very low.
Subsequent to the workshop, numerical allocations were given to the response options, being very positive or very high (2), positive or high (1), neutral (0), negative or low (-1) and very negative or very low (-2). The information was presented graphically on spider diagrams (see Figure 2 for an example in the transport sector). In interpreting these, it is noted that the greater the distance from the centre, the more favourable are the impacts of the action.

Figure 2 Example of spider diagram showing ranking of mitigation options in Colombia

This process commenced during the expert workshop (SBT3) but the matrix was also sent via email to other sectoral experts who were not able to attend the workshop. The process was very time consuming, and unfortunately the credibility and robustness of the results suffered from a low response rate from the experts who were asked to participate in finalising the ranking via email. An additional challenge associated within the workshop approach is that the opinions of the more outspoken individuals tend to dominate. In some sectors the number of participants was very low, while in others there were a lot of people and not all the experts were able to evaluate all the measures, because the list of measures was so long.

By the middle of 2013 Colombia commissioned a piece of work that sought to develop a methodology for co-impacts assessment of individual mitigation options – specifically, monetisation of positive co-impacts. The objective of this work was to “Formulate a general methodology applicable to any sector, to estimate the co-benefits associated with the implementation of mitigation measures.” The methodology considered was used to quantify the co-impacts, through a formula that included an indicator of the scope or scale of the application of the measures, an indicator of effectiveness of the measure in terms of the co-impact and an indicator of value that converts a physical co-impact into monetary terms (Co-benefit = Benefit’s Value x Effectiveness x Scope). In order to apply the co-impacts methodology ten measures were selected across sectors. The marginal abatement cost curves (MACCs) built by Universidad de los Andes was used as an input to the analysis. The methodology was useful in that it provided a consistent approach for assessing co-benefits across the different sectors. However, challenges were experienced when adopting this approach in the different sectors, as detailed information was required which in some instances was confidential, and therefore could not be made public. Secondary data was utilised rather than collecting primary data.

Colombia’s MEG4C, a computable general equilibrium (CGE) model, is currently being used to assess the mitigation scenario of a 20% reduction below business as usual, committed to in Colombia’s INDC. The assessment includes emissions reductions, value of mitigation measures, impact on GDP, household consumption, employment, and the
current account deficit\textsuperscript{2} (Alvarez 2015). A sectoral assessment of the implications of the scenario is also being conducted.

### 3.4 Brazil

Brazil’s voluntary mitigation target for 2020 is expected to be achieved largely as a result of a reduction and stabilisation of deforestation. However, beyond 2020, GHG emissions from the energy system are still expected to increase. Previous emissions scenarios identified possible mitigation actions, evaluating emissions reduction potential and respective costs, from the end user perspective. The IES-Brasil Social and Economic Implications: GHG Mitigation Scenarios 2030 project aimed to explore the implications of mitigation action for Brazil in terms of emissions avoided and economic and social development for the period of 2020 to 2030. This information was to be used to inform the discussion of national mitigation goals to 2030. The project was coordinated by CentroClima / COPPE / UFRI, and involved researchers from several institutions in Brazil.

The IES-Brasil project’s initial goal as defined in the pro-doc was to identify distinct developmental trajectories that simultaneously achieved both socio-economic and environmental goals. The latest version of the pro-doc identifies the specific objectives of IES-Brasil, all of which provide a strong indication of an intention to incorporate co-impacts analysis into the work:

1. Generate various developmental trajectories, GHG emission and mitigation scenarios for the medium and long-term time horizons in Brazil. These trajectories and scenarios shall be developed through a participatory process involving the government, private sector, academia, and civil society whom shall provide inputs to the creation of scenarios in question.
2. Build capacity within the Brazilian Forum on Climate Change (FBMC) to develop a pedagogical tool to show the society that the choices that are made today impact the trajectory of the Brazil in the medium and long term.
3. Identify and analyse the economic and social implications of each mitigation scenario in terms of macro-economic variables (GDP, inflation, debt, sectoral output, etc.) and social variables (unemployment, income distribution, food security, etc.).
4. Study the potential contribution of various recycling options (e.g. carbon revenues) to the reduction of poverty and inequality via income redistribution.
5. Describe and design scenarios for medium and long term (2030 and 2050) with regards to the penetration of new technologies.
6. Evaluate each scenario generated to consider the effects of the mitigation policy in terms of foreign trade and competitiveness with an accompanying analysis of opportunities and barriers presented.
7. Evaluate different trajectories for the Brazilian society based on the outputs from the project.

The IES Mandate also mentions that “wider macro-economic (GDP growth, inflation, public debt) and social (employment generation and income distribution) implications of mitigation scenarios have yet to be assessed to

\textsuperscript{2} Andres Camilo Álvarez Espinosa, National Planning Department (Sustainable Environmental Development Branch), personal communication, 26 August 2015
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To inform the discussion of national goals of GHG emission reduction and/or limitation up to 2030 and 2050. Hence the government supported the implementation of the project, “within the framework of the Brazilian Climate Change Forum, enabling the involvement of the relevant social and economic stakeholders in this field in the country”.

In this sense, the approach taken to co-impacts analysis in Brazil was different from that in the other countries participating in MAPS, in that the focus was on the socio-economic implications of cross-sectoral mitigation rather than attempting to quantify the co-impacts impacts of individual mitigation actions as well.

In order to meet the desired project aims, a model called IMACLIM was used. IMACLIM is a general equilibrium model, which enables the economy wide impacts of energy and climate policies to be evaluated. One of the features specific to IMACLIM compared to other standard General Equilibrium models is that an effort is made to characterise the energy flows in the economy both in physical and monetary terms. This makes it easier to couple (link) with detailed sector specific models, which are generally characterised in physical terms. The coupling allows for more detailed and plausible characterisation of the use of energy in the economy, and associated GHG emissions under different constraints.

The IMACLIM model was initially applied to three different scenarios. The first of these was termed the Government Plan Scenario (GPS) that allowed for determining the impacts of current policies and plans. Thereafter, mitigation actions additional to those already included in the Government Plan were identified for the 2010 to 2030 period. Mitigation actions with an abatement cost of 20 US$/tCO\textsubscript{2}eq or less were used to develop the second scenario, termed Additional Mitigation Scenario 1 (AMS1). In the third scenario, Additional Mitigation Scenario 2 (AMS2), mitigation actions with an abatement cost of 100 US$/tCO\textsubscript{2}eq or less were included.

Two supplementary mitigation scenarios were then simulated, to include the adoption of a carbon tax on fossil fuel burning emissions. In total, four mitigation scenarios were thus modelled alongside the Government Plan scenario: AMS1, with and without a carbon tax, and AMS2, with and without the tax. The scenarios without the tax assume that the mitigation options are implemented with the help of regulation and microeconomic measures, whereas the carbon tax scenarios imply the existence of a fiscal policy.

During the first and second SBT meetings, stakeholders contributed to the design of the qualitative storylines and quantitative assumptions for key variables of the different mitigation scenarios (Governmental Plan Scenario and Additional Mitigation Scenarios). SBT members also contributed to the improvement of IES-Brasil methodological approach and mathematical models.

The macro-economic results of IES-Brasil show that the selected mitigation measures can contribute to an increase in economic growth, depending on the way in which they are implemented. If these measures were to be implemented solely with micro-economic instruments and command and control mechanisms of the scenarios that do not consider a carbon tax, GDP would grow more than in the GPS. However, should the selected measures be implemented with a carbon tax, the impact on GDP will depend on the tax level required. Unemployment rates fall in all additional mitigation scenarios, even those considering a carbon tax, with the energy sector responsible for the most job openings. Results on the average annual household income, distribution of wealth, level of prices, purchasing power, total investment and the investment rate are also presented in different sets of reports, to SBT members, decision makers and academia.
3.5 India

Although India is not one of the countries implementing the MAPS Programme, the authors of this paper have been involved in a related project in that country. The project undertaken in India sought to explore the use of a MCDA framing to explore a multiple objectives approach to two case studies assessing low carbon policy options. The first of these was in the buildings sector and the second in the provision of modern cooking fuels. The cooking sector is important because 700 million people in India do not have access to modern cooking fuels and the adverse health effects of traditional, open-stove cooking result in an estimated one million premature deaths annually. Selecting effective policies to provide modern cooking fuels for rural households is thus a development imperative. Buildings were chosen as they are linked to the rapid urban transformation that is being experienced. Building energy efficiency policies offer benefits that go beyond energy savings, and include GHG mitigation, energy security, job creation and other social and environmental outcomes. However, if energy efficiency opportunities are ignored, the sector could contribute to locking India into a high-carbon growth path. The focus in the buildings study was specifically on evaluating policy options for building envelope energy efficiency in the residential sector, where most new construction is expected.

A MCDA-type approach was used to guide the policy analyses, starting with ensuring that the “right” question was being explored, formulating of the policy options being assessed and choosing the co-impacts considered within the assessment. The MCDA framework chosen was particularly useful in that it allowed for inclusion of both quantitative and qualitative co-benefits in the analysis with the same level of rigour, providing structured approaches to conducting qualitative co-benefits assessment. Finally, it provided an approach to understanding the implicit trade-offs between the co-impacts. The entire process was guided by stakeholder input.

While the work in India largely focused on trialling MCDA approaches in this context rather than providing definitive results (due largely to time and resource constraints), it is argued that the use of MCDA helped to provide important policy insights through the transparency of the process, considering co-impacts that may normally be excluded from policy analysis, and considering factors such as institutional and implementation challenges as part of the analysis, rather than subsequent to the decision process. This provided alternative insights that may not have been observed using other policy analysis approaches. The MCDA problem structuring approach proved to be particularly useful, and is one which in retrospect may have been meaningfully used to guide the MAPS processes. For a full summary of the case study and its findings, see Khosla et al (2015).

4 SUMMARY OF OBSERVATIONS

The paper set out to achieve two aims. The first was to provide a brief overview of co-impacts, references to the literature on this topic, and an indication of the approaches that are available for their quantification and analysis. The second aim was to document the approaches that were used for co-impact analysis in the MAPS countries and India, to show how different these are, and to demonstrate the evolution of thinking about this topic in the Latin American countries through the processes.
The paper has demonstrated that there is already a body of literature available on assessment of health, air quality, water, biodiversity, poverty and other co-impacts of individual mitigation actions. Both quantitative and qualitative assessment approaches exist for this purpose. Each of these has their pros and cons. Quantitative approaches may be considered to be more rigorous by policy makers, being based on detailed analytical research, and give rise to absolute numbers they may be more accustomed to engaging with. Qualitative analyses may be far less time consuming to conduct, and are useful for situations where co-impacts do not readily have a quantitative measurement scale or where there is neither the time nor resources to quantify these. Qualitative approaches are thus useful in that they avoid the importance of such co-impacts being diminished due to lack of quantification approaches or time and resources, thereby offering a more holistic assessment that wouldn’t be possible without qualitative methods.

What became evident through the MAPS Programme is that although various tools for assessing the co-impacts of individual mitigation actions are available in the literature and for quantifying co-impacts of cross sectoral actions (such as a carbon tax), there is less experience on quantifying the macro-economic impacts of baskets of mitigation actions that have been combined into mitigation scenarios.

The experience from the MAPS countries also reflects the fact that there is no one single or preferred approach to co-impacts analysis. Indeed a wide range of approaches was trialled, with an evolution in thinking as the projects progressed. This evolution could be argued to be as a result of a lack of clarity as to how results would be used before beginning the processes, which is understandable given the relative newness of such understandings described previously. The Indian experience suggests that there may be a role for structured decision making approaches to help with problem structuring prior to beginning such complex analyses.

In terms of approaches used in the different countries, it was noted that Brazil relied more strongly on quantitative assessments, while Peru, Colombia and Chile combined quantitative assessments with qualitative approaches. All four countries engage with economy wide modelling of mitigation options, though the models used and the manner in which they are used to quantify co-impacts differed depending on local expertise, model and data availability. Each of the countries also used different approaches for the translation of the results from academic analysis to information that was communicated to policy makers.

It is the authors’ observations that there has been mixed value in conducting co-impacts analysis as part of the MAPS country processes. Whereas the country teams report that they consider there to have been value in conducting the analyses, the ‘usability’ of the results to date by policy makers is varied. The analyses of the impacts of individual mitigation actions has however been used by Peru and Chile in packaging mitigation actions into scenarios for further analysis. There is also evidence that project developers (in particular Nationally Appropriate Mitigation Actions (NAMAs) development) found the information very valuable. The macro-economic impact analysis is reported to have been used by all four countries in determining their INDCs to be put forward ahead of the Paris COP in 2015. Anecdotal evidence suggests that decision makers have requested the outputs of the macro-economic studies to provide confidence that any contributions that are put forward, are not modelled to result in significant negative impacts on their economies.

One of the key challenges moving forward is one of considering how to integrate the results that are produced out of the different methods to assess co-impacts: the economic modelling results, the results derived through the expert-
consultations, and future findings from economic valuation studies all have to be communicated to policy makers. Careful consideration and creativity is required to turn the vast amount of information into presentable and decision-supporting resources. Integration and visualisation of these results will create the next challenge not only for the MAPS processes, but also for the research community as a whole. Furthermore, as part of the communication challenge, it is important to convey that climate and development are not necessarily in competition with each other, and that they can be achieved simultaneously, depending on how you pursue them. Co-benefits work can contribute to overcoming this outdated way of looking at climate and development.

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