# Electric Vehicle Scenarios for India: Implications for mitigation and development

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# Internalising mitigation activities into the development priorities and approaches of developing countries

Proceedings of the
Forum on Development and Mitigation,
Cape Town 2014

*Edited by*
**Meagan Jooste, Emily Tyler, Kim Coetzee, Anya Boyd and Michael Boulle**

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# Contents

# Acknowledgements

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We would also like to thank the authors for their time and effort in writing the papers and in responding to reviewer comments. We hope that many of you will continue both refining and expanding the research featured here. We thank you too for the presentations of your papers at the DevMit Forum itself.

Finally we are very grateful to the MAPS Programme and its funders for their sponsorship which enabled both these proceedings and the DevMit Forum itself. We trust that the conceptual advances enabled by the Forum will advance our collective work on understanding the urgent challenge of 'mitigation in the developing country context.

# Preface

The Development and Mitigation (DevMit) Forum was held in Cape Town, South Africa from 27–29 January 2014. It was hosted as a partnership between the Mitigation Actions Plans and Scenarios (MAPS) programme and the Energy Research Centre (ERC) at the University of Cape Town both based in Cape Town, with the Centre for Policy Research (CPR) in New Delhi, India.

The current framing of mitigation in the domestic policy of most developing countries is not enabling sufficiently ambitious mitigation action, and may even be hindering the identification of synergies, points of contact and leverage between mitigation and development goals. All too often mitigation is pitted against development, as being an either / or choice, which then means mitigation inevitably loses out. This framing also does not assist in ensuring that policy responses to development challenges do not undermine the sustained growth and development of developing countries in a carbon constrained future.

The 'right to develop' is the overriding policy priority in developing countries albeit expressed and implemented in varying ways. This development imperative then becomes the critical factor when considering climate mitigation efforts within these countries. Although the issue is well understood, researched and analysed in the context of international climate mitigation policy negotiations, it is perhaps less so from the domestic perspective of developing countries. The DevMit Forum took this as its starting point and focus: How can developing countries develop in the context of a carbon-constrained future?

The objective of the Forum was to enhance an understanding of how developing countries can effectively internalise mitigation activities into their development priorities and approaches. The Forum provided a space for climate mitigation and development researchers, practitioners and experts from the developing world to present and discuss their work and experiences in this complex contemporary challenge.

The event comprised an extensive compilation of activities, including the presentation of twelve academic papers, nine of which are the offered in these proceedings. The papers covered topics across the development and mitigation nexus and reflected experience of a range of developing countries in the formulation of actions to mitigate climate change. Further information on the Forum and its other outputs can be found online at http://devmitforum.ercresources.org.za.

### Methodology underpinning the review process for DevMit Forum

***The academic review of papers***

A rigorous blind review process underpinned the compilation of the academic papers for the event. This included four main phases, namely: 1) the selection of a Forum Review Committee (FRC) and the call for abstracts; 2) the screening of abstracts by the FRC; 3) the receipt and review of the draft papers; 4) the receipt, compliance check and quality and language editing of final papers by the internal Cape Town-based FRC (CT-FRC). Only when the accepted papers were finalised and made available on the Forum website and in hard copy at the event was the FRC aware of the identity of the authors. The integrity of the blind review process was maintained throughout.

***Selection of the FRC and the call for abstracts***

FRC members were selected from developing country climate change mitigation experts familiar to the ERC and MAPS. An effort was made to select FRC members with familiarity on the topics evidencing themselves from the abstracts submitted, and from a variety of countries. The final FRC comprised experts from across the developing world including China, India, South Africa, Zambia, Brazil, Chile and Argentina. Brief biographies of the FRC are included in the following section.

The CT-FRC comprised certain members of the FRC who operate from Cape Town as well as additional experts drawn both from within the ERC and its networks. It was led by Meagan Jooste as Forum Academic Lead, in consultation with Emily Tyler as overall Forum Lead. Again, brief biographies are included in the following section.

A call for abstracts was circulated in July 2013 with topics invited from within the development and mitigation research theme, including specific sub-themes such as poverty and inequality, climate finance, governance, mitigation activities, co-benefits of mitigation activities, energy security, competitiveness, national planning for a low carbon future, process experiences, tools and alternative development paths.

***Screening of abstracts***
The intention of this process was to utilise the sectoral knowledge and expertise of the FRC to screen both the quality and relevance of the abstracts for development into papers to be presented at the Forum. This process was thereby designed to check for the appropriateness of abstracts in relation to the overarching objectives of the Forum as well as to ensure the abstracts matched academic standards.

Forty-nine abstracts were received within the stipulated timeframe. FRC members were requested to review approximately ten abstracts, and each abstract was reviewed by at least two FRC members to allow for an objective perspective and to provide the CT-FRC the opportunity to track any major concerns raised. Of the forty-nine, thirty-one authors were invited to write and submit full papers.

***Receipt and review of draft papers***
In anticipation of the receipt of draft papers in October 2013, the CT-FRC designed a review assessment form and corresponding review guidelines against which the FRC could assess the draft papers. The review assessment form in particular probed the blind FRC reviewer to report their feedback on the basis of a number of criteria including acceptability, relevance, quality and clarity. Reviewers were also afforded the opportunity to provide suggestions for the improvement of the paper to make it worthy of inclusion in the Forum proceedings.

In practice, fourteen draft papers were received in October 2013 and one blind FRC reviewer was assigned per paper. While in most instances this was the only reviewer assigned to a paper, where the first reviewer proposed an additional review (due to, for example, their limited knowledge on the methodology applied in a paper), or raised a large-scale concern of the acceptability of the paper, this was taken up by the CT-FRC. In such instances the CT-FRC chose to assign a second blind reviewer to assess the paper to meet the reviewer's suggestion or to acquire a second-opinion on the paper to compare to the first reviewer's perspective. While every effort was made to assign a reviewer from within the FRC itself, the CT-FRC also had to utilise its research and sector specific networks to assign reviewers beyond the FRC who could provide inputs based on their specific expertise, or who could avail themselves at short notice to fulfil this duty in a timely manner.

Once the full set of review feedback was acquired from the reviewers, these were then consolidated and transferred to authors in December 2013. Of the fourteen papers reviewed, only twelve papers were selected for invitation to submit a revised final paper due to explicit quality and relevance concerns raised on two of the draft papers. The selected authors were then advised to resubmit their papers by early January 2014 in order to facilitate the finalisation of the papers prior to the Forum. Authors were carefully briefed to submit according to the assigned author guidelines and to provide commentary to show how they specifically addressed the review feedback.

***Compliance and quality screening, and final language editing***
In early January 2014, the twelve revised papers were received. In order to ensure that the papers were in good standing for inclusion in the proceedings, a two-stage process was enacted. The first stage in the process involved the CT-FRC carefully screening each of the twelve papers and cross-checking the amendments made by authors (which in all except one case were done in track change format) to validate author compliance with reviewer feedback or at the very least, a response to why the author could not, or chose not to, undertake the reviewer's suggested changes. Whilst this was a relatively straightforward process, it did require some authors revisiting their paper to either match the reviewer's suggestions or to apply changes proposed by the CT-FRC on their review of the paper.

Once the CT-FRC was content that the papers met their required standing for inclusion in the proceedings, they were progressively relayed to the ERC language-editing team to complete a final language, quality and formatting check on the papers to prepare them for, firstly, hard copy provision at the Forum and, secondly, for inclusion in this Forum proceedings document. It is notable that while twelve papers were finalised in this manner, not all papers could be included in the proceedings due to publishing constraints of three of the twelve authors. All twelve papers were presented and made available in hard copy format at the Forum and all contributed to stimulating discussions at the event.

At the final stage of the review process, authors were afforded the opportunity to quality check the language and format-edited versions of their papers in hard copy at the Forum. Where authors identified errors or proposed further formatting or language edits, these were then undertaken after the Forum to ensure the paper matched the author(s) and the CT-FRC's expectations.

## Forum Review Committee biographies

***Forum Review Committee***
**Chandra Bhushan** (India) is the Deputy Director General of the Centre for Science and Environment, one of India's leading public interest research institu-

tions. Bhushan has a diverse and distinguished track record in research, writing and policy advocacy. He has researched and written about issues ranging from industrial pollution to energy security and climate change and from water crisis in the Indian sub-continent to the political economy of natural resource extraction. His academic qualifications include bachelors degrees in civil engineering and masters degrees in environmental planning and technology. Bhushan has many books and publications to his credit. His recent publication titled 'Challenge of the new balance discusses the low-carbon growth strategy for the six most energy- and emissions-intensive industrial sectors of India.

**Hernan Carlino** (Argentina) is a climate policy specialist, with a background in economics, negotiations, regulatory affairs, and education. He has some 25 years of experience in the area of environmental economics and regulation. For the last 16 years he has worked directly on policy negotiations at the Argentine and international levels on climate change, including REDD. He has also worked directly on UN-level carbon market regulation, as a member of the CDM Executive Board and the CDM Accreditation Panel. He also has experience in designing and implementing projects mainstreaming climate change in national strategies and plans, internalising climate issues and elaborating scenarios, as well in-depth practical knowledge of Latin America and the Caribbean region.

**Kim Coetzee** (South Africa) is a PhD and MAPS Researcher at the Energy Research Centre, University of Cape Town. Kim's research interests lie in global environmental governance, specifically the overlap between the trade and climate change regimes, low-carbon development strategies, and the role of alternative ideational constructs in the governance of climate change. She holds an MSocSc in International Relations, and an Honours degree from the Open University, London.

**Navroz K Dubash** (India) is a Senior Fellow at the Centre for Policy Research, New Delhi, where he works on climate change governance at global, national and sub-national levels, the political economy of energy in India and Asia, and the role of civil society in global environmental governance. He is a lead author and a member of the Synthesis Report-writing team for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, has been a member of India's Expert Committee on Low Carbon Strategies for Inclusive Growth, and served on numerous energy and water related expert groups of the Government of India's Planning Commission. He serves on the editorial boards of several international journals including *Global Environmental Politics*, *Climate Policy*, the *Journal of Environment and Development*, and the newly-launched *Energy Research and Social Science*. His recent publications include an edited *Handbook of Climate Change* and India: Development, Politics and Governance, a co-edited special issue of *Climate Policy* entitled 'Beyond Copenhagen', and a co-edited special issue of *Global Policy* on 'Global energy governance'. He has a long history of engagement with civil society organizations, including being the first international coordinator of the Climate Action Network, from 1990–1992. Navroz holds PhD and MA degrees in Energy and Resources from the University of California, Berkeley, and an AB in Public and International Affairs from Princeton University.

**Rodrigo Palma-Behnke** (Chile) is an IEEE senior member and associate professor in the Electrical Engineering Department of the University of Chile, Santiago. He received his BSc and MSc in Electrical Engineering from the Pontificia Universidad Católica de Chile and a Dr-Ing from the University of Dortmund, Germany. His research field is the planning and operation of electrical systems in competitive power markets, new technologies, microgrids, and power system education. He is the Director of the Energy Center and the Solar Energy Research Center SERC-Chile. He is the research leader of the MAPS-Chile project.

**Amaro Pereira** (Brazil) is a graduate in economics at Universidade Federal Fluminense, with an MSc in Energy Planning and a PhD in Energy Planning, both from the Federal University of Rio de Janeiro. He has been technical advisor of the Energy Research Company and is currently Associate Professor of the Energy Planning Program at COPPE / UFRJ and director of ILUMINA (Instituto de Desenvolvimento Estratégico do Setor Energético). He is also a researcher at CentroClima/ LIMA/COPPE/UFRJ. He has experience in energy and environmental modelling, besides working in subjects such as energy sector regulation, analyses of new technologies and different energy sources and in issues related to climate change.

**Joyashree Roy** (India) is a Professor of Economics and currently ICSSR National Fellow at Jadavpur University, Kolkata. She initiated and also coordinates the Global Change Programme (www.juglobalchangeprogram.org) which focuses on climate change research and beyond. She also directs Ryoichi

Sasakawa Young Leaders Fellowship Fund Project (www.jusylffprogram.org) on 'Tradition, social change and sustainable development: A holistic approach' at Jadavpur University. She was a Ford Foundation Post-doctoral Fellow in Environmental Economics at the Lawrence Berkeley National Laboratory, California, USA. She is among the network of scientists who shared in the 2007 Nobel Peace Prize to the Intergovernmental Panel on Climate Change). She is co-sharer of the Prince Sultan Bin Aziz Prize for water, 2012. She has been involved in preparation of the Stern Review Report, Global Energy Assessment and many other national and global reports. She is on the steering committees of several national and international science-policy interactive platforms and on the editorial boards of many international journals. In her independent research capacity she has authored or co-authored a number of books and written some 75 articles in leading professional journals and books. She is interested in multidisciplinary approaches to understanding development challenges. She has widely travelled for research collaborations and research capacity-building. Current research interests are the economics of climate change; modelling energy demand; economy-wide modelling exercises for deriving policy implications; water quality demand modelling; water pricing; sustainable indicator estimation; natural resource accounting; valuing environmental services; and developmental and environmental issues relevant for informal sectors, Coastal Ecosystem service evaluation.

**Richard Sherman** (South Africa) is a Technical advisor at SouthSouth North. Richard serves as a technical advisor on multilateral environmental agreements, international environmental governance, climate change and sustainable development. He is a member of South Africa's official negotiating delegation to the United Nations Framework Convention on Climate Change, where he focuses on issues relating to climate finance and governance. He is currently the Advisor to the Co-Chair of the Board of the Green Climate Fund and is the convenor of the African Group of Negotiators Finance Working Group.

**PR Shukla** (India) is a Professor in the Public Systems Group at the Indian Institute of Management, Ahmedabad, India. He holds a PhD from Stanford University, USA. Prof Shukla is a member of several international teams working on energy and environment modelling and policy assessments. He has co-authored several reports commissioned by international agencies on energy and environment. He has been a co-coordinating lead author and lead author of ten reports of the Intergovernmental Panel on Climate Change. Prof Shukla has served as a member of committees appointed by the government of India in the areas of energy and environment policy. He was a member of the Indian delegation to the UNFCCC Conference of Parties – COP8 and COP9. He has provided research, consulting and advisory services to the government of India and several international agencies and organisations such as UNDP, UNEP, IEA and The World Bank. Prof Shukla has served on the steering committee of several international initiatives; some recent ones are the UNEP Low Carbon Transport Project in India, Low Carbon Asia Research Network, Joint Japan-UK study on Low Carbon Society, Pacific Northwest National Laboratory's Global Technology Strategy Project, and UNEP RISO Center's Development and Climate Project. He is a member of several global modelling teams making long-term energy and environment projections; such as Asia-Pacific Integrated Model: AIM (led by the National Institute of Environment Studies, Japan), GCAM and SGM (developed by PNNL, USA) and IMACLIM (developed by CIRED, France). He is on the editorial board of several journals in the areas of energy, environment and sustainable development. His publications include thirteen books and numerous papers in international journals in the areas of development, energy, environment and climate change policies.

**Fei Teng** (China) is located at the Institute of Energy, Environment and Economy, Low carbon energy laboratory, and Associate Professor at Tsinghua University, Beijing, China.

**Emily Tyler** (South Africa) is a freelance climate policy specialist who has been involved in the financial and economic implications of climate change mitigation since 2001, when she assisted the auction of carbon allowances in the first round of the UK Emissions Trading Scheme. Between then and 2004 she undertook climate change policy and strategy consulting in the UK and Europe during the early stages of the EU Emissions Trading Scheme, including renewable energy policy development and corporate climate change response. Emily then returned to South Africa to work on Clean Development Mechanism (CDM) project transactions for the NGO SouthSouthNorth, and initiated and managed projects for companies, donors and government involving the use of carbon finance for sustainable energy interventions in the southern African region. In 2007 Emily started the Climate Change Practice of Genesis Analytics, a South African economic development consultancy. The Practice focused on carbon policy and strategy issues in both the public and private sectors, and project transactions in Africa. She worked particularly in the banking and mining sectors, understanding and developing appropriate climate change response strategies for companies. Consulting independently since 2009, Emily has focused on national mitigation policy, planning and strategies in South Africa, and the application of the international concepts of low-carbon development strategies and NAMAs in developing countries. Energy policy, economic mitigation policy instruments and the interface of climate and development are key interest areas. Clients have included the South African government, academic institutions, large corporates, environmental NGOs, and energy and development think tanks. Emily lectures in climate policy and finance at local universities, and serves on a number of NGO, academic and company advisory boards

**Harald Winkler** (South Africa) is the Director of the Energy Research Centre, University of Cape Town. Harald's research interests are focused around climate policy, at international and national level. He led the research work underpinning South Africa's Long-Term Mitigation Scenarios (LTMS). His current work includes work with other developing countries to share the LTMS exprience in the Mitigation Action Plans and Scenarios programme (see www.mapsprogramme.org). He developed the proposal of sustainable development policies and measures (SD-PAMs). Research areas have included equity and future commitments to climate action; economics of climate change mitigation; energy scenarios for South Africa and Cape Town; the links between sustainable development and climate change; renewable energy and mitigation. Harald has taught and supervised at postgraduate level since 2000. He is rated as an 'internationally acclaimed researcher' (B2) by SA's National Research Foundation.

**Francis Yamba** (Zambia) is the Director at the Centre for Energy, Environment and Engineering Zambia (CEEEZ). Professor Yamba holds an MSc (1972) and PhD (1978) and is a full professor in mechanical engineering with a bias on thermal sciences and energy and environment since 1985. He has 40 years of experience in teaching, research and development, consultancy, management, engineering applications. Has served as Dean at the School of Engineering at the University of Zambia, Executive Director-Technical at the Industrial Development Corporation), and Managing Director of the Engineering Services Corporation. He is currently serving as Chairman of Board of Trustees of the Industrial Training Centre. He is on the (Intergovernmental Panel on Climate Change (IPCC) 700 scientists world wide who have been awarded the In 2006 he was awarded the Business Leaders Partnership Forum Award for academia for distinguished achievements that have impact on society.

### Cape Town based Forum Review Committee

**Anya Boyd** is a Senior Researcher in the Energy, Environment and Climate Change group at the Energy Research Centre at the University of Cape Town. and is currently particularly involved in the Mitigation Action Plans and Scenario programme. Her research focuses on low-carbon development actions and policies, NAMAs, MRV and technology negotiations under the UNFCCC.

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**Michael Boulle** is a Researcher at the Energy Research Centre, University of Cape Town and assists with project management for the Mitigation Action Plans and Scenario programme. Prior to this he was an intern at ERC whilst completing his MPhil in Energy and Development Studies. His research focuses on the adaptation-mitigation nexus, NAMAs, and investigating linkages between mitigation and poverty alleviation. He also has research interests in pro-poor low-carbon development strategies and the energy-water nexus. Michael holds a BSc Honours in Geography.

**Meagan Jooste** is a Consultant at Palmer Development Group in Cape Town. She has a Masters degree in Economics and an undergraduate degree in Economics and Environmental and Geographical Sciences both from the University of Cape Town. Prior to joining PDG Meagan conducted research at the German Institute for Economic Research (DIW) in Berlin as well as at the Southern African Labour and Development Research Unit and Energy Research Centre, both at UCT. Through this she developed experience in quantitative macro- and micro-economic analyses which she now applies to research on environmental and economic policy in South Africa. Most recently she has worked on: an economic impact assessment for South Africa's Mitigation Potential Analysis, a review of the impact of inclining block tariffs for electricity on poor households in South Africa as well as providing support in the development of an energy model for the Western Cape Province.

**Anthony Leiman** Associate Professor Tony Leiman is a Director of the Environmental Policy Research Unit in the School of Economics at the University of Cape Town, where he focuses on environmental and resource economics, cost-benefit analysis and related matters surrounding the informal sector.

# A review of sustainable development assessment literature that could be applied to NAMAs

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***Abstract***

The actual contribution of mitigation initiatives to national sustainable development (SD) has been widely debated amongst scholars. The operationalisation of Nationally Appropriate Mitigation Actions (NAMAs) within the United Nations Framework Convention on Climate Change (UNFCCC) could help in reconciling two of the main thrusts of the UNFCCC; its emissions reduction and SD objectives. However, limited attempts have been made to explicitly link the two concepts through integrated approaches. The present paper discusses the existing theoretical considerations on sustainability assessments, as a similar exercise on NAMAs, by reviewing the relevant literature pertaining to the two bodies of knowledge. A number of features have been identified as conducive to easing the assessment of the SD impacts of NAMAs. These include a classification of NAMAs that favour Measurement, Reporting and Verification, requirements for a combination of ex-ante and ex-post assessments, adoption of the Bellagio Principles in the framing of sustainability indicators, freedom for countries to define their own sustainable development vision and methodologies while recognising the limitations in the adoption of any chosen approach, framing of a minimum set of sustainability dimensions, integration of transformational change considerations in the design of NAMAs and the need for informed deliberative discourse at country level while defining SD through the use of Multi-Criteria Analysis. The paper concludes with requirements for further research geared towards comparing and applying the use of similar approaches and methodologies across technologies, sectors and countries, as well as further clarity on conceptualising transformational change within the NAMA debate.

*Keywords:* sustainable development, Nationally Appropriate Mitigation Actions, methodologies, sustainability assessment, co-benefits

## 1. Introduction

The adoption of the United Nations Framework Convention on Climate Change (UNFCCC) has spurred a variety of climate change policies and initiatives across the globe. However, scientific studies and reports published thereafter have hinted that measures taken globally have not set the world on a development path that would prevent dangerous anthropogenic interference with the climate system as delineated by the UNFCCC convention text (UNEP 2012; Bernstein *et al.* 2007).

During the series of complex climate negotiations, Parties to the UNFCCC have agreed to set a long-term global goal of emissions reduction as part of a shared vision of long-term cooperative action, with Nationally Appropriate Mitigation Actions (NAMAs) contributing to this goal. To enhance the crucial participation of developing countries in global mitigation efforts, it was also agreed that NAMAs should be supported, and that support be subject to Measurement, Reporting and Verification (MRV), along with the setting up of a registry of NAMAs (UNFCCC 2011).

It can be argued that such MRV requirements require a minimum of structure and rigor in terms of methodology so as to facilitate the assessment of the likely impacts of NAMA initiatives prior to implementation, as well as their actual efficiency throughout their lifetime to provide for analysis of results obtained and strategic re-orientations, if needed. Moreover, improved methodological requirements will improve transparency and hence credibility in the process, enabling a fair channelling of financial and technical resources from donors to recipients from developing countries.

However, adjustments made to accommodate the varying viewpoints of different UNFCCC Parties, coupled with the concise nature of the wording utilised, have led to wide understanding of the agreement related to NAMAs (Linnér & Pahuja 2012). Issues have thus been raised in relation to their operationalisation, including support, MRV mechanisms and accounting. Moreover, the decision on an essential NAMA registry has not included criteria for sustainable development (SD) but rather encourages countries to develop their low carbon development strategies 'in the context of sustainable development' (UNFCCC 2011). This oversight could hinder the design of an effective NAMA registry – a flaw that would prevent the assessment of the sustainable development and other co-benefits of NAMAs. Experiences from the Clean Development Mechanism (CDM) have also shown that leaving SD to be defined at the national level has not facilitated SD dimensions to be fully taken into consideration in CDM projects (Olsen & Fenhann 2008), with the limited capacities of developing nations as well as opposing agendas of different CDM stakeholders being cited one of the reasons (Kim 2003).

Though SD criteria have not yet been included in core NAMA proposals, the latter should be understood in context of SD, in line with Article 3.4 of the UNFCCC Convention text (Linnér & Pahuja 2012). With NAMAs aspiring to be game changers, Parties could be expected to explain how NAMAs could contribute to systemic change by promoting SD and reducing emissions.

As a relatively newly framed mechanism, literature that explicitly relates NAMAs and their SD impacts is scarce and fragmented, with a wide range of approaches being used by authors (Winkler *et al.* 2007); Winkler *et al.* 2008); (Román 2012; Dubash *et al.* 2013; Garibaldi *et al.* 2013; Olsen 2013; Tyler *et al.* 2013). Expanding the screening process to previous assessments of sustainable development benefits of a wider range of mitigation measures reveals a majority of studies that have either focussed on the CDM, taken a sectoral approach or both (Huq 2002; Olsen 2006; Schmitz 2006; Heuberger *et al.* 2007; Olsen 2007; Sutter & Parreño 2007; Olsen & Fenhann 2008; Musango & Brent 2011). In this context, it can be argued that the body of knowledge on NAMAs could be enriched by taking a bird's eye perspective of sustainability assessments of NAMAs through adopting an integrated approach that could address the following research question; *how can existing theoretical considerations on sustainability assessments inform a similar exercise applied to NAMAs?*

On top of contributing to the body of knowledge regarding expanding theoretical considerations and viewpoints on NAMA linkages with sustainable development, such an exploration has a number of empirical advantages, as highlighted by scholars (Bakker & Huizenga 2010, Lütken *et al.* 2011, Hinostroza *et al.* 2012, Linnér & Pahuja 2012, and van Tilburg *et al.* 2012); such as

a) SD Assessment of NAMAs could help track their successes, build domestic political support, and monitor wider benefits given the broad and transformative nature of NAMAs,
b) contributing towards the establishment of methodologies for MRV of those NAMAs wherein direct quantification of emissions reduction is not direct e.g. by providing options for other processes or proxy indicators,
c) informing discussions at climate negotiations regarding methodologies for ex-ante estimations of SD and co-benefits of NAMAs,
d) providing additional guidance through clear and transparent criteria from prospective funders to

make NAMA proposals more bankable while attending to the needs and circumstances of developing countries,

e) providing guidance to a potential new Executive Board for NAMAs under the UNFCCC, similar to the CDM Executive Board, informing its possible methodology panel on what seems to pose difficulties for countries when proposing NAMAs and which tools might be helpful.

As a further guide to the review, the above empirical considerations have been considered as expected outcomes, the extent of which needs to be maximised, while being informed by existing theories on sustainability assessments. However, an initial screening focussing exclusively on sustainability assessments literature has revealed a number of intrinsically linked bodies of knowledge that cannot be dissociated from such assessments, occurring both upfront and downstream of the process of undertaking the task of gauging the SD impacts of an initiative. These include the concept of SD in itself, the use of indicators and policy evaluation techniques.

With a view towards devising methodologies that could enable the assessment of the SD impacts of nationally appropriate mitigation actions, some fundamental assumptions must be made. A primary assumption would be that there is a common understanding of the two concepts, however, there seem to be as many meanings of the term 'sustainable development' as there are authors trying to describe it (Hopwood *et al.* 2005), while the international climate community is yet to agree on a common definition of the term 'Nationally Appropriate Mitigation Action', if ever the Conference of Parties (COP) to the UNFCCC gets mandated to do so. Faced with two hazy theoretical notions, some clarity of meaning is thus essential, especially so as to be able to justify those fundamental assumptions required to devise an appropriate methodology to measure SD impacts of NAMAs. On a more downstream level, undertaking sustainability assessments will only make sense if they are supported through appropriate indicators and evaluated using an appropriate methodology.

For reasons of breadth of coverage and space limitations, the present paper will only focus on some conceptual understandings of NAMAs *per se*, followed by a review of the debates around framing SD and a critical review of SD assessment tools and SD indicators and frameworks as could be applied to NAMAs, with insights on desired characteristics that could be required to assess the co-benefits of NAMAs. It is to be noted that the purpose of this paper is not to come up with a silver bullet methodology for assessing co-benefits of NAMAs that could be applied universally, but rather to critically analyse the applicability and relevance of different theoretical stances that may have practical application. Peer-reviewed articles have been sourced from Web of Knowledge and Google Scholar, complemented with publications from recognised institutions and grey literature from the internet.

## 2. Conceptualisation

### *2.1 The NAMA mechanism*

International climate negotiations have often stalled, with sovereign nations disagreeing on whether support should be delivered first or actions should be shown first by developing country Parties before support is provided by developed Parties. The concept of NAMAs has thus been coined as a means to incentivise developing country parties to assume a share of the essential reduction of emissions needed to avoid dangerous climate change, while enabling countries to develop sustainably and in light of their national circumstances (Lütken *et al.* 2011, Okubo *et al.* 2011; van Tilburg *et al.* 2012). NAMA pledges could be expected to take precedence over the model of Kyoto Protocol's commitments, though the concept has yet to be operationalised by Parties.

The notion of NAMAs formally stems from the adoption of the Bali Action Plan at the 13th Conference of Parties to the UNFCCC as a framework that clarifies the engagement of developing countries in mitigation actions. Some conceptual similarities can also be traced to the Sustainable Development Policies and Measures (SD-PAM) proposal, wherein SD-PAMs were to be 'policies and measures that are aimed at meeting the domestic objectives of the host country, but that also bring significant benefits to the climate through reduced GHG emissions' (Bradley *et al.* 2005). The concept of NAMAs deviates from the nature of carbon markets, whereby mitigation measures are implemented and development benefits are expected to trickle down, towards a new paradigm emphasising on development measures that bring ancillary emissions reduction benefits.

To-date, no official definition of NAMAs has been agreed at COP level, though some authors have tried to describe NAMAs. A compilation of meanings of the term 'NAMA' within published literature at the time of writing is in Table 1.

As can be observed from Table 1, scholars and practitioners have pre-supposed a wide array of meanings for NAMAs depending on their area of focus and ranging from finance, the nature of intervention, mitigation objective and reporting channel. Such diversity stems from the fact that an agreement has not yet been reached at COP level regarding a

**Table 1: NAMA typologies**

| *Typologies* | *Description* |
|---|---|
| | *Financial flow-focussed definition* (Linnér & Pahuja 2012;Hinostroza et al. 2012) |
| Unilateral NAMAs (domestic NAMAs) | Mitigation initiatives that are domestically funded and unilaterally implemented |
| Supported NAMAs (international NAMAs) | Mitigation is enabled by developed country support |
| Credited NAMAs (allowance NAMAs) | Carbon credits could be generated and traded on an international emissions market, similar in nature to the current CDM |
| | *Nature of intervention – focussed definition* (van Tilburg et al. 2013) |
| Projects | Such as a localised capital investment in either infrastructure or machinery, e.g. construction of concentrated solar power plant, a bus rapid transit system or deployment of energy efficient industrial motors. |
| Policies/regulations | Government-led initiative aiming for inclusion in law, e.g. feed-in tariff, emissions trading scheme, building code |
| Strategies | Long-term comprehensive plan of measures and actions designed to achieve a common goal. It contains many types of activities with various degrees of impact: e.g 20% renewable energy target backed by a market and regulatory strategy to break barriers in RE development. Master plan to improve transit management. |
| | *Mitigation objective-focussed definition* (Sharma & Desgain 2013; adapted from submissions obtained from the Copenhagen Accord) |
| *Goal-specifying NAMAs* | |
| Economy-wide goals | Absolute reduction target, e.g. reducing emissions by 25% below 1990 levels by 2020 (Antigua & Barbuda)<br>BAU deviation target, e.g. reducing national emissions by 30% from BAU emissions in 2020 (South Korea)<br>Intensity target e.g. reduce emissions intensity of GDP by 20-25% by 2020 compared to 2005 level (India) |
| Sectoral goals | e.g. Increase forest cover from 7% in 2005 to 30% in 2050 (Togo) |
| *Non-goal-specifying NAMAs* | |
| Focus areas | Generic sub-sectoral, sectoral or cross-sectoral mitigation options with no specific goals or measures attached to them e.g. energy efficiency, promotion of renewable energy |
| Measures | Specific policies, regulations, or technology initiatives e.g. standards in building sector, promotion of low-energy light bulbs |
| Specific actions | Project or technological action in a specified location e.g. 450 MW hydropower project in Ethiopia |
| Others | e.g. preparation of national communications (Afghanistan), preparation of comprehensive SD programme that prioritises renewable energy and energy efficiency (Mauritius) |
| | *Reporting channel-focussed definition* (Tyler et al. 2013) |
| Copenhagen Accord | Country submissions to Copenhagen Accord |
| Registry submissions | Actions registered on the UNFCCC web-based registry |
| Mitigation Action | All other types of mitigation actions in a developing country, without regards to formal communications to the international community |

common definition for the term. With NAMAs being developed bottom up, such a universal definition might never be formalised, though some common elements can be reasonably expected to emerge. Tyler *et al.* (2013) observe a certain convergence in the NAMA literature towards understanding NAMAs as UNFCCC registry submissions. Common to the four categories identified in Table 1, NAMAs can be viewed as a new conduit through which developing countries will either aim to have national measures with emissions reduction benefits recognised or attempt to market and negotiate international development projects. In so doing they would compete for climate finance with quantification wherever possible of the benefits of such NAMAs.

Though it can be argued that the open-ended interpretation of what can be described as nationally appropriate within a developing country can enable encapsulation of nearly any initiative that has mitigation co-benefits, such definitional uncertainty could also hinder mitigation ambitions (Tyler *et al.* 2013), especially when a structured and strategic approach towards NAMAs is envisaged as would be the case if integrated with a low-carbon/emission development Strategy. The need for such strategic planning has been advocated within the Cancun Agreements, with scholars such as Lütken *et al.* (2011) and Hinostroza *et al.* (2012) understanding such a requirement as the need for NAMAs to be mainstreamed into multidimensional long-term development planning. Being embedded in national policy, NAMAs are expected to enjoy the appropriate level of political support (van Tilburg *et al.* 2012). It can thus be argued that the faster the UNFCCC COP provides better clarity of what should constitute a NAMA, the easier it will be to progress on up-scaling mitigation ambitions by non-Annex 1 Parties. Moreover, it can also be argued that quantification, wherever possible, of SD outcomes of NAMAs can promote the efficient operationalization of the mechanism.

### *2.2 Proposed NAMA framework*

In line with the argument that national appropriateness of a mitigation initiative would require abiding with a country's existing or planned developmental policy and strategic orientations, it can be argued that NAMAs, in one way or the other, would require support from government, private sector and possibly also civil organisations in order to be operationalized at a national scale. Private sector activities being generally market-driven, the success of a NAMA will, amongst other conditions, be dependent on the ability of government to create the necessary conditions that would ease implementation of a NAMA. Whatever mitigation measure, whether solely public, exclusively private sector-driven or involving both, effective governmental frameworks are a key element of the successful implementation of a NAMA. However, public bodies generally operate within governance structures that are bound by more rigid regulatory frameworks and procedural requirements than private entities – a situation that is fair in view of the enhanced requirements for transparency and accountability involved in the management of public funds. This relative rigidity can impede the smooth implementation of NAMAs, including assessment of their sustainable development and other impacts. With a view to attend to the decreased flexibility in manoeuvring, NAMAs should thus be framed in such a way that public sector oversight and operational be eased. To this end, it has been deemed important to reflect such considerations within a NAMA framework, as pictured in Figure 1.

In view of the common public management practice of delineating responsibilities for implementation of public initiatives as being stratified according to sectoral themes, a sector wise categorisation is viewed as bearing good promise in terms of defining NAMAs. Coordination of sector NAMAs will thus be easier with regard to expected MRV requirements of sustainable development impacts.

Having classified NAMAs on a sectoral basis, further classification in terms of reporting intent has been deemed important – whether the NAMA is only meant for international recognition of a national measure (domestic NAMA), or for international funding (International and Credited NAMAs), since each type of NAMA can be reasonably expected to have a different level of stringency of MRV requirements. MRV of domestic NAMAs could make use of existing reporting structures such as from statistics offices, line ministries or other stakeholder institutions with the assessment of impacts being expanded to cover the scope of the NAMA in question. Being embedded within an existing sector or ministry will make reporting easier. International and Credited NAMAs, on the other hand, will need more stringent MRV requirements. A sectoral or ministerial 'one-stop-shop' – operating as a national focal point – would coordinate, implement and MRV the sustainable development and other impacts of NAMAs.

Following the sectoral and reporting classification, a further categorisation of the nature of the intervention (policy, target and/or project) of the proposed NAMA would enhance conceptual clarity and assist development of MRV frameworks at a country level.

With climate talks evolving more and more towards conceptualising NAMAs as a major new cornerstone within international climate policy driven by their sustainable development benefits, undertaking an assessment of the SD impacts of NAMAs becomes essential. However, understandings of the term 'sustainable development' are even more divergent than that of NAMAs. Some scholars refer to the vagueness in definition by describing SD as an oxymoron (Redclift 2005) or 'an open door towards fostering delusions' (Robinson 2004). With this in mind the following section will thus attempt to review the fundamental principles and the different ways SD is conceptualised, before positioning NAMAs within such a context.

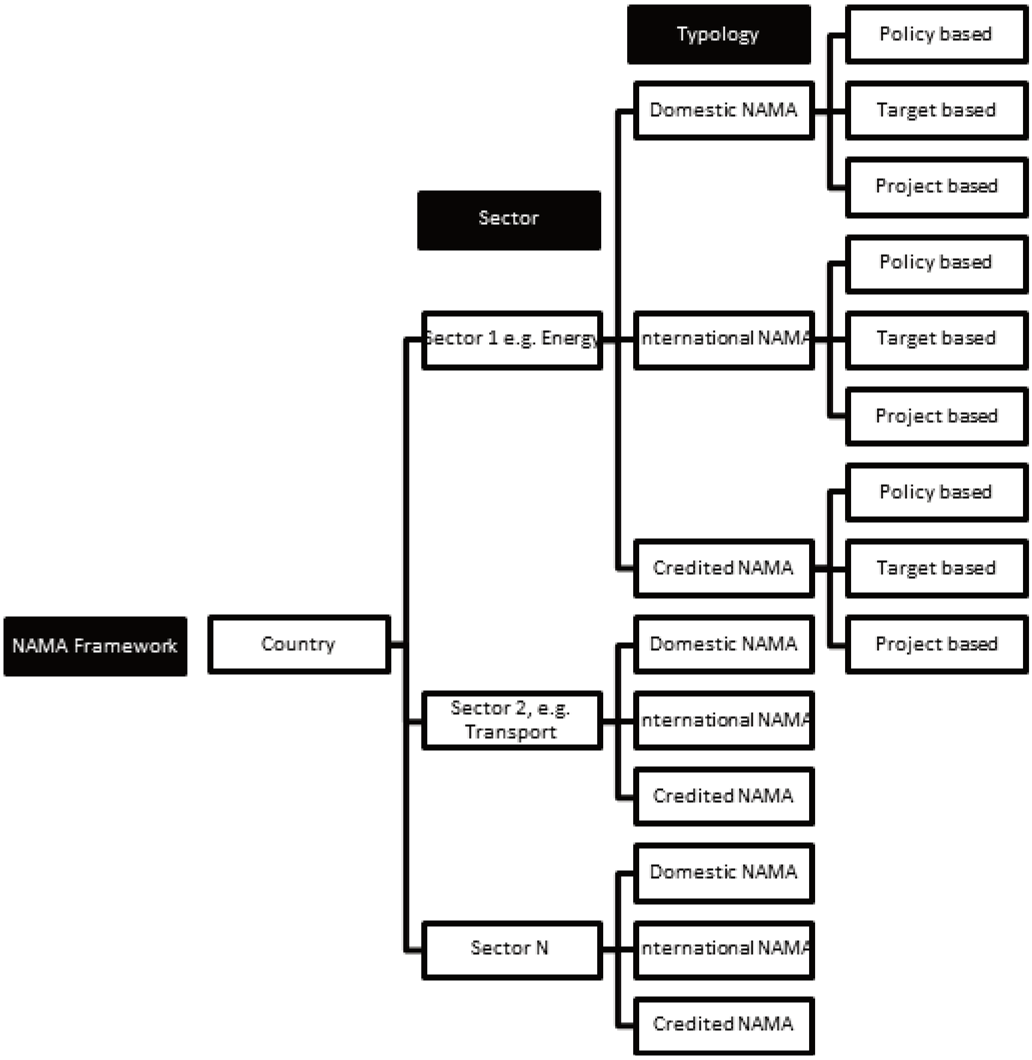


**Figure 1: NAMA framework**

### *2.3 Sustainable development – the debate*

Critiques of sustainable development as an 'ideal' have raised a number of issues that seem to saddle the concept. In his review of the sustainability literature, Lele (1991) opines that the weakness of the sustainable development notion lies in its strength, i.e. although the wide interpretation of the concept of SD implies political acceptance, its lack of intellectual clarity and rigour prevents it from becoming a meaningful paradigm of development. There is concern that its looseness could be used by decision makers (politicians and business leaders) to legitimate virtually any policy or practice without commitment to undertaking the essential changes to their business-as-usual path (Hopwood *et al.* 2005). The idea of 'sustainable growth' has also been criticised as being meaningless within a system in which economic growth is dependent upon finite ecosystems (Daly 1993).

While a universally agreed and clear definition of sustainable development is desirable, in practice, it is highly unlikely that such an agreement will be reached, especially since this involves disentangling the debate from both the need for political acceptance and the respect for the sovereign right of states to define their own visions of sustainable development within their specific national circumstances. To this end, some trade-off is required, such that a definition of sustainable development should be broad enough to encapsulate varying views, and concise enough to enable cross country harmonisation of essential elements of sustainability. Within the NAMA debate, this could entail a minimum number of SD aspects that could be required as essential elements across nations, while leaving specific details to be defined at a national level. The following sections will thus attempt to analyse attempts undertaken by a number of scholars to categorise a variety of sustainability discourses, with the aim of identifying fundamental principles that could guide an assessment of SD impacts of NAMAs, comparing the relative advantages and limitations of adopting different conceptual framings, and lastly, identifying desirable characteristics of such framings that could facilitate the assessment process.

Originating from the concerns with the sustainable yield from renewable resources such as forests and fisheries (Lele 1991), the concept of sustainability was most famously first publicised in the public debate of research undertaken by the Club of Rome (Mitcham 1995), published in the book, 'The Limits to Growth' (Meadows *et al.* 1972), which described catastrophic consequences of traditional global growth patterns. In the Club of Rome's Second Report, the tone shifted from a discourse picturing catastrophic failure of global systems towards a more pragmatic one relating to what could be done – from 'development' towards 'development that is sustainable' (Mesarovic & Pestel 1974). This paradigm shift was further enhanced through publications of 'The World Conservation Strategy' in 1980 by the International Union for the Conservation of Nature and Natural Resources and the 'Our Common Future' report (often referred to as the *Brundtland Report* after commission chairperson Gro Brundtland) by the World Commission on Environment and Development (WCED) in 1987.

The Brundtland Report defined sustainable development as ' development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland 1987). This was a compromise made to cater for the competing interests of, firstly, environmentalists, who were arguing for limits to growth with a view to tackle pollution, protect natural resources and cater for future generations; and, secondly, economists, especially from Third World Countries, advocating for the right to more development and growth.

This anthropocentric, two-pillar interpretation of sustainable development – a trade-off between ecological sustainability and satisfaction of basic human needs – has dominated the SD debate since. In short, sustainable development challenges the assumption that increased global trade and industry can succeed in bringing international prosperity and human well-being (Hopwood *et al.* 2005), while also recognising the failure of traditional growth models at tacking environmental and equity concerns. Since Brundtland's popularisation of the term, SD has reached mainstream international environmental policy, especially through implementation of Agenda 21, as a unifying concept for worldwide development activities (Estes 2004), bringing together actors from different disciplines and sectors with varying theoretical and ideological perspectives.

The ideology whereby some balance is to be sought between competing dimensions has prevailed across the sustainability debate. It can be argued that such a predisposition to favour a democratic discourse should also prevail while attempting to assess the sustainability of NAMAs, operating as a fundamental principle. However, such a quest for balance amongst sometimes converging and often diverging interests has led to wide conceptual framing of the meaning of 'sustainable development' amongst scholars and practitioners alike, which have implications on attempts to assess the SD impacts of an initiative.

### *2.4 Pillar-based description*

One recurring feature in the attempt for definitional clarity visualises SD as comprising of a number of pillars that represent the foundations of sustainability. The most common one is the three pillars or triple bottom-lines (Hacking & Guthrie 2008) which visualise SD as comprising of environment (bio-physical), social and economic dimensions. Some scholars consider the 'triple bottom-line' assessment as one that accounts equally for each pillar during decision making (Pope *et al.* 2004). However, other authors have expanded the scope of the pillar-base description; for instance further dividing the social dimension of SD into political and cultural concerns (Estes 2004). Others have advocated a set hierarchy of elements operating within seven spheres namely moral, ecological, social, economic, legal, technical and political (Pawłowski 2008) or increased the sophistication by moving from a pillar based concept to a system-based description with considerations extending as far as the material and psychological spheres (Bossel 1999).

The triple bottom-line discourse in SD, which varies from 'weak' to 'strong' sustainability concepts, has been the most discussed in literature. Weak sustainability considers that nature and human-made capital are interchangeable and the goal of such models is maintaining total capital stocks (Robinson 2004). For instance this approach believes that a lack of natural resources can substituted for through progress in technology (Hopwood *et al.* 2005). Weak sustainability models (Figure 2) are commonly depicted as three overlapping circles of social, environmental and economic aspects, such that any sustainable development would occur at the point where the three circles overlap (Connelly 2007).

Strong sustainability, on the other hand, refers to an ecological sustainability model that seeks to finding a way to live within the limits of natural sources in view of the fact that source and sink functions provided by natural resources are finite. In contrast to weak sustainability, the argument here is that some natural capital stocks are 'incommensurable and non-substitutable' (Robinson 2004), and thus must be maintained independently of the growth of other forms of capital. It is commonly represented as in Figure 3.

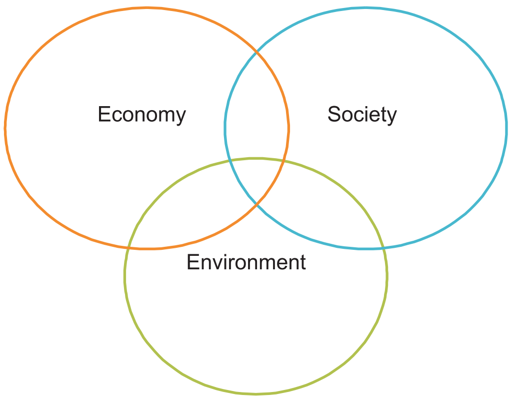


**Figure 2: 'Weak' sustainability**

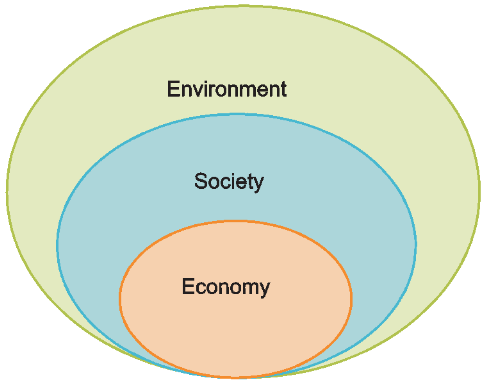


**Figure 3: 'Strong' sustainability**

(Neumayer 2003) further proposes two types of strong sustainability; preservation of nature in value terms and preservation physical stocks of some forms of natural capital.

As a mechanism that operates within a convention that is focussed on climate concerns and assuming a pillar-based description of SD, it can be argued that a strong sustainability perspective is preferable in assessing the SD impacts of NAMAs. However, the multi-disciplinary nature of climate issues as well as related development concerns have also been recognised (Sathaye, Najam *et al* 2007) and thus calls for a balanced stance across pillars, though limits to emissions should be factored into whatever SD stance that is adopted.

Moreover, conceptualising SD within pillars has a number of limitations. Those include the following points that have been noted by Gibson (2001) and Pope *et al.* (2004) regarding the triple bottom line concept, but which can be generalised to any pillar-based description of SD:

- it does not factor in the linkages and interdependencies of the pillars and focuses on the potentially competing interests amongst them;
- there is a tendency to promote trade-offs at the expense of one of the pillars, usually the environment one;
- there is a risk of omitting sustainability-related discourses that do not fall into the pillars;
- run the risk of the sum of parts being less than the whole if the interrelations are not adequately understood or described; and
- the pillar-based notion is restrictive and does not challenge conventional thinking and practice.

A pillar-based description of sustainability for NAMAs will thus have similar limitations. However, while exploring the literature, sticking only to the above mainstream description has been found as rather restrictive, since other relevant types of framings could also be relevant to NAMAs. With a view to deepening the ways in which SD is modelled, the concept of mind-maps will be discussed in the following section.

### *2.5 Mind-maps*

Human-nature relationships can be viewed with different lenses through mind maps – pre-analytic ideas or high generality mental constructs, which, in turn, determine the data needs, questions asked and views of the world to accommodate new results (Glaser 2006). Hopwood *et al.* (2005) have mapped the different views on SD across environmental concerns ranging from low, through technologically centred, to eco-centred viewpoints and socio-economic perspectives covering the importance given to human well-being and equality. To achieve SD, three types of necessary changes can be envisaged:

- status-quo, representing the view that such changes can be achieved within present structures;
- reform, representing the view that deep reforms are needed without significantly disrupting existing arrangements; and
- transformation, representing the view that the issues to achieve SD lie with economic and societal foundations which need to be radically changed.

With NAMAs intended to contribute significantly within global mitigation, it can be argued that a transformative change will be most adequate. This point of view can be expected from NAMA funders who will wish to maximise the return on 'investment'. The NAMA Facility, launched by the UK and German governments to fund NAMAs have already included, amongst other eligibility criteria, the potential for transformational change for financing of NAMAs (International NAMA Facility 2013).

Focussing on the inclusion of social aspects of sustainability, a wider and deeper analysis has been

**Table 2: Human-nature mind-maps**
*Source: Adapted from Glaser (2006: 135)*

| *Description* | *Pros and cons* |
|---|---|
| | *Eco-centric mind-maps* |
| Social needs are considered as secondary to requirements of nature | While eco-centric mind-maps recognise humanity as being embedded in nature and provide the foundation for the quantification of eco-physical limits to human-nature relationships, they reduce the social dynamics and linkages to a simplistic linear model. |
| | *Anthropocentric mind-maps* |
| Defines nature in terms of goods and services it delivers to humanity | Though anthropocentric mind-maps have enabled a comprehensive view of nature's services to humanity as well as increased inclusion of some social dimensions, they either ignore or oversimplify the bio-geo-physical limits to human use of nature and contribute to ecosystems degradation. Denial of the existence of nature also hinders interdisciplinary cooperation. |
| | *Inter-disciplinary mind-maps* |
| Attempts to address ecological, economic and social dimensions of ecosystem management in a balanced way | Interdisciplinary mind-maps (which include triple bottom line assessments) have enabled analysis of social variables such as institutional and legal processes in ecosystems management but have ignored fundamental social drivers such as values, needs, knowledge, power structures and culture. |
| | *Complex systems mind-maps* |
| Attempts to analyse human-nature dynamics by concentrating on intersystem linkages and combining these with internal subsystem dynamics at various temporal, institutional and spatial scales | Complex systems mind-maps could theoretically provide a better framework that includes social dimensions while allowing for trans-disciplinary knowledge generation, but lacks refinement to cater for complexity, uncertainly, non-linear feedback, cross-scale interactions. Moreover, such systems could view humans as being driven in lieu of being capable of reflection and adaptation. |

undertaken by Glaser (2006), where four types of mind-maps have been analysed as a way to compare the pros and cons of alternative concepts of human-nature relationships, as summarised in Table 2.

Though the adoption of purely eco-centric or anthropocentric mind-maps provide good potential for quantification applicability, those mind-maps exhibit limitations in terms of factoring the social dimensions of SD. As mentioned by Glaser (2006), scientific endeavours of societal relevance – NAMAs in this case – would have limited use with the use of approaches that focus exclusively on selected disciplines or on separate parallel spheres. With NAMAs being implemented primarily for SD concerns, the social dimension will be of high importance in their implementation. Glaser further recommends the use of complex systems mind-maps in view of their advantages of allowing 'integrative analyses with the participation of system stakeholders in transformative and adaptive trans-disciplinary work'. From the comparative analysis in Table 2, a complex systems perspective for assessing the sustainability of NAMAs could be a plausible option, especially with a view to include the social dimension of NAMAs as framed within a democratic discourse. However the complexity of such an approach could also be a deterrent.

With the conceptual understanding of sustainable development being so value-laden, time-constrained (covering inter and intra-generational concerns), multidisciplinary and cross-sectoral, tools to be used to assess transitions towards sustainability need to cater for a combination of goals, while considering the complex dynamic relationships between the differing dimensions of sustainable development – hence requiring country-specific democratic debates on the issue. This also implies the recognition that multiple and possibly irreconcilable viewpoints are likely to exist and thus no single approach could be seen as the correct one (Robinson 2004; Glaser 2006; Connelly 2007) and that the actual meaning of the term can only emerge in the course of interdisciplinary and intercultural discussions (Mitcham 1995; Pope *et al.* 2004). Considering the range of developing countries that are expected to submit NAMAs, and with each one working within its own particular context and vision of sustainability, it will be more reasonable to adopt democratic principles whereby the door is left open for each NAMA participating country to adopt its own particular mind-map, while explicitly recognising the associated limitations within the choice made for each NAMA.

This perspective could provide for elements that could lead to a compromise with developing countries as regards to their reported reluctance for an international standard for sustainable development which would impinge on their sovereignty (Olsen 2013). The argument is also in line with Bond and Morrison-Saunders's (2011) statement that political realities need to be factored into the process of designing sustainability assessments so as to ensure that sustainable outcomes are achieved, that incorporate different viewpoints. To this end, a framework for undertaking their sustainability assessment would be crucial. In this respect, the different existing sustainability assessment frameworks will be discussed in the next sections.

### *2.6 Existing SD assessment approaches*

The study of sustainable development, sustainability, sustainability science and its corollaries is one that requires the convergence of different spheres of academia. Despite a significant amount of research in the last 25 years, scholars have not been able to settle on 'one-size fits all' tools that could be utilised to gauge progress towards sustainable development. It is to be noted that making universality claims has not been the aim of those studies conducted. This is probably due to the inherent inter- and trans- disciplinary nature of sustainable development research, demanding informed discussions amongst various actors. The intrinsic link between one's personal interpretation of sustainability and the choice of a particular tool to undertake the assessment has been highlighted by Ness *et al.* (2007) and Gasparatos (2010). Such differences in understanding can unavoidably lead to disappointment amongst participating stakeholders (Bond & Morrison-Saunders 2011).

Originating from environmental assessment tools dating back to the 1970s, sustainability assessments were included in one of the first laws governing environmental impact assessment (EIA) in the USA as a decision support tool. Bond & Morrison-Saunders (2011) and Pope *et al.* (2004) trace a demarcation between two tools that set a direction towards a sustainable outcome target. These comprise:

a) EIA-led integrated assessments, whereby evaluation done *ex-post* aims to minimise negative impacts across the three pillars by comparing impacts as opposed to a baseline (representing weak sustainability and trade-offs between pillars); and
b) 'objectives-led' assessment, whereby evaluation is estimated *ex-ante*, aims to maximise positive impacts across the three pillars by comparing expected performance against aspirational environmental objectives instead of a baseline (sustainability is envisaged as a series of societal goals and measures contributing to those goals across the three pillars).

Sustainability assessments of NAMAs would call for a mix of both approaches. Prior to an international recognition of an initiative as a NAMA, it can be argued that an initial *ex-ante* approach, similar to 'objectives-led' assessments will be required. Subsequently, an *ex-post* evaluation, similar to 'EIA-led' assessments would be essential to ascertain the actual benefits that would have been claimed, thus explicitly justifying a NAMA as following a 'sustainability path' defined by a country. This perspective implies that the establishment of a licensing system could be required for a domestic NAMA, such as a 'NAMA impact assessment' at a national level inspired from similar institutional arrangements for processing of EIA licences. For international NAMAs, such an arrangement could be complemented with a verification system undertaken by the donor country or institution. Credited NAMAs could require a third-party verification system, similar to designated operational entities that currently prevail within the operating framework for the CDM.

However, a number of other factors need to be considered when choosing a methodology for undertaking sustainability assessments. In their analysis, Gasparatos & Scolobig (2012) further distinguish between bio-physical, monetary, and indicator-based tools, with each category of tools representing different valuation perspectives of the assessment, the adoption of a reductionist/non-reductionist perspective during the assessment and the acceptability of trade-offs between the different sustainability issues.

In line with Bond & Morrison-Saunders (2011) and Gasparatos (2010), Gasparatos & Scolobig (2012) suggest that distorted sustainability evaluations could be obtained through the choice of a tool that neglects the valuation perspective of the affected stakeholders. Different tools will thus be more appropriate to cater for different value orientations that humans could exhibit towards the environment, comprising concern for other humans ('social-altruistic'), concern for non-human species ('biospheric'), and self-interest ('egoistic').

The need for such a categorisation is justified from the reported opposition towards the use of neoclassical monetary valuation from eco-centric stakeholders and expected preference for the use of monetary tools for stakeholders having egoistic and social-altruistic value orientations (Gasparatos & Scolobig 2012). Gasparatos and Scolobig further propose that lack of a sound theoretical basis has often undermined tool selection, with choices being usually dependent on the time, data, budgetary constraints, skills of the analysts, and the range of accessible tools. Moreover, the mere choice a particular evaluation tool can have significant influence on its outcome. Gasparatos (2010) has classified major SD assessment tools as adopting either a reductionist or non-reductionist stance, as described in Table 3.

**Table 3: Types and approaches of sustainability assessments**
*Source: Adapted from Gasparatos (2010)*

| Sustainability assessment type | Approach |
|---|---|
| Economic tools | Reductionist |
| Biophysical models | |
| Indicator lists | |
| Multi-criteria analysis | Non-reductionist |

Despite the advantage of simplicity that is obtained through summarising diverse aspects of a project to a small set of numbers (Gasparatos 2010), adopting a merely reductionist approach of splitting a complex problem into smaller units to ease decision-making implicitly ignores the complex interactions within sub-components that contributes towards the effectiveness of a system (Bond & Morrison-Saunders 2011). Reductionist approaches will thus impose a certain broad value system on stakeholders without their prior consultation. The characteristics of approaches outlined in Table 3 are summarised below:

a) Monetary/economic tools will put more focus on the satisfaction of human preferences (whereby happiness is equated with maximising consumption).
b) Biophysical models will mostly gauge appropriation of natural capital (neglecting human preferences).
c) Composite indicator choice and assigning weights within indexes will also represent value choices.

A holistic approach – whereby stakeholders are systematically involved in defining visions and means to achieve visions of sustainability – is thus more desirable, though little research has been reported on value-capturing tools. As shown in Table 5, within the family of indicators, MCA is the one that exhibit non-reductionist properties. However, composite indicators lose their concept of value upon normalisation and aggregation of indicators. In view of the broad consensus-building nature of SD, assuming either an eco-centric or anthropocentric perspective could most likely lead to deadlock, with debates about the right philosophical stance to adopt. To this end, the 'composite indicators' tools bear the most promise in terms of consensus-building potential, with the added advantage of having the best prospect of being understood by a wider audience.

Though resembling composite indicators, the advantage of MCA lies in the absence of aggregation of indicators, which avoids entanglement in trade-off debates between different sustainability issues (Gasparatos 2010). On the other end, overly holistic principles could lead decision-makers to getting entangled in conceptual understandings of complex interactions of sub-systems. Here again, a right balance between the apparent simplicity of a reductionist approach and some combination of a more holistic approach seems to be more reasonable. The Committee on Radioactive Waste Management in the UK, in the process of defining a long-term strategy for the management of radioactive wastes, has adopted such a mix in approaches by combining expert scaling within a MCDA process with stakeholder weighting (Morton *et al.* 2009; Bond & Morrison-Saunders 2011).

The same issues can be expected when applying it to NAMAs. Gasparatos & Scolobig (2012) recommend the use of a combination of assessment tools (such as biophysical, indicator and monetary tools) that covers the value orientations of affected stakeholders, while acknowledging the issues and challenges involved in attempting to combine conflicting value judgements, especially altruistic ones. A democratic discourse leading to the choice of an appropriate tool at a country level could theoretically allay difficulties in tool selection. However, applying such a wide interpretation of choice within NAMAs can be tricky and increase the difficulties of enabling cross country comparisons or achieving standardised minimum properties for sustainability assessments. In that respect, MCA could be a plausible option to assess sustainability of NAMAs, as a tool that can combine such value judgements.

### 2.7 Desired characteristics

Alongside the need to capture different value judgements across countries, a number of authors describe desirable characteristics of SD assessment tools. Sustainability assessments should:

a) be comprehensive (i.e. cover the different themes of SD so as to allow for the full range of impacts of an initiative), integrated (assessment techniques used and themes covered that are aligned, connected, compared or combined) and strategic (having a wide and forward-looking perspective) (Hacking & Guthrie 2008);
b) operate within a structured framework and be applied by all sectors of society, function within the prevailing policy and legal paradigm, operate within existing and new initiatives at all levels of decision making and sectors (Pope *et al.* 2004);
(c) be consistent with the needs of stakeholders, their expectations and practical applications; possess relevant desired features of sustainability assessments (be integrated and predictive, cover inter and intra-generational distribution effects, acknowledge uncertainties and be participatory), be

aligned with a chosen acceptability criterion (such as minimising unsustainable outcomes, maximising sustainable ones or leaving society to define and assess against defined notion of sustainability) (Gasparatos & Scolobig 2012);

d) recognise the need for continual reflection on the original objective of the assessment as well as the probable policy controversies, while applying an appropriate framing to tackle such controversies (Bond & Morrison-Saunders 2011).

While it would be difficult to frame an assessment methodology for assessing SD impacts of NAMAs that would be an exact fit for all the desired characteristics outlined above, one could conceive a tool that maximises comprehensiveness, integratedness, and strategic orientation, while operating within existing institutional, legal and policy frameworks and favouring a democratic discourse.

The Bellagio principles (IISD 1996), which have a stepwise, cradle-to-grave approach in the form of guidelines towards undertaking sustainability assessments, as well as their proposed review undertaken by Pintér *et al.* (2012), could be relevant in determining the right methodology towards assessing sustainability of NAMAs.

Since assessing sustainability perspectives can only make sense if they are actually gauged, the following section will discuss the different aspects to consider in assessing sustainability through indicators.

### *2.8 Sustainability indicators*

The adage that 'what cannot be measured cannot be managed' has been floating in management circles for some time. The underlying logic behind it is convincing – that only through undertaking monitoring that progresses or digresses towards achieving set goals can be gauged and appropriate actions be taken. On top of aiding decision-making and management (Stiglitz *et al.* 2009), measuring sustainable development impacts can also help in promoting advocacy, enhancing participation and consensus-building, as well as boosting research and analysis (Parris & Kates 2003). In this context, the use of indicators is tuned towards accounting for an activity to be recognised as a NAMA that fits into broader sustainable development objectives.

Previous research on sustainability indicators has evolved from an initial focus on conceptual debates about the actual meaning of sustainable development and the possibility to produce indicators, followed by a concern for the creation of optimum models and methods to frame optimal indicators, towards a niche research area that views sustainability indicators as policy tools and part of governance discourses (Mineur 2007). It is within the last category that research into assessing NAMA impacts can be positioned. However, whether geared towards a policy-, target- or project-based NAMA, not all aspects of sustainability can be quantified. There are some aspects, especially those with an attached value component, that can only be judged qualitatively, and thus will imply some subjective judgement. Furthermore, there is broad consensus that MRV mechanisms within NAMAs need to be simple while allowing for an element of freedom to pinpoint the sustainable development benefits. On the basis of analysis pilot projects, Jung *et al.* (2010) identified three types of MRVs – those with direct effects (where MRV could be based on existing methods such as modelling, measurements, and proxies on the basis of data and emission factors), those with indirect effects (where MRV could focus on activities and outcomes), and those which can only be rated by its broader SD benefits (e.g. reduction of other pollutants, job creation, other social and economic effects).

However, factoring in qualitative assessments is not the only limitation in sustainability assessments. Poorly chosen indicators can also create serious malfunctions in socio-economic and ecological indicators (Meadows 1998). The common pitfalls in choosing indicators include:

- over-aggregation of information, leading to results leading to incorrect interpretations (e.g. GDP),
- using only measurable/quantifiable data instead of other important data (e.g. forest cover instead of size, diversity and health of trees),
- wrongly framed conceptual models (e.g. price of oil as a proxy for oil reserves),
- deliberate falsification of data (e.g. using only selected time-scales so that results show only positive outcomes),
- diversion of attention from personal experience (e.g. the stock market rising despite the population getting poorer),
- overconfidence from decision-makers (e.g. believing that the right choice is made despite indicators being faulty),
- incompleteness (e.g. indicators are not the whole system and may miss some tangible and intangible specificities of a system).

To respond to the above pitfalls, Meadows (1998) has posited the most desirable characteristics of good sustainability indicators as those that would be clear in value (no uncertainty on which direction is good or bad), clear in content (easily understandable with values that makes sense), compelling (suggestive of effective action), policy-relevant (for all stakeholders), feasible (reasonable cost), sufficient (not too little nor too much detail), timely (not too much delay), appropriate in scale (not over- or under-aggregated), democratic (people to participate in framing and use of indicators), supplementary (should include what people cannot monitor by themselves), participatory (include what people can measure by themselves), hierarchical (can go to details or highlights easily), physical (use physical units as far as possible), leading (so as to get time to react to it), and tentative (can be discussed and, if necessary, changed).

With a view to easing the selection process, Ness *et al.* (2007) classify the different tools developed to support the formulation of indicators for sustainability based on temporal (*ex-post* or *ex-ante* assessment), coverage (product or policy focus), and integrative (combination of economic, social and environmental systems) dimensions of sustainability. They argue for three distinct umbrellas, comprising:

a) indicators, which are mostly quantitative measures representing the level of development within a specific area (often at country level),
b) product-related assessment tools, that mainly cover the flows related to the production and consumption of goods and services, and
c) integrated assessments, using systems analysis approaches to analyse multi-disciplinary, complex issues, with a view to supporting decisions related to a policy or project within a given region (often having an *ex-ante* focus and often carried out in the form of scenarios).

Of particular relevance in the above study are those tools that can integrate nature-society systems. Of these, integrated assessment tools (comprising tools such as conceptual modelling, system dynamics, multi-criteria analysis, risk analysis, uncertainty analysis, vulnerability analysis, cost-benefit analysis and EU sustainability assessment), which can be used for policies and projects, bear the most promise in terms of applicability to NAMAs.

However, directly applying any of the tools would not suffice to assess the sustainability of NAMAs, since those tools are not integrated within any conceptualisation of sustainable development. Such a gap has been addressed by a number of scholars and international institutions through the use of indicator frameworks. A number of such frameworks, defined as 'conceptual structure based on sustainability principles and used to facilitate indicator selection, development, and interpretation' (Wu & Wu 2012: 72) have been identified (see Table 4.

Applying the indicator frameworks in Table 4 to the proposed NAMA framework in Figure 1, and taking into consideration the relative advantages and disadvantages of each one, it can be argued that, though capital-based, integrated accounting and aggregated indicators could provide useful guidance on sustainability, their limited coverage of SD dimensions could inhibit agreeing on a methodology or sets of methodologies to assess the impacts of NAMAs. The PSR or DPSIR framework, though a popular tool, might not

**Table 4: Indicator frameworks**

*Source:adapted from UN (2007) and Wu & Wu (2012)*

| *Short description* | *Remarks* |
|---|---|
| *1. Pressure-state-response (PSR)-based* | |
| PSR framework, which has been expanded to DPSIR (driving force – pressure – state – impacts – response), is more generally used to develop environmentally oriented indicators.<br>Those indicators identify the causal relationships between the DPSIR spheres and are related to driving forces that impact SD and corresponding pressures exerted, causing changes in states, impacts and response measures required. | Ambiguous classification of indicators into more than one dimension.<br>Does not capture causalities and inter-linkages.<br>Does not adequately capture link between indicators and policy issues |
| *2. Theme-based* | |
| Indicators are organised across typically four dimensions representing SD as determined by their policy relevance (social, environment, economic and institutional), further split into 15 themes, which in turn are divided into 38 sub-themes, corresponding to 58 indicators.<br>The theme-based methodology was reviewed in 2007 and ceased to categorise SD within the 4 pillars with a view to accommodate for the multi-dimensional character of SD. A new categorisation was recommended comprising 14 themes (poverty, governance, health, education, demographics, natural hazards, atmosphere, land, oceans, seas and coasts, freshwater, biodiversity, economic development, global economic partnership, and consumption and production patterns), 44 sub-themes, 50 core indicators, and a total of 96 indicators. | Ability to link indicators to policy processes and targets.<br>Provide clear and direct message to decision-makers.<br>Ease communication and sensitisation with public.<br>Can enable monitoring of progress in attaining the objectives and goals stipulated in national sustainable development strategies.<br>Flexible enough to adjust to new priorities and policy targets over time. |

**Table 4, continued**

| *Short description* | *Remarks* |
|---|---|
| *3. Capital-based* | |
| Attempts to calculate national wealth as a function of the sum of and interaction among different kinds of capital (including financial capital, produced capital goods, natural, human, social and institutional capital). Capital-based frameworks requires that all forms of capital be expressed in common terms, usually in monetary terms and assumes substitution amongst different forms of capital. | Pro: can be a powerful tool for decision making<br>Cons: difficulties in representing all forms of capital in monetary terms; data availability issues; not all capitals can be substituted; does not consider intra-generational equity concerns within and across countries. |
| *4. Integrated accounting* | |
| Accounting framework that draws all indicators from a single database that allows for sectoral aggregation while using consistent classifications and definitions. The most popular form is the System of Integrated Environmental and Economic Accounting, which is linked to the standard system of national accounts, and comprises of four types of accounts:<br>physical data on material and energy flows,<br>data on environmental management and environment-related transactions,<br>accounts of environmental assets, and<br>accounts of transactions and adjustments related to the impact of the economy on the environment. | Pros: provides full accounts of environmental and economic capitals and flows; can be used for policy analysis also; can complement capital-based frameworks and theme-based frameworks (from the use of a consistent database)<br>Con: does not factor in the social and institutional aspects of sustainable development |
| *5. Bossel's Orientor-based* | |
| Consist of a systems-theoretical framework for developing indicators of sustainable development that is intended to provide a holistic and comprehensive conceptual structure to guide indicator development. Orientors represented as categories of key concerns, values or interests that 'orient most of our decisions', comprising of 'Existence', 'Effectiveness', 'Freedom of action', 'Security', 'Adaptability', 'Coexistence' and 'Psychological needs' (relevant only for sentient beings). Satisfaction of those orientors is required for a system to achieve sustainability. They usually cannot be measured directly, but their states of fulfllment can be inferred from appropriate indicators. | Claims to capture sustainability across all spatial scales<br>Avoids the problems of incompleteness and double-counting common in ad-hoc methods of indicator selection<br>Orientor-based indicators are expected to capture the essential aspects of the vitality, performance, and sustainability of human–environmental systems. |
| *6. Aggregated indicators* | |
| Comprise a combination of indicators to capture elements of sustainable development. These are primarily used for raising public awareness e.g. Ecological Footprint, Environmental Performance Index, Adjusted Net Savings, Genuine Progress Indicator | Pro: easy to communicate<br>Con: pictures a limited view of sustainable development |

be appropriate in view of its limited ability to link indicators to policy issues. The theme-based methodology from the United Nations Commission for Sustainable Development and Bossel's proposed orientor framework could be promising avenues in assessing the sustainability impacts of NAMAs.

Having explored the major theoretical and conceptual ideas from sustainable development literature that could be applied to NAMAs, we move in the following sections to review the studies that have explicitly related NAMAs and their SD linkages.

## 3. NAMAs/SD linkages

### *3.1 Existing research on NAMAs and SD*

The need to increase research on the linkages between sustainable development and climate change mitigation has been most notably highlighted by authors of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Sathaye *et al.* 2007). The following challenges in assessing the impact of specific policies on GHG emissions, which would be relevant to policy NAMAs, have thus been highlighted:

- differentiating the effects of a wide array of measures encompassing policy packages;
- policies are only one of many incentives that decision-makers react to (command and control, government controlled emissions-producing sectors);
- indirect effects of policies are difficult to evaluate (e.g. rebound effect of energy efficiency measures);
- difficulties in baseline evaluation.

A review of practical applications towards methodological development into the SD arena which relates to climate change mitigation initiatives reveals an overwhelming number of sustainable assessment tools and methodologies (Bond & Morrison-Saunders 2011; Olsen 2007; Musango & Brent 2011; Özdemir *et al.* 2011; Gasparatos & Scolobig 2012; Huang & Yang 2012; Musango *et al.* 2012).

As a recently coined mechanism with no formal definition, peer-reviewed literature on NAMAs *per se* is fragmented, though less so regarding possible linkages with SD. The review on such explicit NAMA/SD linkages has thus been expanded to different types of mitigation activities that most closely relate to main conceptual framings of NAMAs at the time of writing. Those are summarised in Table 5, followed by a brief description of the main methodologies employed, as well as their advantages and limitations.

Winkler *et al.* (2007) have proposed to adapt the use of a system of indicators of sustainable development to SD-PAMs based on MARKAL – an energy-modelling framework. The implications for annual energy saving, costs (savings, avoided investment in power stations), pollutants (carbon dioxide, oxides of nitrogen, sulphur dioxide, total suspended solids), water savings and jobs (additional jobs created) of implementing a policy scenario, through a series of policy measures, and derived from South Africa's energy-efficiency target are explored and projected as compared to a reference case.

Winkler *et al.* 2008 explore the means to operationalise SD policies and measures (SD-PAMs) – a precursor to NAMAs within a multilateral climate regime – using four methods to quantify the benefits of SD-PAMs: case studies, national energy modelling, analysis of sectoral data. and using global emissions allocation models. The comparative advantages and loopholes of each methodology are summarised in Table 6.

Román (2012) has utilised intervention theory to guide empirical studies onto the application of SD-PAMs mechanism to selected mitigation case studies in Brazil and China and an adaptation project in Mozambique, with the goal of identifying favourable conditions whereby development policies can drive climate change actions. Román furthermore stresses particular challenges related to MRV of SD-PAMs with regard to establishing baseline criteria for GHG emissions, time-scales for mitigation, additionality definition and criteria for assessing sustainability.

Olsen (2013) has also analysed the respective sustainable objectives of policy frameworks of existing and emerging mechanisms for mitigation actions comprising of the CDM, low-carbon development strategies, NAMAs, REDD+ conservation, new market mechanisms, and the framework for various

**Table 5: Peer-reviewed publications related to NAMA-SD linkages**

| *No* | *Typology* | *Author(s)* |
|---|---|---|
| 1 | SD-PAM related | Winkler et al. 2007; Winkler et al. 2008; Román 2012 |
| 2 | Policy-framework based | Olsen (2013) |
| 3 | Co-benefits approach | Dubash, Raghunandan et al. (2013) |
| 4 | Mitigation action | Garibaldi et al. (2013) |

**Table 6: Comparison of methodologies to assess SD impacts of SD-PAMs**
*Source: Adapted from Winkler et al. (2008)*

| | *Methodology proposed* | *Strengths* | *Weaknesses* |
|---|---|---|---|
| 1 | Case studies | Detailed example of SD-pams<br>Operationalization within a specific context and national circumstances | Results not very comparable across countries – need general guidelines |
| 2 | National energy modelling | Provides a link to energy policy and planning<br>Capable of providing an overview of | No comparable method for land use, land emissions from fuel combustion use change and forestry available |
| 3 | Analysis of sectoral data | Allows comparable studies of energy and GHG intensity across countries<br>Combines detailed analysis of the national level for sectors with international projections | Setting up comparable indices limits the extent of accounting for national circumstances |
| 4 | Inclusion of policies in global emission allocation models | Provides a comprehensive overview of implications of SD-pams | Limited data availability to represent national policies and measures in enough detail. |

approaches, as well as their relative strengths and weaknesses. With a view to promoting NAMA contribution to SD, Olsen (2013) recommends a new integrated approach to assess the SD co-benefits and transformational changes towards low-carbon development that would consider SD objectives from the strategic planning and design stages, while incorporating stakeholder involvement and safeguards against negative impacts.

Dubash, Raghunandan *et al.* (2013) explore a co-benefits approach towards prioritising climate change policy options in India. Using multi-criteria decision analysis (MCDA), policy options related to modal shift in urban transport, promotion of biofuels, and improved efficiency of domestic appliances, have been gauged across four co-benefits outcomes identified from India's national strategic plan (comprising economic growth, inclusion, local environment, and GHG mitigation). The likely impacts of policy options are then qualitatively described on a scale of 1 (strong negative impact) to 5 (strongly positive impact) and represented as spider diagrams (see Figure 4).

Dubash *et al.* (2013) have also extended the MCDA to cover likely implementation issues across sub-dimensions of (a) political economy, (b) transaction and institutional costs, (c) cost per unit energy saved or provided, and (d) ease of financing. A similar qualitative scoring (1 to 5) was undertaken and represented on spider diagrams. This type of analysis allows an examination of the multiple strengths and weaknesses of a policy objective across many desired outcomes through debate, discussion and peer review. Although such a methodology does not assess the absolute effects of the policy measures, it enables a relative comparison of impacts across desired outcomes.

Garibaldi *et al.* (2013) make a cross-country comparative analysis of mitigation actions undertaken in Brazil, Columbia, Chile, Peru and South Africa. They argue for flexibility in design of mitigation actions, hence also their MRV requirements, in view of the highly different policy environments and time horizons of interventions, while also stressing for a broadening of such an assessment to include Asian and more African states.

As mentioned in Table 5 and described above, the conceptual understanding of what constitutes a NAMA, as well as approaches and methodologies employed to gauge the sustainable development impacts of NAMAs, vary considerably. These can be described as early attempts towards methodological clarity on NAMA SD impact assessment. With NAMAs being currently developed bottom-up, such variances are also expected to occur. However, such wealth of concepts restricts cross-country comparisons, especially for international NAMAs. Such comparisons would be particularly useful to the country-driven approach advocated by the Green Climate Fund (established at the 16th Conference of Parties to the UNFCCC and which could become one of the major institutions in future climate financing (GCF 2013)) and other donor communities, in easing the setting-up of fair and transparent mechanisms for financing NAMAs in the developing world. To this end, the needs for more harmonised and integrated assessment approaches, embedded within documented conceptualisations of sustainability for each NAMA, are heightened. Such a structured approach can, moreover, bring more credibility to the overall NAMA process.

### *3.2 NAMA-SD future avenues*

Attempting to delineate what is meant by SD invariably leads to fundamental questions about what is to be sustained, what is to be developed, the extent to which sustainability is to be reached, the complex interlinkages amongst spheres of sustainability, as well as the time horizon within which sustainability is being viewed. In the case of NAMAs, the driving motive that would crystallise such a mitigation measure will primarily be the development objectives to be sustained and developed, of a particular nationally elected administration within a particular country, operating at a certain point in time, at a particular level of development and within a socio-economic and cultural context – referred to as the national circumstances. With national circumstances expected to vary as much

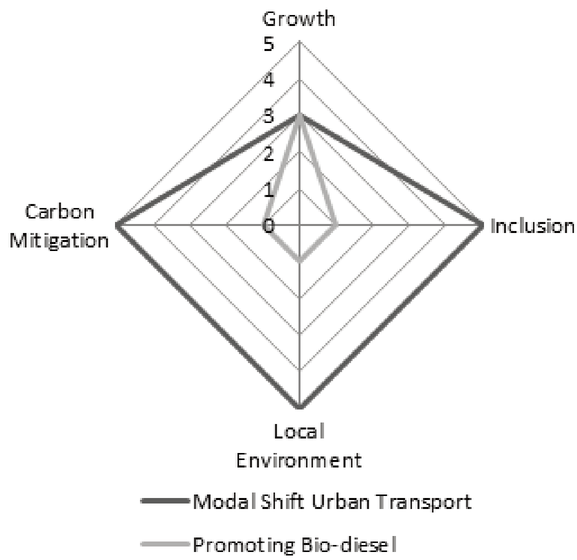


**Figure 4: Likely SD impacts of policy measures in India**

*Source: adapted from from Dubash et al. (2013)*

as there are countries proposing NAMAs, the likelihood of having commonalities in describing SD could be low. Moreover, the range of diversity in contexts is not the only issue in this case.

In a study of twelve efforts towards characterising and measuring sustainable development, Parris & Kates (2003) reveal that:

- with a view towards being inclusive, a broad list of items to be sustained and developed can be identified. That could be explained by both the vagueness of the concept and specifics of individual characterisation and measurement efforts;
- few efforts are explicit about the time frame of sustainable development, with a clear bias towards the present or near term, or, at most, picturing a single generation (15 – 25 years);
- most initiatives are deductive, with the choice of indicators being guided on the basis of first principles or negotiated consensus of definitions of sustainability.

Robinson (2004) further suggests that for sustainable development to be meaningful,

- it should be considered as an integrative concept across fields, sectors and scales;
- since fundamental divisions will prevent the creation of a single coherent conceptual approach, stakeholders should shift from those attempts to conceptualise it towards more concrete actions;
- one should move beyond technical fixes towards addressing deep issues of opportunity, distribution, material needs, consumption and empowerment;
- scientific analysis, which embeds value judgements and social commitments, can only inform, rather than resolve issues about sustainability;
- 'it should be part of an incremental process of collective decision making that is based on, but not determined by, expert knowledge; that is open to multiple perspective but not paralyzed by them; that allows for, and reinforces, social learning and changes in views over time; and that is provisional but concrete'.

However, as mentioned in Sathaye *et al.* (2007), despite criticisms, some commonly held principles of SD are emerging. These include the welfare of future generations, the maintenance of essential biophysical life support systems, ecosystem wellbeing, more universal participation in development processes and decision making, and the achievement of an acceptable standard of human well-being.

The Millennium Development Goals, whereby nations pledged towards eight time-bound goals and targets to be achieved by the year 2015 using a baseline of 1990 is an example that it is possible to have at least some universal concepts of sustainability, with significant progress reported across the different MDGs as at 2013 (United Nations Dept of Public Information 2013) though with uneven achievements across countries (United Nations 2013). The outcome of the Rio+20 conference process, whereby member states agreed to pursue a 'green economy ' agenda as well as develop a set of SD goals by 2015 (United Nations General Assembly 2012) could thus provide the basis of assessing cross-country NAMA sustainability (Linnér & Pahuja 2012 in Linner, Mickwitz *et al.* 2012).

## 4. Conclusions and remarks

From a starting point of literature related to sustainable development assessments, the present paper has attempted to unpack the theoretical requirements that could better inform an integrated approach to gauging the sustainable development benefits of NAMAs. A number of conclusions can be drawn based on this review.

Assessment of the SD impacts of NAMAs will be facilitated by adopting a sectoral focus, whereby oversight and operational control, especially regarding MRV requirements, is maximised under a sectoral or ministerial 'one-stop-shop'. The paper has proposed a NAMA framework for this purpose that further categorises NAMAs by the nature of the intended intervention (i.e. across policy-, target or project themes) and further classified as either domestic, international or credited NAMAs.

A review of the explicit linkages between NAMAs and SD has shown that a wide variety of approaches and methodologies has been adopted by scholars, which is an indication of early attempts to provide clarity when assessing SD impacts of NAMAs. However, such an array of concepts limits cross-country comparisons. On the other hand, imposing universal sustainable development assessment methodologies will incur the critique voiced by developing parties regarding the possible impingement to sovereignty. To attend to this concern in light of the array of approaches revealed by the SD literature review, it would make sense to leave each developing country Party to define its own vision of sustainable development. However, a minimum set of common features should prevail, especially for NAMAs that require international funding, while leaving room for flexibility to accommodate particular national circumstances. These minimum features would provide the foundations for cross-country comparison of SD impacts for NAMAs.

When working at individual country level, framing sustainable development will require merging views from stakeholders with sometimes radically different values, contribution from varying disciplines and sectors and consideration of different time-frames and agendas. The literature review points to the use of holistic approaches in defining visions and means to achieve sustainability which provide for a systematic involvement of stakeholders. Countries could thus favour a democratic discourse to attend to those expected multiple and conflicting viewpoints, while being explicitly informed of the relative strengths and weaknesses of the different approaches that could be chosen. The use of Multi-Criteria Analysis has been shown to be a plausible option which could attend to such concerns, especially through promoting consensus building amongst stakeholders.

As one of the most common representations of sustainability, pillar-based descriptions (especially triple-bottom line (TBL) assessments) are potential options for countries to use to define their visions of sustainable development. When applied to assessing NAMAs, the adoption of TBL approaches should be geared towards favouring a balanced, strong sustainability perspective. For methodological clarity and transparency, the limitations of such pillar-based descriptions should also be explicitly recognised.

The need for NAMAs to generate transformational change could be integrated within the respective conceptualisations of sustainability adopted by individual countries. However, as is the case for sustainability, this will require further clarity on what transformational change actually means and how sustainable development, as an overriding paradigm, could be more conducive to the transformation of sectors within which NAMAs operate.

Further exploration of the SD literature as applied to NAMAs has revealed that such sustainability assessments will require a combination of ex-ante and ex-post assessments. Gauging the potential SD impacts of NAMAs in a first phase will assist prioritisation, while assessing their actual SD impacts through ex-post assessments will allow decision making to rectify deviations from a chosen sustainability path. To support the process, it would be essential to set up appropriate corresponding administrative and institutional arrangements, such as 'NAMA Impact Assessments', which could borrow from existing Environmental Impact Assessment licence processing setups. In the case of externally funded NAMAs those setups could also be expanded to cater for an extended verification system from a donor country or institution.

Furthermore, the review has revealed a wide array of characteristics that sustainability assessments should possess. Those include considerations for such assessments to be comprehensive, integrated and strategic, while operating within existing institutional, legal and policy frameworks. However, from a pragmatic point of view, an exact fit for all those properties might not be realistic. Hence, attempting to maximise those desired properties would be advisable. To attend to those concerns, the adoption of the Bellagio Principles as a guidance towards indicator framing is a plausible option.

An analysis of existing sustainable development indicator frameworks has also shown that further inspiration could be taken from the United Nations Commission for Sustainable Development's theme based methodology and Bossel's orientor framework. However, such frameworks do not preclude the right for any country to develop its own framework, which would then need to be analysed for methodological sense by a potential new Methodological Panel for NAMAs similar to CDM or by an independent third party.

Furthermore, the above remarks calls for a 'process' line of thought that shifts sustainability assessments away from a rigid and pragmatic debate towards a more deliberative sustainability discourse. This perspective has been highlighted by members of the Green Climate Fund, who have recommended developing countries to develop co-benefits as a process-based approach rather than an outcome requirement (Green Climate Fund 2013). However, as highlighted by Mineur (2007), there is also the risk of efficiency driven processes being favoured in lieu of a more democratic rhetoric, with participation being envisaged at most in its softer form through wide stakeholders being informed ex-post or through invitations to attend meetings due to extended trust expressed by politicians to expert knowledge and difficulties viewed onto the involvement of the public.

In line with the arguments raised in the present paper and with a view to further clarify NAMA-SD linkages, a number of research avenues could be pursued, such as comparing similar assessment approaches across different technologies operating within the same sector, across sectors, and across different developing countries as well as exploring theoretical considerations while applying different policy evaluation approaches. Further research is also required towards conceptualising transformational change as a new development paradigm that could combine enhanced sustainable development with a significant decrease in greenhouse gas emissions.

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# Mainstreaming development imperatives into NAMAs: An approach

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***Abstract***

NAMAs (Nationally Appropriate Mitigation Actions) in developing countries are a political choice, given the complexity of issues involved at national as well as international level. There are political implications of which mitigation actions are reported as NAMAs, and which of the emerging categories of NAMAs (domestic, supported, credited, hybrid, mutually appropriate, sectoral etc) they are assigned to. These actions need to conform to countries' positions in climate negotiations, particularly on climate finance, technology transfer, capacity building and measurement, reporting and verification. They also need to ensure socio-political acceptability and economic viability in a national context of sustainable development. This paper offers a structured approach to making these decisions. Building on the review of climate negotiations, and national policies in developing countries along with stakeholder consultations, it develops an approach arranging a range of criteria clubbed under key desirable outcome clusters. Recognising that each criterion within an outcome cluster may have different significance for a country, and scoring against a criterion may involve multiple options, towards which countries may have different positions, the approach allows individual countries to reflect their weighting for each criterion within an outcome cluster and attitudes towards various options for a criterion. Accordingly, each outcome cluster gets positive and negative scores depending upon the specific project details. These scores are intended to assist the decision-makers in deliberating on and comparing various NAMA proposals, their eligibilities, acceptability and categories. Moreover, the negative scores also provide an indication how a proposal which is rejected can be revised and modified to achieve an appropriate scale and design.

*Keywords:* NAMAs, decision tool, multi-criteria, deliberation, co-benefits

## 1. Introduction

Mitigation in developing countries has always been a controversial issue in climate policy discourses broadly couched in the language of development versus environment and ethical distribution of responsibilities along the emission continuum (Mintzer & Leonard 1994; Grubb 1995; Tóth 1999; Bauer *et al.* 2008; Shrivastva & Goel 2010; Winkler 2010). The discourse has visibly gone through a transition with the general acceptance of the idea that the objectives of economic growth and development planning need to be situated within the framework of a transition to a low-carbon economy and the decision at COP-13 (COP = Conference of Parties) stating that developing countries will take 'nationally appropriate mitigation actions (NAMAs)' in the context of sustainable development and in line with support from developed countries (UNFCCC 2008). Recently, these two ideas have become inseparable, and NAMAs are increasingly being seen, and promoted, as a conceptual vehicle for this transition in developing countries (Shrivastava, 2013; UNEP, 2011a). In parallel, discussions on NAMAs have also gone through a considerable transition in both academic and policy circles. While it is widely recognised that varied national circumstances, including capabilities, would necessitate NAMAs being specifically identified, prioritised and designed for each country (Hänsel *et al.* 2013), there has emerged a variety of ideas about how NAMAs could be implemented (Linnér & Pahuja 2012). These discussions, along with developments at recent COPs, have virtually transformed the phrase 'nationally appropriate mitigation actions' from a politically condensed articulation of conditions under which developing countries may be willing to take mitigation actions to a mechanism by which mitigation actions in developing countries may be promoted.

The conceptual and institutional apparatus that the evolving discourse has produced so far includes a NAMA-registry and a range of categories of NAMAs broadly depending upon the financing mechanism of particular NAMAs. A prototype of a NAMA registry has already been set up.[1] The registry is expected to function not only as a NAMA database but also as a match-making platform for those who seek support and those who intend to provide it. The registry provides options for submitting NAMAs seeking international support and NAMAs seeking recognition. Subsequently, it will also have information on support for the preparation and implementation of NAMAs and information on supported NAMAs and associated support after matching has taken place.[2] Many countries have already submitted information while the debates are still underway.[3] Most of these NAMAs are at the concept and proposal stage, with few ready for implementation. Alongside, research community and other stakeholders have started identifying NAMAs in various sectors and countries (Agarwal 2012a; Tewari 2012; 2013; Tyler *et al.* 2013; Hänsel *et al.* 2013). In addition to the obvious categories of domestically supported and internationally supported NAMAs, other categories that have emerged include credited NAMAs, hybrid NAMAs, mutually appropriate mitigation actions (MAMAs), sectoral NAMAs, poverty-alleviating mitigation actions (PAMAs) etc (Sharma 2013; UNEP 2011a; UNFCCC 2013). Of course, these categories do have significant overlaps, and arguably are symptomatic of the ambiguities and uncertainties that surround NAMAs, both in terms of definition as well as the evolving institutional arrangements within and outside the UNFCCC (United Nations Framework Convention on Climate Change) framework.

From a developing country perspective, NAMAs are a political choice. What mitigation actions are reported as NAMAs, and which of the emerging categories of NAMAs they are assigned to, have political implications. These actions need to conform to countries' positions in climate negotiations, particularly on climate finance, technology transfer, capacity building and measurement, reporting and verification (MRV). They also need to ensure socio-political acceptability and economic viability in national context of sustainable development (Shrivastava 2010; 2012). The complexity and incompleteness of mechanisms under COP, particularly the NAMA registry (Tewari 2012) and the Green Climate Fund (GCF) (euractive.com 2013), along with the growing activity on the ground in many developing countries through bilateral initiatives – e.g. the Nordic Partnership Initiative on Upscaled Mitigation Actions (Laurikka & Leskela 2012) and the NAMA Facility by the governments of Germany and UK – broadly driven by the donor agencies' agendas (Hänsel *et al.* 2013), makes the choice of NAMAs very difficult at national level.

Speculation is rife that the governance of NAMAs would largely follow the institutional structure of the Clean Development Mechanism (CDM), where the role of the counterpart of the CDM Executive Board would be limited to maintaining the registry, and may also, perhaps, involve selection of NAMAs submitted by developing countries for support from the relevant international funding mechanism, including the GCF. To some extent, the evolving NAMA registry is performing the first task. However, it is still uncertain whether NAMAs would emerge as an international mechanism with clearly laid out negotiated guidelines or would largely remain a category where developing countries may report part or all of their mitigation actions as NAMAs. What is certain, however, is that the mitigation actions reported by developing countries as NAMAs would be subjected to some kind of MRV process. As of now, depending upon the type of NAMAs – i.e. domestically supported NAMAs (d-NAMAs) and internationally supported NAMAs (s-NAMAs) – MRV guidelines may be different wherein the d-NAMAs will be domestically MRVed according to international guidelines and s-NAMAs will be internationally MRVed (UNFCCC 2010). While these guidelines and rules are being negotiated, the issue of MRV is further complicated by the possibility that a mitigation action may have some components which are domestically supported while others receive international support. What MRV procedures would be applicable under these circumstances? Further, with respect to international support for NAMAs, whether there would be a dedicated centralised body deciding upon the allocation of financial support, or if it would be the responsibility of GCF, or left to the match-making role of the NAMA registry, is still to be resolved. With this ambiguity comes the uncertainty of the type and source of finance and associated political issues. With regard to technological support, the relationship between NAMAs and the Technology Executive Committee and Climate Technology Centre and Network is yet to emerge. Given institutional uncertainty at international level, alongside the increasing flow of bilateral support, it is important that developing countries are prepared with an institutional arrangement at the national level to streamline their negotiating interests with the mitigation actions, flow of support and various reporting requirements.

A government buy-in of any action labeled as a NAMA has been taken as a given requirement. Many reports and studies have suggested that the need for a designated national body for NAMAs is on the horizon. Such a body would require a framework for decision-making and streamlining the various concerns related to NAMAs. This paper offers a structured approach to making these decisions. The proposed approach could be used to design a NAMA or assess national appropriateness of mitigation actions. In the case of already developed proposals, the approach can not only help in assessing the degree to which a proposal is in the national interest, it can also be an instrument to find ways to improve the proposal. However, the most important use of the approach is at the stage of designing a NAMA. It is recommended that the approach is applied in an iterative fashion at that stage. There have been developed some insightful approaches which directly or indirectly relate to mitigation actions and policies (e.g. UNEP 2011b; Dubash *et al.* 2013). These approaches lay out important steps that should be followed in making choices, and also offer a set of criteria against which a proposed mitigation option should be scored. These approaches broadly follow multi-criteria methods and provide, very justifiably, scope for deliberation. However, these approaches also give considerable space for subjective scoring, which leaves room for transparency lapses in decision making. Further, the negotiation dynamics of NAMAs has been given little attention. The approach presented in this paper attempts to address these issues as well. It is important to mention here, however, that the presented approach has evolved almost simultaneously with, and hence is not a critique of, existing work. Instead, the overlaps are primarily due to similar concerns relating to mitigation and development imperative in policy-making, and divergences result from different entry points, and methodologies, to a similar problem. In that, this paper contributes to the existing body of literature to better understand, structure and think through the national and international agendas of development and mitigation.

## *2. Methodological steps*

The entry point of this research is an exploration of the idea and meaning of 'national appropriateness' of mitigation actions. Given the diversity of ideas, we assumed that a NAMA may actually take many forms, from being a standalone project, to a large programme, to a policy and regulatory intervention (Linnér & Pahuja 2012; Sharma 2013), and may be owned or operated by private as well as public sector actors, with necessary government approval. Accordingly, it is also assumed that a national designated authority or an agency with approving authority will be a necessary institutional arrangement for implementing NAMAs (Linnér & Pahuja 2012). The authority may be decentralised depending upon the governance structure in a country. Nonetheless, this authority will make a choice, the appropriateness of which is to be established with reference to national context and goals.[4] Exploration of the normative aspects of the decision-making process with a given context and goal, therefore, forms the core conceptual exercise towards developing the approach and selection of criteria.

In this exercise, three parallel steps were followed: (a) a literature review; (b) stakeholder engagement through consultation workshops and a questionnaire survey; and (c) interpretation of existing NAMA proposals to unravel the underlying normative assumptions. A stakeholder consultation was organised in August 2011 in New Delhi to seek inputs and validate this methodological approach.[5] These three steps provided a range of criteria that are appealed to in adjudging appropriateness of an action in the context of national development priorities and climate change negotiations. Interim findings and discussions from these three steps are published in the project research letter 'Mitigation talks' (Agarwal 2012a, b; Pahuja 2010; Tewari 2012; Shrivastava 2010, 2012). A roundtable was organised in New Delhi in November 2012 to discuss the draft synthesis of these findings.[6] The participants in the roundtable included policy makers, funding agencies and researchers. Based on the comments received in the roundtable, findings of the survey results (Pahuja & Agarwal 2013) along with the discussions during the various side events on NAMAs held during the COP 18 (Tewari 2013) and bilateral discussions with some of the members of the NAMA committee of India, the approach was revised into its present form, which at present is under review by international experts engaged with NAMA policy and implementation.

### 3. Normative guidelines for developing the approach

From the three methodological steps, the following six normative guidelines emerged as necessary in order to develop any approach and criteria to assess national appropriateness of a mitigation action:

#### 3.1 Flexibility to country context

Mitigation in developing countries is a complex choice. Like any other environmental problem, it has a strong political undercurrent, and has multiple ways of constructing and solving the problem of rising GHG emissions (Bardwell 1991). Mitigation actions can range from purely policy to technological and behavioral or as combinations. A mitigation action entails more than a technical solution and requires a combination of social, economic, political, and institutional buy-in (Solomon & Hughey 2007). Therefore, a key question for developing countries relates to the complex choice of most 'appropriate' mitigation actions from the available options. But there are gaps in evaluation of climate policy instruments to select the most appropriate instruments (Konidari & Mavrakis 2007). Moreover, an instrument that works well in one country may not work well in another country with different social norms and institutions (IPCC 2007), which further makes choosing the most 'appropriate' action a complex process. Hence, a flexible, yet comprehensive evaluation framework is required.

#### 3.2 A multi-criteria approach is unavoidable

Since any action is likely to have different implications depending upon the prevailing circumstances, it is extremely important that the process of making a choice is considerate of those circumstances. A comprehensive understanding of circumstances necessarily involves a number of factors. In a national policy context, these factors include concerns relating to different, often competing, national priorities; resource endowments; institutional, economic and physical infrastructure; terms of trade in global economy; social, cultural and political values; and so on. This implies that a choice in national context is necessarily a 'balancing exercise' between multiple concerns. Hence, for any action to be 'nationally appropriate' it needs to be justified against multiple criteria, separately as well as collectively.[7]

Different stakeholders expect a variety of outcomes from NAMAs, such as transformation of an economy (Linnér & Pahuja 2012; Escalante & Roeser 2013), co-benefits of development and economic growth (Pahuja & Agarwal 2013), sustainable development (Linnér & Pahuja 2012a) amongst others. Many also discuss the consideration of local capacities and institutional feasibilities while designing NAMAs. In general, while environmental problems are complex, involving a high level of uncertainty and being political in nature (Bardwell 1991), selection of appropriate mitigation options is a further complex problem (Ramanathan 1998). Many argue that there are different ways of constructing the problem and different paths to solving it. This necessitates the need to analyse different mitigation options to identify the most appropriate mitigation action. Such a choice involves a combination of technical social, economic, political, and institutional buy-in (Solomon & Hughey, 2007). While the choice of NAMAs is largely political, determined by the concerns in international negotiations, the implementation of actions is at domestic or local levels, which necessitates making the choice more inclusive and participatory.

We chose an approach which deals with decision-making problems under the presence of a number of decision criteria, both multi-objective decision-making (MODM) and multi-attribute decision making (MADM), as multi-criteria decision-making methods and tools (MCDM) are considered appropriate for capturing complexity of the problem and multiple perspectives of the environmental sustainability goal (Greening & Bernow 2004; Solomon & Hughey 2007; Wang *et al.* 2009; Konidari & Mavrakis 2007) and provide participatory analysis and qualitative assessment, along with a complete environmental and socio-economic impact assessment approach (Browne & Ryan 2010). MCDM helps with transparency by making key considerations explicit in policy-making process.

Literature on multi-criteria approaches suggests that a choice problem is generally a ranking problem among various choice options. Each option is assessed against a fixed set of criteria, particularly defined for a context, and the top-ranking option is deemed the most appropriate choice. It also suggests that most of the multi-criteria models are a variation of the analytical hierarchy process (AHP). However, one of the major drawbacks of the AHP, which is extremely relevant in the context of NAMA design, is that it is not very suitable to situations which involve interdependencies among different criteria. In such situations, use of an analytical network process (ANP) is recommended. ANP is a generalisation of AHP, where hierarchies are replaced by networks that enable assessment of outcome of various dependencies and feedback relations between factors (Gasiea et.al. 2010; Saaty 2001).

Many studies have used different versions of the multi-criteria approach. The choice of indicators in each shows varying degree of overlap (see Table 1). For this study, in addition to a review of literature, stakeholder consultations and an online survey were used to identify independent criteria as well as define the independent criteria where there is possibility of interdependence.

### *3.3 Criteria must be measurable*

In applying any criterion, the scale of measurement is crucial. In the context of NAMAs it is all the more important due to the concerns of MRV. It is not surprising, therefore, that the conceptual debate on the efficiency of application of AHP or ANP revolves around the use of a suitable scale to give scores to various options against different criteria. While different authors advocate use of different scales – linear, logarithmic, square root, verbal, geometric etc – there is unanimity that no single scale can entirely capture the complexity of choice parameters. Therefore, some also suggest using combination of scales (Ji & Jiang 2003). While the focus is on measurability, the criteria chosen also allow for some kind of qualitative matrix along with quantitative matrix given the complexity of criteria.

### *3.4 Discursive application of criteria*

While the use of a multi-criteria approach is broadly recommended in either AHP or ANP format, some critical challenges remain in ascertaining accuracy and reliability in the outcome. The two most important challenges relate to the problems of 'rank reversal' and 'incommensurability of values'. The problem of

**Table 1: Summary of studies analysing climate policy instruments using a multi-criteria approach**

| *Study* | *Objective/ Need for evaluation* | *Used sets of criteria* |
|---|---|---|
| Hoerner & Muller (1996) | Carbon taxes | Effectiveness, environmental incentive, administrability, fairness (actual and perceived) and revenue loss |
| Wu Zongxin & Wet Zhihong, (1997) | Mitigation assessment for China's energy sector | Mitigation potential, local environmental impacts, energy and resources efficiency, economic costs, consistency with national developmental goals, availability of resources, infrastructure requirements and capacity for localisation of manufacturing |
| Ramnathan (1999) | Selection of appropriate mitigation options | Cost-effectiveness, extent of reduction, local pollution benefit, other national benefit, adverse side effect, political and social feasibility, replicability, ease of implementation |
| Pearce & Howarth (2000) | Climate policy instruments | Causal, efficiency, equity, macro-economic and jurisdictional |
| Perrels (2000) | Finnish climate policy | Social cost, used potential, compliance risks, distribution effects and public/administrative cost |
| Government of New Zealand (2001) | New Zealand's climate change mitigation policies | Economic efficiency, equity, feasibility, environmental integrity and competitiveness |
| IPCC (2001) | Climate change mitigation policy options | Environmental effectiveness, cost-effectiveness, distributional considerations, administrative and political feasibility |
| Kete & Petkova (2001) | National case studies (Central and Eastern Europe), climate mitigation policies and measures | Environmental outcomes, economic/social outcomes, technical outcomes, institution building potential, project sustainability, dissemination/replication potential |
| Philibert & Pershing (2001) | Fixed, binding, dynamic, non-binding, sectoral targets, policies and measures for climate change mitigation policy | Environmental effectiveness, cost-effectiveness, contribution to economic growth and sustainable development, and equity |
| Smith & Sorrell (2001) | EU-ETS, national climate policy instruments (France, Germany, Netherlands, UK, Greece) and policy interactions | Environmental effectiveness, static economic efficiency, dynamic economic efficiency, administrative simplicity, equity, transparency and participation, political acceptability |

**Table 1 (continued)**

| *Study* | *Objective/ Need for evaluation* | *Used sets of criteria* |
|---|---|---|
| Johannsen (2002) | Danish agreements scheme on energy-efficiency in industry | Static concerns, dynamic concerns, institutional demands on the regulator and regulatee, political dimensions, risk. |
| Torvanger & Ringius (2002) | Burden-sharing rules in international climate policy | Responsibility, need, capacity, universal applicability and simplicity, easiness of making it operational, allowance for future refinements, allowance for flexibility and allowance of country-specific circumstances |
| Geoegopoulou *et al.* (2003) | Defining national priority for a NAP for GHG mitigation in energy sector for Greece and formulate a relevant time schedule for actions implementation | Cost of measure, contribution to fulfilment of the national emission reduction target, synergies with other actions related to the improvement of life quality, applicability, contribution to employment |
| Aldy *et al.* (2003) | Global climate policy architectures | Environmental outcome, dynamic efficiency, cost-effectiveness, equity, flexibility, in the presence of new information and incentives for participation and compliance |
| Governmental departments of Netherlands (1990), (2002), (2005) | Netherlands GHG mitigation policies; domestic climate policy instruments | Cost-effectiveness, equity, flexibility, transparency, efficiency, innovation, implementation according to schedule, certainty of the intended emission reductions, administrative costs, differentiated responsibilities |
| German BMU (2005) | Renewable Energy Sources Act | Ecological effectiveness, investment security, socially acceptable, cost-efficiency, administrative effort, openness |
| Ericsson Karin (2006) | Danish agreements scheme on energy-efficiency in industry | Competitiveness, cost-efficiency, side-effects (free riding), effectiveness, flexibility |
| Konidari & Mavrakis (2007) | Performance of EU emission trading scheme in 8 countries | Direct contribution to GHG emission reduction, Indirect environmental effects, cost-efficiency, dynamic cost-efficiency, competitiveness, equity, flexibility, stringency for non-compliance, implementation network capacity, administrative feasibility, financial feasibility |
| Solomon & Hughey (2007) | Evaluation of mitigation options from aviation sector | Environmental emissions, particulate emissions, noise, economic impact on GDP, competitiveness, economic distortion, cost-effectiveness, jobs and tourism, social-equity, distributional aspect, cultural, affordability and accessibility, institutional – political willingness, institutional feasibility, legal and statutory requirements, technological innovation |
| Wang *et al.* (2009) | Multi-criteria aid in decision-making | Efficiency, energy-efficiency, primary energy ratio, safety, reliability, maturity, investment cost, operation and maintenance, fuel cost, electric cost, net present value worth, payback period, service life, equivalent annual cost, emission of different gases, land use, noise, social acceptability, job creation, social benefits |
| Mundaca & Neij (2009) | Evaluation of tradable white certificate schemes | Energy-saving and environmental effectiveness, economic efficiency, cost-effectiveness, transaction costs, political feasibility, administrative burden, technical change |
| Grafakos *et al.* (2010) | Assessing policy interactions. | Climate: reduction in GHG emissions, increase in environmental awareness; energy: security of supply, reduction in energy intensity; financial: compliance costs, administration costs, transaction costs, governmental revenues; macro- economic: market competition, employment, competitiveness, business opportunities and trade; technological: innovation cycle, diffusion of existing technologies |
| Halsnaes & Garg (2011) | Assessing the role of energy in development and climate policies | Economic: cost-effectiveness, growth, employment, investments, energy sector; environmental: climate change air pollution, water, soil, waste, exhaustible resources, biodiversity; social: local participation, equity, poverty alleviation, education, health |

'rank reversal' refers to the situation when a change in the order (not weighting) of a criterion results in change in the outcome (Saaty 2001). Clearly, this should not be the case while assessing 'national appropriateness' of an action. The problem of 'incommensurability of values' refers to the fact that not all relevant aspects can be measured against a single scale and therefore scores against various criteria cannot be aggregated into a single score (Martinez-Alier *et al.* 1998). Moreover, different people are likely to assign different scores to an option depending upon their perceptions and 'reasons to value' (O'Neill 2001). While the ANP approach does reduce the problem of 'rank reversal' to a considerable extent, the problem of incommensurability of values remains. As a solution, it has been suggested that while a multi-criteria approach should be deployed to have a fuller understanding of the choice problem, final decision should be made taking into account various qualitative factors as well as quantitative information on different criteria considered relevant (Martinez-Alier *et al.* 1998). Survey findings (Agarwal 2012a; Pahuja & Agarwal 2013) reveal that different stakeholders attribute different weighting to a particular criterion. For example, while consistency with national developmental goals and environmental performance are considered equally important by all stakeholders, 'co-benefits' and 'quantification of actual mitigation' are rated relatively higher by government and multilateral agencies, whereas private sector and not-for profit organizations give higher importance to 'ease of implementation' and 'economic efficiency' considerations. The responses of developed country respondents also differed from developing country respondents on many criteria.

The survey asked respondents to reflect on their perceptions on importance of different considerations while designing NAMA proposals to determine the weightings for each criterion. 'Consistency with national development goals' was considered the most important criterion in designing NAMAs, by both developed and developing country respondents. This reinforces the understanding that national circumstances are pertinent while designing NAMAs proposals and it is important to allow for flexibility in their design. 'Environmental performance of actions' and 'ability to measure and quantify emissions reductions achieved' were considered the next most important criteria, with developing country respondents considering the latter more important. This relates to lack of clarity with respect to what, how, when, and to what extent the action would be MRVed; and the fear is that MRV would be even more cumbersome for NAMAs as compared to the CDM. It is therefore important to have clear and simple guidelines on MRV for both domestically and internationally supported NAMAs. The developed country respondents, on the other hand, considered 'environmental performance' as more important, clearly indicating their emphasis on a result-based approach. At the same time,'ambition of level of actions' was considered the least important consideration while designing NAMAs by both developed and developing country respondents. This resonates with the idea that developed country Parties must take the lead and come up with higher levels of ambition. The results from each stakeholder group vary and corroborate the Arrow's impossibility theorem (http://gatton.uky.edu/Faculty/hoytw/751/articles/arrow.pdf). No decision-making tool can be designed that satisfies every decision maker or user. Therefore, given that the primary beneficiary of the proposed approach will be various stakeholders including developing country governments, private sector, funders, involved in designing/ approving NAMAs, the approach allows for flexibility in assigning the weights.

### *3.5 Political sensitivity of negotiations*

Further, amidst a range of speculations, the NAMA registry under the UNFCCC has begun to take shape, many bilaterally supported mitigation concepts in developing countries outside the UNFCCC process are in the pipeline and many feasibility studies are in process. It is important to note that the bulk of NAMA activity is driven by bilateral support from developed countries largely in the form of ODA (Hänsel *et al.* 2013; Kuramochi *et al.* 2012), which from developing countries' point of view should not be accounted as climate finance. Moreover, the reasoning for most of these activities is that the experience from pilot actions is a better guide to design the governance structure of NAMAs. Arguably, this is creating a laboratory outside UNFCCC for a future climate regime in which developing countries are on the receiving end. It is therefore in the interest of developing countries that an objective approach exists, explicitly reflecting their negotiating interests, in judging under what conditions, any proposed mitigation action should be labelled as a NAMA.

### *3.6 Utility and ease of application*

The strength of an approach lies in its utility for the maximum number of stakeholders and in ease of application. In the case of NAMAs, different stakeholders need evaluation frameworks at different stages and for different goals. While different aspects are taken care of by the use of a multi-criteria method, use of the approach at different stages, particularly *ex-ante* as well as *ex-post* evaluation needs to be inbuilt. In particular, the approach to evaluate NAMAs should also serve as a background for developing a MRV framework. The ease of application can be best captured if the approach can be translated into a ready-to-use tool.

## 4. The proposed approach

The primary beneficiary of the proposed approach will be developing country governments. In addition to helping policy-makers select more 'appropriate' mitigation actions from a broad spectrum of choices, the proposed criteria can also help governments in classifying NAMAs.The emerging discourse on NAMAs indicates that NAMAs could be categorised in two different ways. One is according to the type of action (policy, programme or project) and the other is according to the source of support (domestic, international, mixed etc). These two types could be arranged in a matrix. It is likely that each combination in this matrix will have different political sensitivities attached to it, particularly with regard to MRV implications. The proposed criteria offer a structured approach to establish boundaries between domestic and supported NAMAs, to ensure synchronisation with national priorities to the maximum detail possible, and may also help in determining what mitigation actions over a period of time are possible in a country and why. Moreover, the proposed criteria could be applied in making *ex-ante* choices of mitigation actions and in *ex-post* evaluation of the performance of mitigation actions. It is, however, important to note that it is not an alternative to the normal policy process, but, rather, a tool to inform the policy process. A structured approach that clearly spells out national priorities and concerns will also serve as a guide for prospective NAMA developers (government agencies, private players, technical consultants). The criteria, if applied in the prescribed manner (see section 4), will be useful in determining the appropriate scope and scale at which an action becomes 'nationally appropriate'. The proposed approach arranges multiple social, economic and environmental concerns in a structured order. It will help funding agencies to assess a proposal with reference to their funding priorities. It may also be useful in streamlining various lines of funds dedicated to specific developmental objectives.

While developing the proposed approach, we began with a listing of key concerns, based on the review of climate negotiations, and national policies in developing countries, along with stakeholder consultations. We found that each NAMA is expected to have a set of desirable outcomes. These possible outcomes are clubbed into eight normative objectives – *the outcome clusters*. Each outcome is further translated into '*criteria*'. Recognizing that each criterion within an *outcome cluster* may have different significance for a country, the approach allows flexibility to users to assign weighting to each criterion within an outcome cluster, which essentially reflect national circumstances and priorities. Each criterion may have multiple *options* (see Annexure 1) for which different countries' attitude may be different. The approach allows the users to reflect their attitudes, reflecting the sensitivity to negotiating positions as well as political and socio-cultural acceptability conditions.

Users can assign *weightage* for each criterion within an *outcome cluster* along with *attitudes* towards various options: (acceptable (+1), indifference (0) and not-acceptable (-1)). A proposed NAMA is mapped against these options in terms of qualitative and/or quantitative scores, expressed numerically as per the scoring guide (see Annexure 1). These scores are aggregated for outcome clusters. Since it is advised not to reduce impacts of an action to a single score, but at the same time it is also recognised that some degree of aggregation is necessary for making the criteria accessible and useful, it is proposed that each outcome cluster is given two scores: one signifying the qualitative strength of positive impacts and other recognising negative impacts. This is achieved by aggregating the option scores as per the sign of attitude (positive or negative). Accordingly, each outcome cluster gets *positive* and *negative scores*, in a *'deliberation matrix'*. The 'deliberation matrix' of various NAMA proposals can be used to ascertain their eligibilities, acceptability and categories. Moreover, the negative scores also provide an indication of modification of NAMA design. It is important to note here that the user may add or delete more criteria and corresponding options within each outcome clusters. Figure 1 presents the general scheme of the approach.

### *4.1 Outcome clusters and criteria*

*(i) Political acceptability of international support*

Mitigation in developing countries in the context of climate change has always been a politically contentious issue. Any discussion or opinion about NAMAs, therefore, can be insulated from reference to its international context. The two most important aspects are the international support (technology and finance) and MRV requirements. While it is a well-known position of developing countries that mitigation actions are dependent upon the international financial, technological and capacity building support, the need to scrutinise the package of support itself has also been pointed out, citing sovereignty and accountability concerns. For example, the source of support, or the channel through which support flows to developing countries and the conditions with which support is provided, needs to be carefully examined. A better way of doing this is to reflect upon it at the design

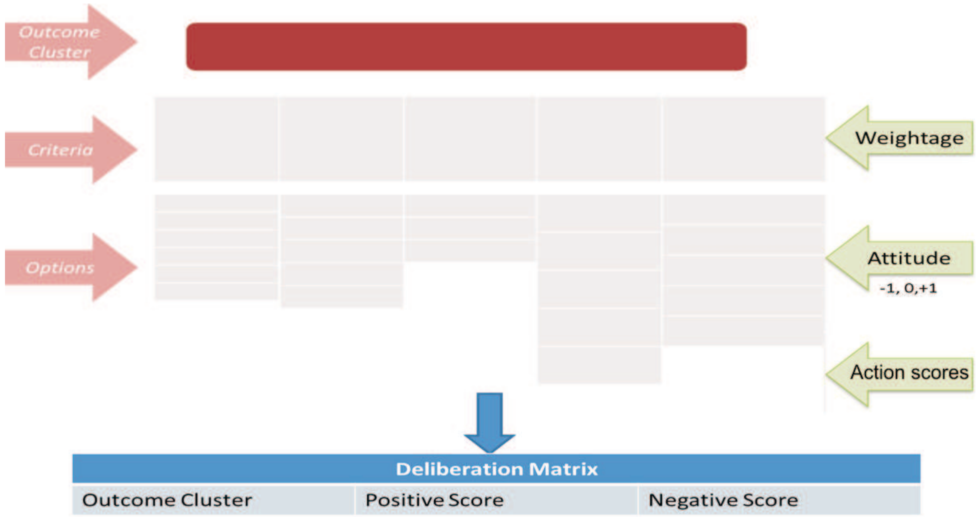


**Figure 1: General scheme of the approach**

stage of the action, mentioning the acceptable package of support. With reference to MRV requirements, transparency and an upfront statement of national circumstances and priorities that a proposed action caters to are imperative in any design criteria for NAMAs. Implicit in this is the requirement of measurability. Many studies (Ramnathan 1999; Sorrell 2001; Johannsen 2001; Solomon & Hughey 2007; Mundaca & Neij 2009) have considered political acceptability as a criterion to exert choice. However, choice of NAMAs would also have the elements of international political acceptability. Therefore, criteria such as finance, technology, capacity building and MRV are considered in the decision-making tool. However, the weightings, options and attitudes could be determined by each user.

*(ii) Transformation of the economy*

Although expressed through various concepts such as energy and resource efficiency (Zongxin & Zhihong 1997), sustainable development (Linnér and Pahuja 2012a), low-carbon economy and green growth (Shrivastava 2013) and so on, the underlying assumption has been that a NAMA should help the economy transform itself over a period of time into a more environment-friendly economic system bringing about transformational change (Escalante & Roeser 2013). This transformation may be brought about through technological changes, increases in private sector participation, changes in life-style, associated changes in manufacturing capability and shift in energy mix. It is also noted that such a transformation of the economy should not be at the cost of compromising national developmental priorities and overall environmental well-being. In other words, the transformation should be measured in terms of contribution to national developmental priorities, such as energy security, poverty alleviation, and enhanced manufacturing capabilities. These concerns may be further broken down into considerations of not only the immediate effects of the action but also the long-term effects (Escalante & Roeser, 2013). Hence, consideration of the 'time dimension' and 'second order effects' is integral to assessing contribution of an action towards transformation imperatives. Many studies have used similar criteria for exerting choice on climate policies, such as infrastructure requirements and capacity for localisation of manufacturing (Zongxin & Zhihong 1997), improvement of quality of time (Geoegopoulou 2003), technological innovation cycle and diffusion of existing technologies (Grafakos *et al.* 2010). However, each user may have a different perception of transformation, so the weightings, options and attitudes in the decision making tool could be determined by each user.

*(iii) Social and cultural acceptability*

The social dimension of the sustainable development agenda, along with acceptability among the local and political community, emerges from the discourse as one of the core priorities. Almost all studies evaluating climate policy instruments (see Table 1) use social acceptability as a criterion. In particular, reduction in economic and social inequalities, job creation and sensitivity to the cultural practices of local community are considered critical considerations.

*(iv) Environmental consequences*

The trade-off between mitigation benefits and other environmental benefits finds an increasing resonance in climate policy discourse. Mostly, other environmental benefits are articulated as co-benefits of climate action, highlighting added advantages and hence justifying certain mitigation actions. However, it is also articulated in a reverse order, pointing out that mitigation actions should not be undertaken at the cost of other environmental considerations, like air quality, biodiversity, water quality, soil etc. Most of the earlier studies evaluating climate policy instrument (see Table 1) use environmental co-benefits as a criterion. However, articulation of each differs. The survey asked the respondents about their perception on what best describes 'environmental performance of actions' in the context of NAMAs. Direct contribution to GHG reduction (84%) was considered the best indicator of environmental performance, followed by 'environmental co-benefits' (70%). Surprisingly, 'Indirect contributions to GHG reduction' was considered less important, contrary to the increased emphasis on systemic transformational change (see for details Linnér & Pahuja (2012)) that NAMAs could bring about.

*(v) Cost-effectiveness*
Cost-effectiveness of an action emerges as one of the primary criteria in all the studies evaluating climate policy instruments (see Table 1). These considerations include cost implications not only for the project implementer but also for the regulatory agencies, government and the beneficiaries of the action.

*(vi) Institutional feasibility*
All actions take place within an institutional context. Therefore, in order for an action to be implemented it is a pre-requisite that it is a feasible action not only according to economic rationality but also in terms of institutional requirements.[8] Mostly, these concerns are expressed in terms of fulfillment of regulatory requirements, favorable legal and policy environment, environmental standards, safety measures and so on.

*(vii) Domestic resource use*
Efficient and optimum utilisation of, and greater reliance on, domestic resources are well established guiding principles of development planning. The discourses on low-carbon transition, energy security and sustainable development underscore this principle.

*(viii) Reduction in undesirable impacts*
Any action might have positive as well as negative impacts across multiple dimensions. As a general rule the positive impacts must be maximised and negative impacts should be minimised. While these concerns are expressed in positive as well as negative requirements, a generalisation of views expressed could be made so as to imply that as long as certain negative impacts are avoided an action could be considered appropriate. However, it might not be possible to eliminate all the negative impacts of a project. The choice, therefore, would be between two different combinations of negative impacts. Moreover, in different country contexts the list of negative impacts may be different. The negative impacts, over which very strong opinions emerged from discourse include (a) social and economic inequality should not increase; (b) no action described as NAMA should allow the economy to get locked into high-emission economic activities that cannot be closed down within economic rationality before a certain period of time; (c) a NAMA should not imply diversion of resources from other development activities; (d) conditionality of support should not infringe upon sovereignty; (e) balance of payment condition of a country should not be worsened; (f) the action should not lead to loss of livelihood of poor; (g) import dependence of an action should be as minimal as possible.

An illustrative list of possible criteria under each outcome cluster and a range of options that could be available to score against each criterion is given in Annexure 1 along with an illustrative guide of scoring against each option.

### *4.2 Scoring scheme*
Since it is advised not to reduce impacts of an action to a single score, but at the same time it is also recognised that some degree of aggregation is necessary for making the criteria accessible and useful, we propose that each cluster is given two scores: one signifying the strength of positive impacts and other recognising negative impacts. The positive (or negative) score for an 'Outcome cluster' is calculated according to the following equation:

$$L^+ = \Sigma_i[WC_i * \Sigma_{ij}(C_iP_j * SC_iP_j)^+]$$

Where,
$L^+$ = positive score of Outcome cluster L
$WC_i$ = Weight assigned to $i^{th}$ criterion of Outcome cluster L
$C_iP_j$ = 'attitude' given to $j^{th}$ option of $i^{th}$ criterion of Outcome cluster L
$SC_iP_j$ = Score given to the proposed NAMA against $j^{th}$ option of $i^{th}$ criterion of Outcome cluster L
$\Sigma_{ij}(C_iP_j * SC_iP_j)^+$ = sum of the positive values
Similarly, the negative score for the cluster is to be calculated.

To illustrate, Table 2 shows how the scores for the Outcome cluster 'Political acceptability of international support' may be calculated in a hypothetical case. In this illustration, we assume that each criterion is equally important, and in order to ease the comparison between positive and negative scores we have

**Table 2: Illustration of calculation of Outcome cluster scores for 'Political acceptability of international support'**

| Criteria [C] | Weighting of criteria[a] [WCi s.t. ΣWCi=10] | Options: Attitude[b] [CiPj] | Options: Options [SCiPj] | Project score[c] | Guide for project score | Criteria positive score [CiPj*SCiPj] | Criteria negative score [CiPj*SCiPj] | Cluster score (+) | Cluster score (-) |
|---|---|---|---|---|---|---|---|---|---|
| Type of finance | 2 | 1 | Grant | 0.6 | % of total investment | 1.2 | -0.8 | **12.4** | **-5.6** |
| | | 0 | Equity | 0 | | | | | |
| | | 1 | Concessional loan | 0 | | | | | |
| | | -1 | Commercial loan | 0.4 | | | | | |
| | | 0 | ODA | 0 | | | | | |
| | | 0 | Philanthropic | 0 | | | | | |
| Nature of technology transfer | 2 | 1 | Concessional | 0 | Yes (1) /No (0) | 2 | -2 | | |
| | | -1 | Commercial | 1 | | | | | |
| | | 1 | IPR license | 1 | | | | | |
| | | 1 | Joint R&D | 0 | | | | | |
| | | 1 | Knowledge | 0 | | | | | |
| Capacity building | 2 | 1 | Institution level | 1 | Yes (1) / No (0) | 6 | 0 | | |
| | | 1 | Systemic level | 1 | | | | | |
| | | 1 | Individual level | 1 | | | | | |
| Source of finance (under/ outside FCCC) | 2 | 1 | GCF/UNFCCC | 0.6 | % of total investment | 1.2 | -0.8 | | |
| | | -1 | Multilateral financial inst-institutions/outside UNFCCC | 0 | | | | | |
| | | -1 | Bilateral funding/ODA | 0 | | | | | |
| | | -1 | Private investors/FDI | 0.4 | | | | | |
| | | 0 | Individual/philanthropic | 0 | | | | | |
| MRV implications | 2 | -1 | International MRV of all aspects of project | 1 | Yes (1) / No (0) | 2 | -2 | | |
| | | 1 | International MRV of only supported component of project | 0 | | | | | |
| | | 1 | Only domestic MRV | 0 | | | | | |
| | | 1 | Part domestic, part international MRV | 0 | | | | | |
| | | 1 | MRV of support | 1 | | | | | |

*Note:*
a. Weighting within a cluster/decided by government/user
b. Acceptable (+1), Indifference (0), unacceptable (-1) decided by government/user
c. To be filled in by project developer, verified by DNA.

taken the weightings to add up to 10. Based on our assessment of climate change negotiations and positions generally taken by developing countries on various options listed in the table (grant as type of finance, concessional as one of the modes of technology transfer, etc) we have assigned 'attitudes' of an average developing country. For example, grant would be acceptable (+1) climate finance, whereas a commercial loan is most likely to be unacceptable (-1) to developing countries as climate finance. For all practical purposes, we assume that the weightage and attitudes are given *ex-ante* by the user, and how they arrive at them is beyond the scope of this paper. Accordingly, they may add more criteria and options. Now, suppose there is a candidate NAMA project in a super-critical power project involving a multinational company in collaboration with the public sector enterprise in India, Bharat Heavy Electricals Limited (BHEL). This project receives 60% as grant from the GCF and 40% comes in the form of foreign direct investment (FDI), to the effect that the multinational company owns the plant. The involvement of BHEL in the project is to build the boilers through a technology transfer agreement with Alstom on full commercial basis. The MRV requirements include a considerable part of how BHEL has implemented and benefited from the technology transfer agreement. These aspects are reflected in the project scores for options as per the scoring guide. It is very likely that the full commercial basis of the technology transfer agreement, FDI in power sector, and scope of MRV of BHEL functioning will be unacceptable for a range of policy and political reasons. The positive criteria scores are calculated by multiplying the sum of the project scores of the acceptable options by the weighting assigned to criteria. For example, 0.6 is the sum of the scores of acceptable options of type of finance, which, upon multiplication with weighting (i.e. 2), gives a positive criterion score of 1.2. Similarly, the negative criteria score is -0.8. Further, by summing up the positive and negative scores of each criterion we arrive as the positive and negative scores of the outcome cluster 'political acceptability of international support', i.e. 12.4 and -5.6 respectively.

### *4.3 Application of the criteria*

It is important to keep in mind that the proposed criteria are not aimed at making final decision; rather the purpose is to facilitate decision making in a more transparent and MRVable manner. The scoring scheme will give an 8 x 2 matrix as below. These scores are to be used for deliberation for making the final decision. Hence, we call the matrix below the 'deliberation matrix'.

**The deliberation matrix**

| *Cluster* | *Positive score* | *Negative score* |
|---|---|---|
| Political acceptability of international support | | |
| Transformation of economy | | |
| Social and local acceptability | | |
| Environmental consequences | | |
| Cost-effectiveness | | |
| Institutional feasibility | | |
| Domestic resource use | | |
| Reduction in undesirable impacts | | |
| | | |

As mentioned earlier, the proposed criteria could be used to design a NAMA or assess national appropriateness of mitigation actions. In the case of already developed proposals, the application of criteria cannot only help in assessing the degree to which a proposal is in the national interest, but also be an instrument to find ways to improve the proposal. However, the most important use of the criteria is at the stage of designing a NAMA. It is recommended that the approach is applied in an iterative fashion while designing a NAMA.The purpose of iterations is, first, to eliminate the negative scores or reduce them to an acceptable level; and, secondly, to find an adequate financial, institutional and technological scale as well as scope under which an action is most appropriate.

This implies that, for the iterative process, if a proposed action does not attain acceptable scores against each cluster, corrective measures must be included as part of the proposed action and scores should be reworked. This would necessarily affect the scale and scope of the action. Moreover, if a fully internationally supported action does not meet the conditions of political acceptability, that action must not be undertaken. A schematic representation of how to apply the approach is given in Figure 2. Since iterations can go on for innumerable rounds and there is no clear rationale for the number of iterations an evaluation exercise should go through, we propose that a timeframe of assessing impacts of proposed action over a period of 15-20 years after iplementation should be considered.[9] Further, governments may choose to fix a minimum net score for each cluster for a project to be considered nationally appropriate, thereby incorporating a threshold for action into government policy.

To illustrate, let us take the example of fully domestically supported large hydropower projects in India. A likely deliberation matrix for the project is given in Table 3. For the sake of simplicity we have given descriptive scores with explanation.

Given the huge hydro potential and experience within India, it is expected that the project will have high positive scores for outcome clusters 'transformation of economy', 'institutional feasibility', 'domestic resource use', 'political acceptability of international support' and 'cost-effectiveness'. One may also reasonably expect mixed positive and negative scores for 'environmental consequences' and 'reduction in undesirable impacts'. However, experience has shown that large hydro projects in India have faced serious protests and hence, in their current form, will have high negative scores on 'social and local acceptability'. Any large hydropower project becoming NAMA as per the proposed scheme will have to reduce the high

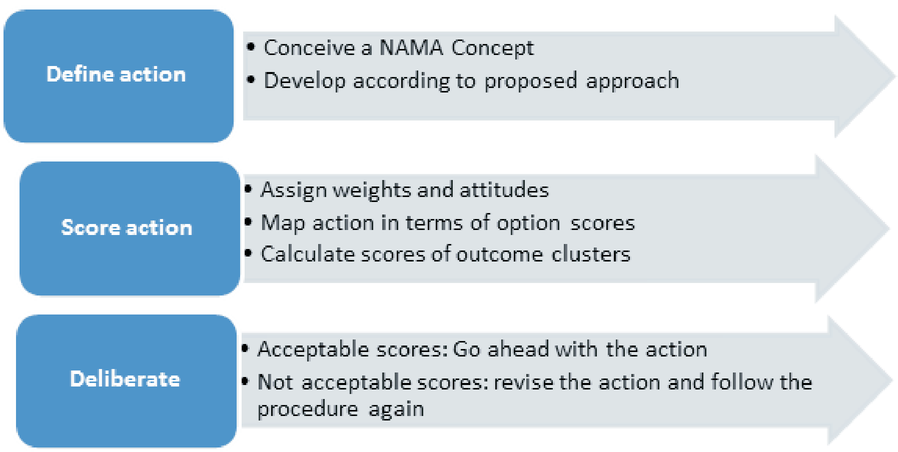


**Figure 2: How to apply the NAMA design and approval approach**

**Table 3: Likely deliberation matrix for a large hydro power project in India**

| *Cluster* | *Positive score* | *Negative score* |
|---|---|---|
| Political acceptability of international support | High, since it is fully domestically funded | Low, assuming only domestic MRV and no judgment on ambition under ICA. |
| Transformation of economy | High, increased share of renewable energy and reduced dependence of imported exhaustive fossile fuels sources (energy security) | Low |
| Social and local acceptability | Medium, job creation, cultural acceptance of hydro-power, safe | High, displacement of marginalised sections and possible empoverishment |
| Environmental consequences | Medium, comparatively low GHG emissions, improved ground water table, | Medium /low, biodiversity implications |
| Cost-effectiveness | High, proven cheap power | Low/medium |
| Institutional feasibility | High, already in place | Low, already in place |
| Domestic resource use | High, domestic resources and technology | Low |
| Reduction in undesirable impacts | Medium. Reduced emissions and import dependence | High, livelihood losses and increased income disparity due to displacement, political unrest |

negative scores on ‘environmental consequences’ (e.g. biodiversity loss), ‘reduction in undesirable impacts’ (e.g. political unrest), and ‘social and local acceptability (e.g. proper relocation and resettlement of displaced communities). Obviously, this would have cost and scale implications, but at the same time would also improve positive scores on ‘transformation of economy’ (more equitable). These are the subjective choices a decision-maker will have to make while deliberating and revising a proposal for a large hydropower project.

Although in the case of large hydro projects in India the conclusion that a proper relocation and resettlement arrangement of displaced communities is the only way forward is already well understood, from the perspective of whether to label such a project as NAMA the proposed approach is useful. As is clear from the ‘deliberation matrix’, it helps in assessing the areas where negative scores are too high and need improvement. Further, at the second stage when increased costs are to be met with additional financial resources, whether it can be mobilised through domestic sources or through international funding, it helps make a decision depending upon the various criteria under the political acceptability of international support outcome-cluster. Hence, the iterative application of the proposed approach systematically helps in first harmonising a mitigation option with national developmental concerns and circumstances and then acceptability of international support.

## 5. Conclusion

In this paper we have proposed a systematic step by step approach to operationalise NAMAs from conception through implementation, from the perspective of bridging the national political context of decision-making, development imperatives, and their positions in global climate change negotiations. Although we have listed illustrative set of criteria, by allowing flexibility to users to prepare their list of criteria and include options as they emerge, along with making their weightings and attitudes explicit, we hope that a clearer communication among various stakeholders will help decision-making become more transparent and more attuned to various objectives that stakeholders pursue. For example, it may be the case that a project has different deliberation matrix scores for the governments and funding agencies but they both might find it acceptable and appropriate. In such a situation, the reasons will be clearer and the areas where improvement is needed are well documented in the project score sheet. However, it is important to make it clear that the proposed approach aims only at assisting the decision-making based on user’s priorities and by no means prescribe any norms.

### Notes

1. A publicly available full version of the registry was due to be uploaded in October 2013 on the UNFCCC platform. Updates on prototype registry could be accessed at: https://unfccc.int/cooperation_support/nama/items/7476.php.
2. More information can be found in UNFCCC (undated), available at http://unfccc.int/files/adaptation/application/pdf/info_note_on_the_registry.pdf.
3. Details can be accessed at https://unfccc.int/cooperation_support/nama/items/6945.php.
4. A very rich discussion on these lines is found in the debates on the literature on social choice. For a comprehensive summary and discussion see Sen (1982; 2002).

5. Minutes of the stakeholder consultation can be accessed at www.teriin.org/projects/nfa/pdf/NFA_NAMA_Stakeholder_Proceedings.pdf.
6. Minutes of the roundtable discussion can be accessed at www.teriin.org/projects/nfa/pdf/NFA_NAMA_Roundtable_Proceedings.pdf.
7. It is worth noting here that economist F.A. Hayek, in his critique of planning for a whole economy, pointed out that such an exercise would require undertaking an impossible task of gathering and synthesising enormous amounts of information.
8. There is a rich debate on the meaning and interpretation of the term 'rationality' and its application to economic decision making. Here we use it in the standard neo-classical sense of the term and not in the sense the critics such as Simon (1985), Sen (2002), Fine (2003) and some institutional economists refer to it. However, their concerns are embedded, we believe, in the multiple criteria and method to apply the criteria.
9. This time frame is loosely based on the work of Freeman and Perez on the pattern of changes in techno-economic paradigms (Perez 2004).

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**Annexure 1: Outcome clusters, criteria, options and guide for proposal scoring (an illustrative list)**

| *Criteria* | *Options** |
|---|---|
| | ***Political acceptability of international support*** |
| Type of finance | Grant, equity, concessional loan, commercial loan, oda, philanthropic, private sector… |
| Nature of technology transfer | Concessional, commercial, IPR license, joint R&D, knowledge… |
| Capacity building | Institution level, systemic level, Individual level |
| Source of finance (under/outside FCCC) | Green climate fund/UNFCCC, multilateral financial, institutions/outside UNFCCC, bilateral funding/ODA, private investors/FDI, Individual/philanthropic |
| MRV implications | International MRV of all aspects of project, International MRV of only supported component of project, Only domestic MRV, part domestic, part international MRV, MRV of support |
| | ***Transformation of economy*** |
| Technological | Technology transfer agreement in case of imported technology, diffusion of domestically best available technology, enhancement in R&D infrastructure and/or domestic manufacturing capability, strengthening of national/sectoral innovation systems, market creation for new technologies |
| Private sector participation | Increased corporate social responsibility, leverages private finance, encourages private sector R&D, Voluntary initiative of private sector, public private partnership |
| Energy security | Increased exploitation of renewable energy, improvement in energy efficiency, reduced reliance on imported fuel, reduced demand for energy through behavioral change, reduced energy prices / improved access to energy |
| Impact on manufacturing capability | Addition to domestic manufacturing strength, domestic content of total input/raw material, improvement in competitiveness in international market, increased demand for domestic products (manufacture) |
| Lifestylechanges | Incentives for change in consumption patterns, Incentives for adoption of best practices, increased willingness to pay for environment friendly products, enhanced awareness |
| | ***Social and cultural acceptability*** |
| Reducing income disparity | Benefits for population below USD1 (PPP) per day, Proportion of employed people living below USD1 (PPP) per day, |
| Job creation | Nature (skilled, unskilled etc), type (permanent, temporary, seasonal etc.), reduces unemployment rate, no. of jobs per unit of investment |
| Impact on marginalised sections of society | Lower gender inequality, Increased resilience, improved social justice |
| Safeguards against risks | Health hazards adequately addressed, safety concerns adequately addressed, risk performance against (industry) benchmarks |
| Cultural acceptance | Involves a lifestyle change, Involves acceptance of a new paradigm/system/process, promotes change in attitudes |
| | ***Environmental impacts*** |
| GHG reduction potential | Increase in green cover (impact on sinks), Decrease in primary energy use (impact on sources), scale of impact (local, state, national) |
| Impact on air quality | No impact, increase in emissions of other GHGs i.e. GHGs not covered under KP (SPM/RSPM etc), Emissions of toxic air pollutants (acid rain, dioxins etc.), |
| Impact on biodiversity | No impact, ecosystem/biome spread (e.g. fragmentation, connectivity), abundance and distribution of species (diversity index), change in status (e.g. from threatened to protected etc) |
| Impact on water resources | No impact, water quality, availibility of water, local access to water, groundwater table |
| Waste management | Quantity of waste generated, type of waste generated, availibility of suitable waste disposal facilities, No impact |

| *Criteria* | *Options** |
|---|---|
| Impact on soil | Top soil (pollution/productivity), ground cover (erosion), salinization (from anthropogenic sources such as irrigation, fertiliser use etc) |
| | ***Cost-effectiveness*** |
| Cost of action | Investment per unit emission reduction, total cost per unit emission reduction, total cost per unit co-benefits accrued (whether the costs are lower than a pre-determined benchmark) |
| Cost of compliance | Costs incurred for meeting all the regulatory requirements within the project boundary per unit emission reduction achieved (whether the costs are lower than a pre-determined benchmark) |
| Cost to government | Costs incurred by the government in ensuring/enforcing compliance in terms of per unit of emission reduction or output (whether the costs are lower than a pre-determined benchmark) |
| Cost to beneficiaries | Reduce prices of goods and services, development of community assets or other tangible assets, ease of access of credit, introducing tax burden on beneficiaries |
| Cost recovery period /economic viability of the project | A positive economic NPV, a positive discounted net cash flow, cost of capital <IRR, duration of payback period |
| Resource (input) efficiency | Extraction of natural resources per unit of output, non-compliance with one or more than one laws and regulations applicable to the action |
| | ***Institutional feasibility*** |
| Compliance with existing laws and regulations | Compliance with all laws and regulations applicable to the action |
| Changes in institutional arrangement | Existing institutional structures are adequate for undertaking the action, action requires modifications within the existing institutional structure, Action requires establishment of new institutional arrangement |
| | ***Domestic resource component*** |
| Human resources | Action enhances the awareness levels of the local population, enhances the knowledge and expertise (skills) of the local population/leads to building green societies through green (job) training, enhances (provides) job opportunities for the local population, brings about a behavioural change in the local population (as a response mechanism to climate change), promotes good health and well-being of the local population, enhances economic prosperity and stability amongst the local population, enhances economic prosperity and stability amongst marginalised sections of the local population |
| Natural resource | Action enhances the natural resource base of the region, enhances the natural resource base of the region, promotes the use of locally available natural resources as raw materials/inputs for the mitigation actions, outsources/imports raw materials, etc. from other regions to protect/maintain the natural resource base of the region, outsources/imports raw materials, etc, from other regions to address the paucity of natural resources in the region, outsources/imports raw materials, etc. from other regions to achieve the desired efficiency levels of the employed technologies/processes (in the absence of required materials locally) |
| Financial capital | Actions strengthens the local financial market and institutions, promotes the use of local financial resources/inputs, promotes investment by external sources/parties |
| Technological capital | Action enhances the technological capital of the region by promoting/incentivising deployment and utilisation of new climate friendly technologies, enhances the technological capital of the region by promoting/incentivising innovation/development of new technologies, enhances the local technological capability of the region by promoting diffusion (commercialization) of certain technologies (through demonstration of the environmental effectiveness of the technologies/cost reduction), enhances the technological capital of the region by reducing/meeting the 'learning costs' of adoption of new technologies, i.e. the additional cost involved in adapting to the new technology, enhances the 'spill-overs', that is, transfer of the knowledge or the economic benefits of innovation/technology adoption amongst the potential users in the region |
| | ***Reduction in undesirable impacts*** |
| High emission lock-in | Duration of lock in compared to a pre-determined period: Scoring guide High (-1), Low (+1) |
| Import intensity | Share of imports to total input value: Scoring guide: increases (-1), declines (+1) |
| Impact on domestic manufacturers | Whether it puts domestic manufacturers out of business?: Scoring guide, yes (-1), no (+1) |
| Diversion of resources | Does the action needs government support that necessitates limiting support to MDG programs: Scoring guide, yes (-1), no (+1) |
| Livelihood losses | Does implementing the action leads loss of livelihood |
| Conditionality of support | Does the international support impose conditionalities other than MRV (e.g. IMF's structural adjustment program): Scoring guide, yes (-1), no (+1) |
| Hazardous waste | Does the action produces hazardous waste? : Scoring guide, yes (-1), no (+1) |
| Balance of payments | Does the action have potential to negatively affect balance of payments: Scoring guide, yes (-1), no (+1) |

*Note:*
* The list of options is likely to keep evolving with policy, market and technology innovations. We propose these options to be scored as yes (1) and no (0) except for the outcome cluster "reduction in undesirable impacts". Particular users may define scoring differently, provided it maintains comparative consistency and sensitivity of scores)

# Electric vehicle scenarios for India: Implications for development and mitigation

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***Abstract***
The transport sector globally is overly dependent on liquid fossil fuels. Electric vehicles (EVs) are touted as a way of diversifying the fuel mix and helping to reduce dependence on fossil fuels. There could also be other co-benefits of EVs, such as improved energy security, decarbonising of the electricity sector, $CO_2$ mitigation and reduction in local air pollution. The Indian government has recently launched a national electricity mobility mission to promote EVs. There is, however, much uncertainty in terms of the penetration of EVs in the transport sector, particularly those related to infrastructure and policies. While the literature on EVs has focused more on the role of electric cars, it could be electric two-wheelers which could make early headway, as is the case in China where nearly 120 million such vehicles had been sold by the end of 2012. Three scenarios (Business as Usual (BAU), Electric Vehicles, and Electric Vehicles Plus 2°), for EVs from 2010 to 2050, are analysed using the bottom-up energy system ANSWER MARKAL model. The paper makes use of global $CO_2$ prices for aligning the model with global stabilisation targets. Electric two-wheelers and electric four-wheelers achieve cost competitiveness in the BAU scenario by 2035, but tax incentives in the EV scenario help in advancing this to 2020 for electric two-wheelers and to 2025 for electric four-wheelers. The diffusion of EVs would, however, depend on availability for charging infrastructures and a strengthened grid for handling increased electricity demand. EVs are not a mitigation option unless electricity is cleaned up, and EVs, together with smart grids and renewables, can provide a solution for this.

Keywords: electric vehicles, energy security, $CO_2$ mitigation, co-benefits

## 1. Introduction

The transport sector, amongst the largest energy-consuming sectors, is globally overly dependent on liquid fossil fuels. Of all the fuel used in the transport sector in 2010, 93% was oil-based, of which road transportation accounted for 77% (IEA 2011: 109). The sector's share in total oil consumption has increased over the years, up from 45% in 1973 to 61% in 2010 (IEA 2012). The sector is also a major source of GHG emissions and accounts for 23% of total global energy-related $CO_2$ emissions (IEA 2010). The transport sector is also associated with several environmental and health hazards. As a result, emission mitigation and reducing energy consumption have been at the centre of various national and global energy and environmental policy debates in recent years, with transport one of the key sectors involved. In the BLUE scenario prepared by the International Energy Agency (IEA) (2010), transport accounts for 37% of total emission reduction in the long term up to 2050, compared with the baseline scenario.

Several options have been considered to reduce emissions and energy consumption of the road transport sector. These include various supply-side measures such as fuelswitching (e.g. increased use of biofuels and compressed natural gas), improved fuel standards, advanced internal combustion (IC) engine technology; and demand-side measures such as modal shifts (e.g. the extension of rail and urban transport networks). One of the key ways in which future emissions can be avoided is through the development and use of low-carbon technologies (IPCC 2007). In the context of decarbonising transport, electric vehicles (EVs) are one such option. EVs include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel-cell vehicles (FCVs). EVs are important to decarbonise transport sector in the long-run (IEA 2013; Offer *et al.* 2010: 24). According to IEA projections, in order to meet the global 2°C stabilisation target by 2050, three-fourths of all vehicles sold in 2050 would need to be EVs of some type (IEA 2013). EVs are touted as a way of bringing in more renewable energy within the electricity sector if the batteries can be used as storage and therefore help to reduce dependence on fossil fuels. There could also be other co-benefits of increase in share of renewable electricity and EVs, such as decarbonising of the electricity sector, $CO_2$ mitigation, and reduction in local air pollution.

### *1.1 Electric vehicles*

The history of EVs in transportation goes back to the late 1880s, when the first electric car was introduced in the German market. Such vehicles gained popularity, and more vehicles were introduced in other European and US markets. However, after the introduction of petrol-based vehicles in the early 20th century, interest in EVs started declining, and after the economic crash of 1929 many companies manufacturing EVs went bankrupt (Hoyer 2008: 65). EVs again came into prominence for a short period briefly after World War II, but it was in the early 1990s, when concerns around vehicular emissions and global climate change started growing, that EVs started getting attention from manufacturers and policy makers. This renewed interest in EVs has been referred to as 'third age' of EVs (IEA 2013). It has witnessed large improvements in battery capacity and technology, and a sharp decline in costs of EVs and related components. Improvements in technology have also opened up the possibility of deploying EVs as both a generation and storage device, thereby using it for bidirectional power transfer (Guille & Gross 2009: 4379).

Today the global EV stock has passed 180 000, representing 0.02% of total passenger cars (Guille & Gross 2009), with the USA and Japan the two biggest markets. Different countries have adopted different strategies and policies to promote EVs. While some, like the US, have focused on demand and supply side incentives, others, like Japan and Germany, have focused more on building the charging infrastructure for EVs (NEMMP 2012). India has also launched a national electricity mobility mission plan (NEMMP) to incentivise production and use of EVs, including exploring their role in public transportation. While other countries have focused more on electric four-wheelers (E4Ws), it is electric two-wheelers (E2Ws) which have witnessed rapid increase in sales in China. For example while the global cumulative sales of electric and hybrids (including plug-in hybrids) were only 5.8 million by end of 2012, E2Ws have achieved a near-commercial status in China with nearly 120 million such vehicles being sold by end of 2012. However, this success of E2Ws in China has not been replicated elsewhere.

While several policies are being used to promote EVs, little is known about the effectiveness of policies and the development trends of EVs (Choi & Oh 2010: 2263). There is also much uncertainty about the future role of EVs in the transportation sector, particularly matters related to infrastructure and policies. In this paper we look at the scenarios for EVs in India and attempt to resolve some of these issues. We first offer a literature review of different modelling exercises and policy documents within India, and on the basis of it create alterative storylines for electric vehicles. These alternative storylines are then used to analyse a business-as-usual (BAU) scenario, an electric vehicle (EV) scenario, and and electric vehicle scenario in a low-carbon society (EV_LCS). The LCS is pegged to a global stabilisation target of 2°C. Using the scenario analysis, the three alternative storylines for EV in the case of India are explored. The scenarios span from 2010 to 2050 and are analysed using the bottom-up energy system ANSWER MARKAL model.

### *1.2 the Indian transport sector*

The Indian transport sector is dominated by two-wheelers, which account for 75% of total vehicles sold in the country (NEMMP 2012). Production of vehicles has increased by more than 80% in the last five years (2007-12) (see Figure 1). Despite this rise in production, the current level of vehicle penetration in India is amongst the lowest in the world at 11 cars and 32 two-wheelers per thousand persons. This leaves a large scope for upward movement, which is further evidenced by demand projections. For example, in the short term, India's demand for passenger vehicles is expected to go up from a little over two million units in 2010–11 to around ten million units by 2020. During this period the global demand is expected to rise from 73 million units to 108 million units (NEMMP 2012).

In terms of fuel, Indian transport is mostly dependent on liquid fossil fuels, most of which is imported. India today imports close to 80% of its crude oil demand (Figure 2). Transport accounts for about one-third of total crude oil consumption in the country, of which road transportation accounts for 80% (NEMMP

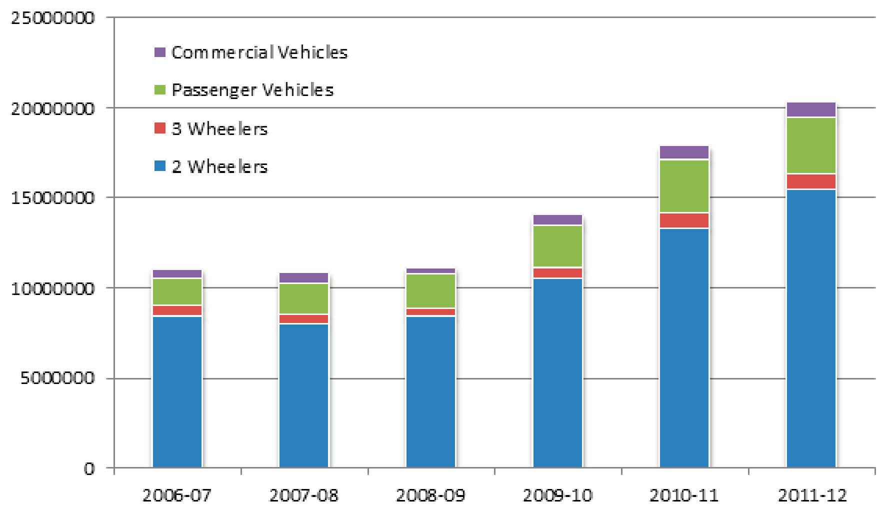


**Figure 1: Production of vehicles in India**
*Source: NEMMP (2010)*

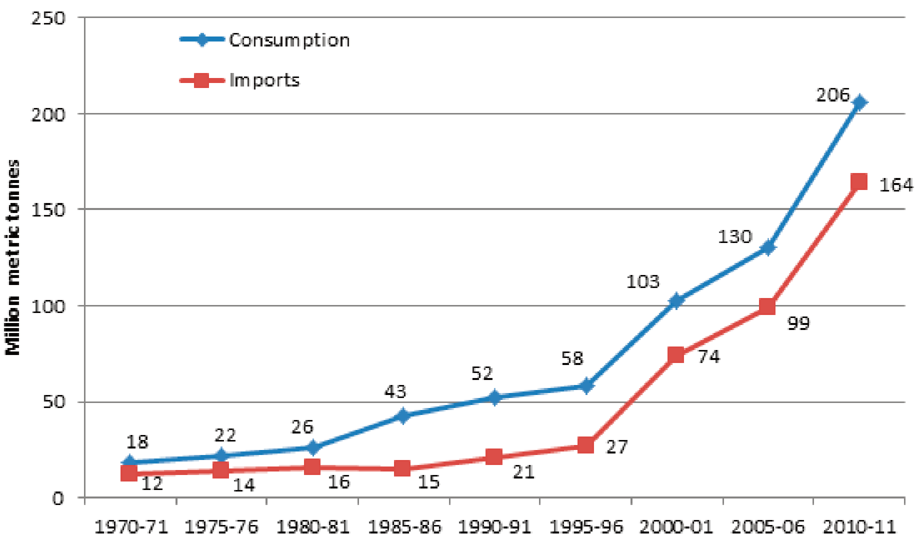


**Figure 2: Crude oil in India: Consumption and imports**
*Source: MoSPI (2012)*

2012). Consumption as well as imports of crude oil have increased exponentially in recent years. While consumption has increased fourfold during 1991-2011, imports have gone up by eight times in the same period.

This high share of imports has implications for the Indian economy and also for energy security. Overdependence on liquid fossil fuels also leads to increased emissions of GHG gases and other pollutants such as $SO_2$ and $NO_x$, which not only cause local air pollution but also contribute to global climate change. Rising energy consumption in the transport sector has also led to a rise in emissions. Between 1994 and 2007, total GHG emissions from India went up by more than 40%, while those from the transport sector increased by more than 77% (MoF 2012a).

In the case of alternative fuels, India currently has a national policy for biofuels which runs up to 2017. The policy mandates blending biofuels, currently 10% by 2017 and 20% in the longer term. India has also recently launched a national electric mobility mission plan (NEMMP) with a total proposed investment of INR 224 billion (equivalent to USD 3.6 billion) till 2020. The current market for EVs is very small in India. Though there are different types of E2Ws (scooters and motorcycles), E4Ws (electric cars), and electric buses, the overall share of EVs is negligible. In the 1990s, some Indian firms (Vikram, Mahindra & Mahindra, Bajaj Auto) had introduced electric two- and three-wheelers in the market, but they had to discontinue them few years later for various reasons. Another Indian firm, Reva (now acquired by Mahindra & Mahindra), launched an electric car in the early 2000s which continues to sell few units even today. Mahindra & Mahindra launched another electric car, Mahindra e2O, in India in 2013. In 2010, Toyota introduced the Prius Hybrid model and has followed it up by introducing the Camry Hybrid in 2013. In the same year, Tata Motors introduced a CNG-electric hybrid bus, the first such bus in India (Tata Motors 2010). Recently a few other Indian firms, such as Maruti Suzuki and Tata Motors, have announced plans to introduce electric cars in the short-to-medium term (Banerjee 2013; Tata Motors 2012).

## 2. Literature review

Studies examining various aspects of EVs have grown in recent years. EVs have been studied in a global context (IEA 2013; IEA 2010; UNEP 2009), a regional context (Pasaoglu at al. 2012), a national one (Choi & Oh 2010; Diamond 2009; Guille & Gross 2009; Huo *et al.* 2011; Offer *et al.* 2010; Ou *et al.* 2010; Skerlos & Winebrake 2010; Weinert *et al.* 2008), and a sub-national one (Perujo & Ciuoffo 2010; Wu *et al.* 2012). Some studies have looked at separate aspects of EVs (e.g. technical, economic, and energy and environmental) (He *et al.* 2012; Huo *et al.* 2012; Pasaoglu *et al.* 2012); while a few others have tried to study multiple aspects of EVs (Choi & Oh 2010; He 2012; Offer *et al.* 2010). Studies which model EVs in the short-to-medium term are limited but growing (Offer *et al.* 2010; Ou *et al.* 2010).

Within EVs, electric 4Ws have generally drawn more attention; though there have been recent studies which have specifically looked at electric 2Ws (Weinert *et al.* 2008). There have also been studies which have tried to analyse growth drivers and barriers to EVs (Ou *et al.* 2010; Weinert *et al.* 2008). While a majority of such studies have considered barriers from a macro-economic perspective, there have been few which have specifically considered the behavioural aspects, giving insights into barriers to large-scale adoption of EVs and other alternative fuel vehicles (Eppstein *et al.* 2011; Offer *et al.* 2011).

The literature has enumerated several co-benefits of EVs, such as greater energy security (Offer *et al.* 2010: 24; Skerlos & Winebrake 2010: 706), reduced GHG emissions (Skerlos & Winebrake 2010: 706), and improved urban air quality (Fontaine 2008: 23; Offer *et al.* 2010: 25). However, quite a few studies have also pointed out that the ability of EVs to reduce GHG emissions could be limited when electricity is derived from coal (Huo *et al.* 2011: 37; Weinert *et al.* 2008: 2544). This suggests that the source of electricity becomes important when one considers the GHG mitigating potential of EVs. Achieving the full GHG reduction potential of EVs would then demand decarbonising the electricity sector, which could give a push to renewable energy in the electricity sector. Common barriers to EVs include the relatively high purchase cost compared to conventional vehicles, lack of charging infrastructure, the high cost of batteries, slow charging of batteries, and the limited range of EVs (Densing *et al.* 2012: 137; Fontaine 2008: 23; Iyer & Badami 2007: 4326; Offer *et al.* 2010: 25; NEMMP 2012; Weinert *et al.* 2008: 2553)

There are few India-centric studies on EVs. EVs in India have been mostly studied within the global context (IEA 2013; IEA 2010; Kyle & Kim 2011; Magne *et al.* 2010) and therefore have limited coverage in terms of parameters such as electricity prices and additional investments in electricity production. The document released along with NEMMP contains a detailed description of the current status of EVs in the country and the planned scenario for EVs, but only up to 2020. While the existing literature on the Indian scenario offers several important insights, these suffer a few limitations. Most of the studies have a short-term horizon. A few global studies have considered the long-term horizon but they lack details of developments in the domestic electricity sector which could impact on EVs and their co-benefits. As has been pointed out in some literature, there are linkages between the transport and electricity sectors. Many changes are proposed in the Indian electricity sector which could have far-reaching implications. For example, several initiatives such as the Jawaharlal Nehru National Solar Mission (JNNSM) have been launched to promote the share of renewables in the generation mix. Similarly, carbon capture and storage technologies have been proposed for coal power plants to sequester carbon. A roadmap for transition to smart grids has also been drawn. These changes, as and when they occur, hold the potential to both decarbonise the electricity sector and make load management in the Indian electricity system more efficient. There is a need to consider the implications of these changes in the Indian electricity sector on EVs in the long term. EVs could in turn have vital implications for energy security, local air quality, GHG mitigation, and increasing renewables share in the electricity sector. India is still at a relatively early stage of development and, as mentioned, the per capita penetration of vehicles is still low. There is thus a need to consider these development and mitigation aspects of EVs in the long term. The next section describes the methodology used to model future role of EVs in India.

## 3. Methodology

### *3.1 Modelling framework*

The assessment of future paths for analysing the role of electric vehicles in India is carried out using an energy system model, ANSWER MARKAL. The assessment includes transport as well as the power sector, embedded within the model to study long-term transitions up to 2050. An integrated bottom-up modelling framework is used, with an energy system model and end-use sector models. The ANSWER MARKAL model framework has a detailed representation of transport as well as power sector technologies. It is supported by an end-use demand model, which provides demand projections for alternative scenarios. Technology choices within the transport sector depend a lot on the investments into infrastructures (rail, road, metros, etc) and therefore the model transitions within the transport sector are handled separately in the transport model. In the ANSWER MARKAL model, only the competition between alternative technologies for a given mode is handled (e.g. between electric and petrol cars).

The modelling framework uses the strength of bottom-up models which have a highly disaggregated representation of the economy with a very detailed characterisation of technologies and reflecting the optimistic engineering paradigm (Grubb *et al.* 1993). Bottom-up models primarily focus on the energy sector of economy and have been extensively used for analysis at national and regional level (Chiodi *et al.* 2013; Hainoun 2010; Kesicki 2012; McDowall *et al.* 2012; Winkler *et al.* 2009). Bottom-up models are used to assess the energy supply and demand-side technology-based policies that are not driven by price (Sarica & Tyner, 2013; Börjesson & Ahlgren, 2012). They have detailed representation of technological options in energy supply and the end-use sector in terms of costs, fuel inputs, and emission characteristics.

Assessing the role of EVs in the long term involves analysing different energy markets and the interaction between them (such as the electricity, oil and gas markets). It also requires a detailed representation of the technologies involved. A bottom-up modelling framework like MARKAL is well suited to this and has been used previously to study long-term transitions in India (Shukla & Dhar 2011; Shukla *et al.* 2008).

### *3.2 Scenarios*

Three scenarios are considered for the study and are described below

#### *3.2.1 Business as Usual scenario (BAU)*

This scenario assumes future economic development along the conventional path and therefore the future socio-economic development mirrors the resource intensive development path which has been followed by the current developed countries. The annual GDP growth rate of 8% for the time period 2011–2032 is consistent with economic growth projections for India (Government of India [GoI] 2006) from 2007–2032 period. Population growth and urbanization are assumed to follow the UN median demographic forecast (UNPD, 2013). The demand for road transportation has been forecasted using a logistic regression function to project the growth of transport sector passenger and freight demand. The modewise break-up for the BAU and EV scenarios are given in Table 1.

The penetration of EVs for intercity road transportation is challenging on account of the limited distance they can travel on a single charge, and therefore constraints were introduced to limit the EV at the maximum to urban transportation. The demand for urban transportation was taken from Dhar *et al.* 2013.

This BAU scenario assumes a mild mitigation action and therefore a stabilisation target of 650 parts per million by volume $CO_2$ equivalent is considered. The carbon price is assumed to rise from USD3/t $CO_2$ in 2010 to USD 20/t $CO_2$ in 2050 (Clarke *et al.* 2007).

The BAU scenario considers that cities will develop better infrastructures for public transport as an integral

**Table 1: Transport demand from road transport (in BPKms*)**

| Mode | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| 2-wheeler | 260 | 353 | 479 | 545 | 521 |
| 3-wheeler | 114 | 146 | 185 | 197 | 174 |
| 4-wheeler† | 544 (28.0%) | 1230 (40.0%) | 2782 (40.0%) | 5154 (45.0%) | 7817 53.0%) |
| Bus† | 5596 (4.2%) | 8796 (5.5%) | 9334 (7.1%) | 9149 (9.7%) | 8859 (11.6%) |
| Goods LCV | 92 | 169 | 230 | 298 | 375 |

* Btkms for goods transport.
† Figure in brackets show the share of urban transport.

part of urban planning. In line with government intent (MoUD 2006) all Indian cities of two million people or more are assumed to have metros or bus rapid transit systems in the future. This is the reason for the rising share of buses in urban transport.

Electric and hybrid vehicles currently face low taxes and excise duty, but receive support in terms of other enabling conditions (Table 2). The BAU scenario assumes future policies will follow the current trends.

**Table 2: Enabling environment for EVs in BAU and EV scenarios**
*Source: Facilitations for propagating electric vehicles (n.d.); MoF (2012b); MoF (2012c); State government taxes in India (n.d.); Tiwari & Jain (2013)*

| *BAU scenario* | *EV scenario* |
|---|---|
| *Excise duty / import duty* | |
| Currently EV and hybrid cars carry 12% duty, the same as petrol or diesel cars with engine capacities under 1500 cc and shorter than 4m. Bigger and longer cars have 24-27% duty. Batteries and other parts for EV have no preferential treatment in imports. | Considers full duty exemption till 2025 on cars and batteries, which can help lower capital costs by around 30% from BAU. The post-2025 tax rate increases and tax parity is achieved by 2040. |
| *Sales tax (VAT)* | |
| Varies across states, resulting in different prices for cars, but incentives are provided in a few states. No concessionsfor VAT considered. | Considers half the VAT as in BAU to factor for positive local environmental benefits till 2025; thereafter an increasing tax rate with tax parity by 2040. |
| *Charging infrastructures* | |
| No specific investment in charging infrastructures, so EVs make use of spare grid capacity. Therefore a maximum share constraint put on two-wheelers: 10% by 2050; 7% by 2050 for cars. | An intelligent electric grid which can allow usage of EVs both as storage and source of electricity. This would also entail strengthening the primary transmission (132/220/400/765 KV) and secondary transmission (66/132 KV) and distribution networks. As a result, 10% increased investment on transmission and distribution is considered but constraints on EVs are removed. |
| *Dedicated lanes for cycles* | |
| A few cities have dedicated cycle lanes or good infrastructures for cycles. Funding from the centre under the Jawaharlal Nehru National Urban Renewal Mission should create cycle lanes and a better infrastructure for cycles in the cities, but these limited to non-motorised cycles. Motorised two-wheelers, unlike cyclists, will receive no priority. | Dedicated cycle lanes created in million-plus cities and E2Ws with a maximum speed of 25 km/hour allowed on them. Two-wheelers could move faster than average traffic, increasing the appeal of E2Ws. A minimum share of 40% of motorised two-wheelers are considered electric by 2050. A shift of at least 25% of non-EV bicycles to EV also considered. |
| *Public transport* | |
| BRT systems expected in all million-plus cities. | With improvement in infrastructure for electricity charging, city bus companies should use it; so a minimum 10% share for buses for intra-city is considered. |
| *Goods transport* | |
| Goods transport within cities mainly done by LCVs, tempos, etc, mainly running on diesel. In future, LCVs are expected to diversify into CNG as fuel. | Improvement in infrastructure for electricity charging and tax incentives mean that transport companies are expected to move to Evs, so a minimum 10% share for EV LCVs for intra-city is considered. |

*Electric Vehicle scenario*

Electric vehicles can deliver multiple co-benefits (improved environment, energy security, renewable integration, etc), and the scenario assumes that governments recognise these aspects of EVs and push their penetration. Therefore the scenario considers that there will be domestic policy support (see Table 2) for EVs which improve their competitiveness. Governments also provide greater incentives for research and development in battery technologies, EV drive trains and smart grid technologies to enable usage of EVs as a storage for renewable technologies. The EV scenario also considers that battery costs, which account for close to half of EV cars' costs, come down to less than half of today's levels in the next 10-15 years (Bloomberg New Energy Finance 2012). Advancements in battery technologies, improvements in battery capacities, declining component costs, and economies of scale in production will drive the price reduction of batteries. Improved batteries with higher energy density will also help reduce the weight of batteries which will further lead to reduction in the cost of EVs.

*Electric Vehicles Plus 2°C (EV_LCS) scenario*

EVs can increase or decrease the emissions from transport, depending on the $CO_2$ content of electricity – which can get sufficiently altered if there are stringent climate regimes (Shukla & Dhar 2011). This scenario combines the policy support together with a high carbon tax corresponding to the globally agreed vision of a 2°C temperature rise, which in turn corresponds to a stabilisation target of 450 ppmv $CO_2$-eq. The carbon price trajectory corresponding to stabilisation at 450 ppmv $CO_2$-eq concentration target, is USD 46 per ton of $CO_2$ in 2020 and rises to USD 200 per ton of $CO_2$ in 2050 and based on outputs from IMAGE and MESSAGE models (Rao *et al.* 2008).

## 4.0 Results

### *4.1 Energy demand*

*BAU scenario*

In the BAU scenario the overall demand for energy increases nearly sixfold between 2010 and 2050. The overall dependence on fossil fuels continues, though there is diversification towards natural gas. Electricity starts emerging as a significant option after 2020. This is driven by three trends: investments in rail-based transportation for inter-city passenger and freight movements, implementation of metro projects in all major cities, and diffusion of EVs (buses, cars, three- and two-wheelers). The share of EVs in overall electricity demand is 53.8% in 2020 and this increases to 67.3% in 2050. See Figure 3.

*EV and EV_LCS scenarios*

The overall demand for energy in the EV scenario is lower due to the greater role of EVs which are typically more energy-efficient at the end-use level. In the EV_LCS scenario, the high carbon price means the hybrids and more efficient vehicles become cost-competitive, which further reduces demand for energy. The fuel mix in the EV_LCS scenario also gets further diversified with a greater penetration of biofuels. See Figure 4.

### *4.2 Technology choices*

*BAU scenario*

Electric two-wheelers using lead acid batteries at the current cost structures achieve cost competitiveness with conventional two-wheelers by around 2035. Small two-wheelers and electric bicycles are cost-competitive as early as 2020, but their limited carrying

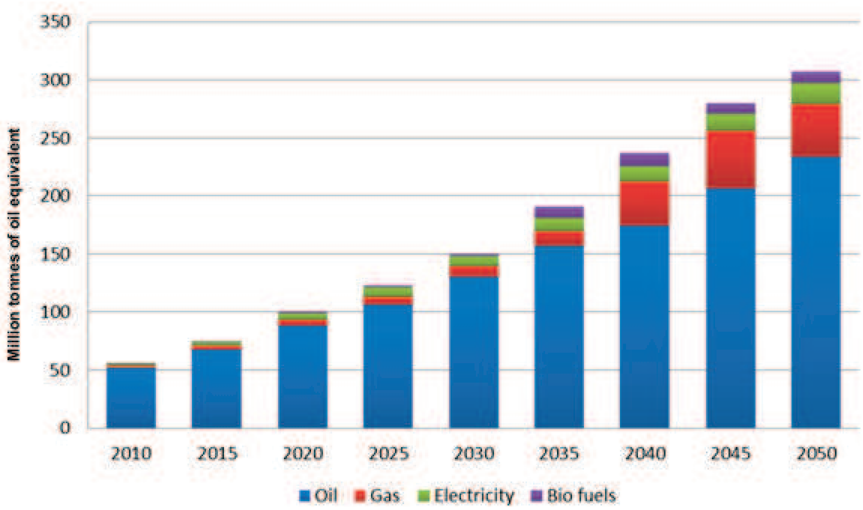


**Figure 3: Fuel mix for transport in BAU scenario**

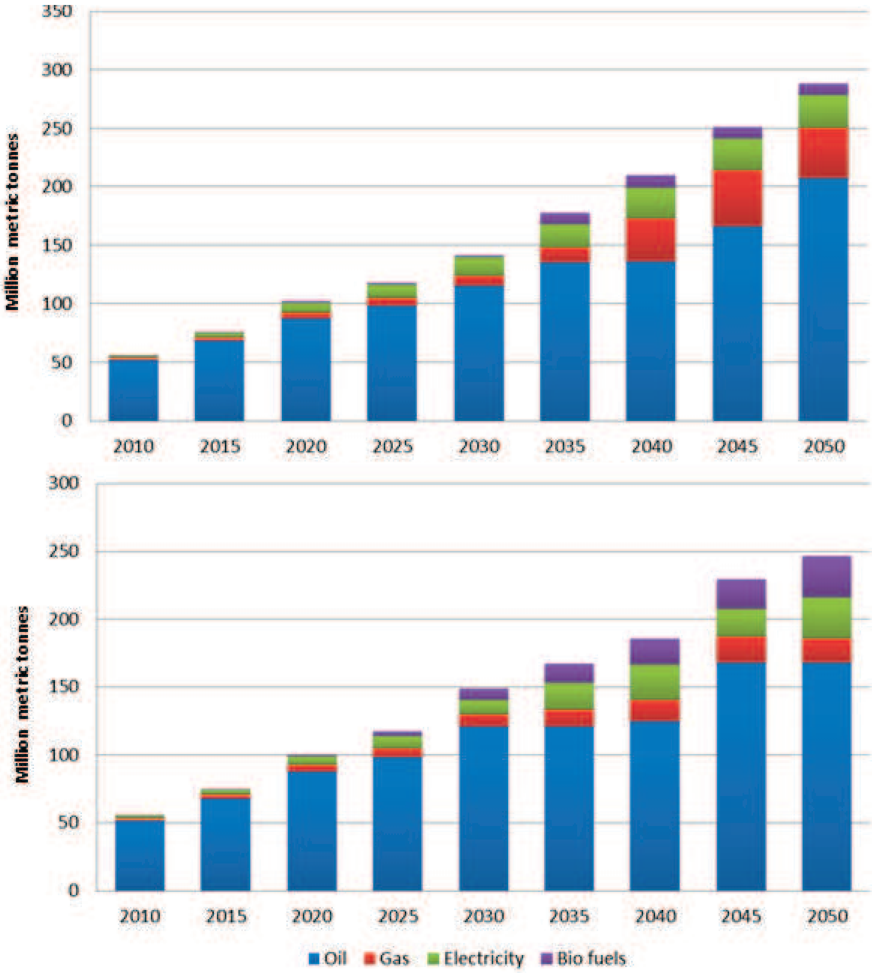


**Figure 4: Fuel mix for transport in (top graph) EV and (bottom graph) EV_LCS scenarios**

capacity, speed limits and issues with regard to reliability restrict their wider diffusion.

Electric cars using lithium ion batteries but with a limited driving range (below 100 km) achieve cost competitiveness with conventional gasoline- and diesel-based vehicles by 2035. However, this technology may not be easily scalable for a wider set of users who require a longer driving range and features comparable to conventional cars.

*EV and EV_LCS scenarios*

The policy actions (see Table 2) for EV help in advancing the EV story, and by 2020 a substantial share of electricity is seen in the fuel mix (Figure 4a). Due to the policy incentives, EV two-wheelers become competitive by 2020. The policy of allowing them on cycle tracks gives a further fillip, but there is also a shift from non-motorised to motorised bicycles and smaller EV two-wheelers. Electric cars also become competitive due to tax incentives by 2025 (10 years earlier than BAU), but the more expensive electric cars with a driving range beyond 300 km do not become competitive even with the proposed policy incentives.

### *4.2 $CO_2$ emissions*

*BAU scenario*

The overall $CO_2$ emissions from transport increase nearly five times between 2010 and 2050 and electricity is also a major contributor towards these and therefore greater diffusion of EVs does not deliver any significant benefits for mitigation. See Figure 5.

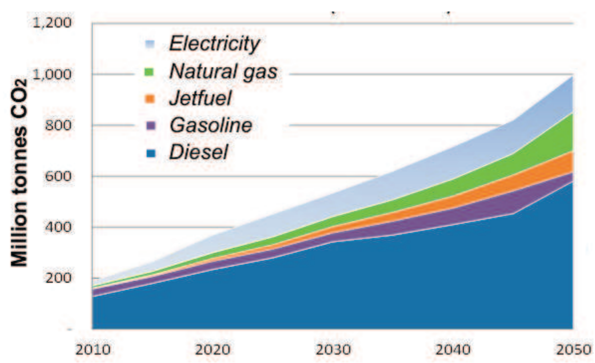


**Figure 5: $CO_2$ emissions in the BAU scenario**

*EV and EV_LCS scenarios*

The EVs help to lower energy demand (Figure 4a), but the $CO_2$ emissions in most cases remain either equal or slightly higher than in BAU. This is on account of the high $CO_2$-intensity of electricity (Table 3). However, when the policy actions for EV are combined with a high carbon tax, as happens in EV_LCS scenario, a major overall reduction in $CO_2$ emissions happens. See Figure 6.

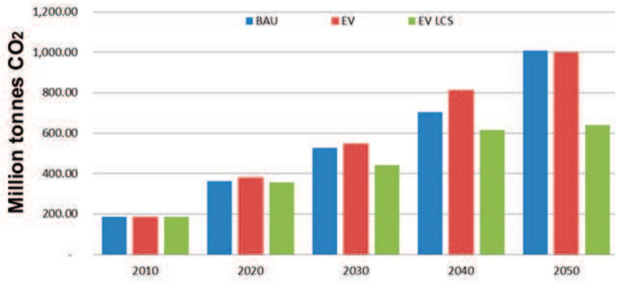


**Figure 6: $CO_2$ emissions: BAU, EV & EV_LCS scenarios**

The role of electric vehicles in mitigating $CO_2$ emissions is closely related to the $CO_2$ content of electricity. In the low-carbon scenario, due to increased share of renewable, nuclear, and carbon capture and storage, the emission intensity of grid electricity becomes nearly one eighth of the corresponding BAU figure in 2050 (see Table 3).

**Table 3: Emissions intensity of the grid (t $CO_2$ /MWh)**

| *Scenario* | *2010* | *2020* | *2030* | *2040* | *2050* |
|---|---|---|---|---|---|
| EV LCS | 0.99 | 0.73 | 0.34 | 0.19 | 0.08 |
| BAU | 0.99 | 0.94 | 0.86 | 0.74 | 0.69 |

## 5. Discussions and conclusions

There is already some production experience of EVs in India. These include E2Ws (scooters and motorbikes), E4Ws (cars), and electric heavy vehicles (buses). However, the penetration of these vehicles is still limited. There are limited incentives for EVs, but they require all the elements of the enabling framework, including infrastructures for charging and smart grids to leverage renewables. The EVs currently available have attractive costs but limited driving range, lower carrying capacity and very low volumes, which are not helpful in building customer confidence.

India exhibits a pattern of EV sales more similar to China's than to other markets (like Japan and the USA), where E2Ws have had a larger market penetration than E4Ws. This, then, indicates a possibility that the same growth pattern of EVs could continue in the short-to-medium term. However, significant penetration of E2Ws may not be realised till cities develop the necessary infrastructure.

In the BAU scenario, current policy trends were followed and both E2Ws and E4Ws achieve cost competiveness by 2035. Inadequate investments into grids and charging for EVs would act as a barrier, however. Battery costs emerged as a significant barrier as more than 30% of the cost of the vehicle is the cost of the battery. In the analysis we considered a battery life of three years, but if manufacturers are able to provide a longer warranty for battery the competitiveness of EVs would improve. Policy support in the form of excise and sales tax waivers for two-wheelers helps in making them cost-competitive by 2020, whereas EV cars achieve cost competiveness by 2025. A wider diffusion for these would require the strengthening of transmission networks and the creation of smart grids to make use of EVs as a storage for electricity.

The role of EVs in mitigation of $CO_2$ emissions is closely related to the $CO_2$ content of the electricity. In the BAU scenario, EVs can even lead to higher $CO_2$ emissions – though if climate constraints exist, a cleaner electricity can convert EVs into a mitigation option. EVs can, however, deliver other co-benefits such as improved urban air quality, reduced local pollution and direct health impacts, and could therefore offer win-win solutions in a carbon-constrained world. Indian cities have a high use of bicycles and many cities are creating bicycle lanes under the Jawaharlal Nehru National Urban Renewal Mission. Most E2Ws have speeds below 25 km per hour, and if they were allowed on bicycle lanes it could provide an additional incentive to switch from gasoline-powered to electricity-powered two-wheelers.

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HOW COMPATIBLE ARE DEVELOPMENT AND MITIGATION NOW AND INTO THE FUTURE?

# Visionary development of India by 2050 – what will be the implications for carbon emissions?

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***Abstract***
Studying development in a climate change context, it is important to analyse the implications of development on GDP growth, expenditure and resulting emissions. We use the IRADe LCSD (low-carbon strategy for development activity) analysis model to analyse this issue. Results show that our Visionary Development scenario, including poverty alleviation and reaching the level of 'high human development' countries by 2050 for indicators like life expectancy at birth, infant mortality rate, mean years of schooling, universal access to water and sanitation, durable housing and clean cooking fuel, are possible with a step up in government expenditure, proper reallocation of resources, and good governance. It can be done with the similar high GDP growth rate achieved in the Dynamics as Usual scenario, and with an increase in $CO_2$ emissions similar to the level of $CO_2$ emissions in that scenario.

*Keywords:* development, carbon emissions, India, climate modeling

## 1. Introduction

India has many development priorities. It has to lift 354 million people out of poverty (Planning Commission, 2010). A large part of the population is denied the basic necessities of life such as food and nutrition, potable drinking water, access to sanitation, health and education facilities, good housing and so on. The Indian government is already taking steps to improve the conditions through its inclusive development strategy. However, there is a lack of clear vision of the present status of India on well-being indicators and where India should be in the next 35 years (by 2050), what should be long-term targets for well-being indicators and what kind of interventions are needed to reach those targets. Most of the official documents (five year plans, Millennium Development Goals' report, economic surveys) do not go beyond the framework of next five to seven years.

Since the climate negotiations are centered around medium-term (2030) and long-term (2050) effects, it is important for India to assess the required GDP growth, development expenditure and resulting emissions from development over this time-frame before making commitments.

We have built a scenario, Dynamics as Usual (DAU), which is a business as usual scenario, including the impacts of government policies. It was found that DAU will have a high GDP growth rate, private consumption expenditure will increase by 2050 and will achieve a substantial improvement in poverty alleviation and many well-being indicators. However, DAU itself will not be sufficient to achieve targets in all well-being indicators in a reasonable time. Hence, we suggest a Visionary Development scenario (VD) which identifies important well-being indicators for India, sets targets for various indicators and lays out a pathway to achieve each target by 2050 at the latest. The two scenarios are then compared for GDP, private consumption, $CO_2$ emissions and energy intensity, $CO_2$ intensity etc.

It should be noted here that DAU itself will see many technological improvements, increased renewable and so on. The same assumptions are kept constant for VD, to make the comparison possible and to analyse the impacts of development.

We use the Integrated Research and Action for Development (IRADe) LCSD (low-carbon strategy for development) model which is a dynamic activity analysis model.

## 2. Literature survey

Models that assess the economic impact of climate change in the literature can be classified as bottom-up, top-down, or integrated. A few modeling studies have explored India's options in low-carbon development. Weyant and Parikh (2004) analysed how various global models have projected India's emissions. In recent years, Shukla et al (2009) have studied a low-carbon pathway for India. It uses a combination of the ANSWER-MARKAL model and the AIM End use model to obtain the low-carbon pathway for India. The model uses a soft linkage between top-down and bottom-up approaches and demand projections are done outside the model.

IRADe, the Energy and Resource Institute (TERI), and the National Council of Applied Economic Research (NCAER) created models for the Ministry of Environment and Forests in 2009 to study the $CO_2$ emissions profile of India (MoEF, 2009). The IRADe model optimises consumer welfare, states explicit technological choices, provides energy-economy-investment-consumption feedback, dynamically optimal investment, resource constraints, endogenous income distribution and separate consumer demand systems for each consumer class. The TERI model is a MARKAL model with pre-determined energy demand, explicit technological choices and a least-cost energy solution. The model from NCAER is a year-by-year simulation model with endogenously determined prices, energy-economy-investment-consumption feed- back, demand determined by demand system, myopic market economy, no resource constraints and non explicit technological choices.

The McKinsey report (2009) provides a global greenhouse gas abatement cost curve for 21 world regions up to 2030. It assumes GDP and population growth rates are set exogenously. The report finds that the GHG emissions can be reduced by 70% by 2030 compared to 1990 levels.

There are few studies which consider development goals in climate change framework. Vuuren & Kriegler (2011) have built global socio-economic scenarios which consider many possibilities of development levels in the world by 2050 andthe resulting impact of emissions as well as the necessity of mitigation and adaptation efforts.

IIASA (Austria) has made a global energy assessment (GEA, 2011) and provides low-carbon pathways for different regions of the world, including South Asia, which can be applied to India. These scenarios ensure energy security, electricity access and clean cooking fuel to all and make an assessment of costs.

Parikh et al (2013) assess the impacts of development initiatives like poverty alleviation, inequality and rural urban disparity reduction on $CO_2$ emissions in India in a macroeconomic framework using the IRADe activity analysis model.

## 3. Methodology

*3.1 IRADe activity analysis model*

Among energy models, the bottom-up models bring technological knowledge and specificity, but often techno-economic evaluations are incomplete and overly optimistic, in that policy and institutional obstacles are not fully accounted for. Top-down models bring macro-consistency but simplify the sectoral details by judgments and assumptions. Among them are econometric models which use reduced form equations, but the structural relationships behind these remain unclear and implicitly constant. Another approach of top-down modelling is the computable general equilibrium (CGE) approach where a sequence of single period equilibria is worked out. In econometric and CGE models, often a high elasticity of substitution is assumed which makes it easy and relatively costless to adjust to $CO_2$ constraints. The problem is thus assumed away. An activity analysis approach permits macro-consistency, dynamic behaviour, new and specific technological options and thus limited substitution. It can constitute a truly integrated top-down-bottom-up approach.

The IRADe LCSD model is a dynamic multi-sectoral inter-temporal linear programming activity analysis model based on an input-output framework. The input-output matrix used in the model is based on the Social Accounting Matrix for India 2003–04. (Saluja, Yadav, 2006). The model runs at constant prices of 2003–04.

The model maximises the present discounted value of private consumption over the planning period (45 years (2005-50).

Objective function:

$$MaxU = \sum_{t=0}^{T} \frac{POP_t * PC_t}{(1+r)^t} + \overline{PC} \quad (1)$$

Where $POP_t$ and $PC_t$ are the total population and total per capita consumption at time t. T is the planning horizon (2005 to 2050). The discount rate is denoted by r. The term PC bar is the discounted sum of per capita consumption beyond the period of optimisation after which the consumption is assumed to grow at a fixed rate called the post-terminal growth rate.

The model scenarios cover the period from 2005 to 2050 and have nine time periods, five years apart. Thus, it is solved simultaneously for 2005, 2010, and 2015 up to 2050. Scenario results are reported for 2050 as well as decadal values of 2020, 2030 and 2040. Investments to different sectors of the economy are determined endogenously in the model, which eliminates the need for arbitrary determination of allocation that is required in a sequential model solved period by period. To smoothe the growth path of the model, monotonicity constraints are added for per capita total consumption, sectoral output and sectoral investments. (Constraint equations used in the model are given in Annexure 1.)

The various consistencies in the model ensure that all the feedback is taken into account and that there are no supply sources or demand sinks in the system unaccounted for. Thus, the model is suited for multi-sectoral, inter-temporal dynamic optimisation. This permits exploration of alternative technologies and $CO_2$ reduction strategies from a long-term dynamic perspective and permits substitution of various kinds.

The model is solved using the general algebraic modelling system (GAMS) programming tool developed by Brooke et al (1988). For consistency in endogenous income distribution, optimal solutions are iterated, changing distribution parameters among iterations until they converge.

The major instruments of control in the model are: the upper bound on the marginal savings rate, the exogenous government consumption growth rate, the exogenous discount rate and the upper bound on the consumption growth rate. The assumptions about these parameters are given below. The assumptions noted below remain the same across all scenarios.

**Table 1: Assumptions about important control parameters in the IRADe–LCDS model**

| *Assumptions* | *Rate (%per annum)* |
|---|---|
| Upper bound on savings rate | 35(of GDP) |
| Upper bound on growth rate of household consumption | 9 |
| Discount rate | 4 |
| Post terminal growth rate | 2 |
| Growth rate of government consumption | 7 |
| Total factor productivity growth rate for agriculture | 1 |
| Total factor productivity growth rate for industry and services | 1.5 |

Total factor productivity growth (TFPG) represents the percentage increase in output that can be produced for the same amount of capital stock and labour force. Various studies have estimated India's TFPG as ranging from 1.4% per year to 2.5% per year (Fuglie 2010; Das et al 2010; Goldar & Mitra 2008; Bosworth et al 2006; Rodrik & Subramanian 2005; Jorgenson 2005). This study assumes a TFPG rate of 1.5% per year in DAU.

## 4. Assumptions behind DAU

Some assumptions behind the DAU scenario regarding the role of government and technology options in the power sector are specified in detail below.

### *4.1. Role of government*

The government consumption growth rate is prescribed exogenously and is assumed to be a uniform 7% per annum for all commodities over time. This will keep roughly constant the share of government expenditure in GDP. All the government expenditure including that on welfare schemes incurred on and before 2003–04 is accounted for in DAU. Similarly, government initiatives on the climate change front taken on or before 2003–04 are accounted for, and the trend is assumed to continue until 2050 in DAU.

However, the government has started many welfare schemes like the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), and the right to education, etc since 2005. For action on climate change, the National Action Plan on Climate Change (NAPCC) has been developed. The policies and schemes started after 2005 are not accounted for in the DAU scenario. If these measures were accounted for, the DAU scenario would show a lower growth rate and lower emissions, as NAPCC measures involve additional costs, such as the subsidy provided to solar power through a higher feed-in tariff compared to the cost of power from conventional sources.

### *4.2 Electricity generation options*

The DAU scenario considers various options in electricity generation.

*Coal*

Coal is the main fuel for power plants in India. Two types of plants are considered, sub-critical and supercritical. The latter is more expensive but uses less coal. The government has already taken steps to replace sub-critical coal with super-critical coal technology. The target is to replace 70% of coal-based electricity generation plants with supercritical coal-based technology power plants by 2050 (Planning Commission 2011), hence DAU incorporates this target. An increased cost of coal has already been taken into account by imposing a constraint on total coal availability and through higher price of imported coal.

*Nuclear energy*

India's installed nuclear capacity as on March 31, 2013 was 4 780 MW, consisting mainly of domestic pressurised heavy water reactors, which require natural uranium as the fuel. By the end of the twelfth five-year plan (in 2017), a capacity of 5 300 MW will be added. Thus, existing plants plus plants under construction will give an installed capacity of 11 000 MW. DAU freezes the nuclear capacity at this level. The same upper bound is imposed on the other scenario. Nuclear power poses many issues of waste disposal, costs of decommissioning and the consequences of large accidents, even though the probability of such accidents may be very small.

*Hydropower*

The ultimate potential for generating power from hydro plants is 150 000 MW at 35% load factor (Planning Commission 2006). According to the expert group on low-carbon strategy, only when the costs of resettlement, deforestation and emissions from land clearing are accounted for should a hydro project be considered viable (Planning Commission 2011).

*Natural gas*

India's natural gas potential is limited and an import ceiling of 50% of total domestic requirement is imposed. The infrastructure to import and use gas is limited but dependence on external resources is a risk that must be kept in check.

*Renewables*

Renewable technologies like wind, solar thermal, and solar photovoltaic with and without storage are available as options. Investments are already being made in renewables and hydro; solar PV with and without storage and wind are expected to come up by 2050 in both DAU and VD scenarios. The costs of these technologies is assumed to fall over the years and targets of the NAPCC are incorporated in DAU and VD.

### *4.3 Autonomous energy efficiency improvement*

The change in the energy/GDP ratio that is not related to the change in the relative price of energy is called autonomous energy efficiency improvement (AEEI). It is an empirical representation of non-price-driven changes in technology that are increasingly energy-efficient. Table 2 shows the AEEI values used in the DAU scenario. However, the AEEI valuesfor coal use in electricity generation and gas input in gas]based power plants have been restricted to 1.0% per annum. Electricity used in electricity generation has an AEEI of 0.5%.

**Table 2: AEEI parameters in DAU (percentage per year)**

| | |
|---|---|
| Coal | 1.2% |
| Petroleum products | 1.2% |
| Natural gas | 1.2% |
| Electricity | 1.0% |

## 5. Visionary Development scenario

The construction of the VD scenario is detailed below. The analysis is done in three steps. In the first, well-being indicators for India are determined and development thresholds for 2050 fixed. Secondly, the causal factors behind the indicators are identified and statistically tested. Finally, the interventions necessary to achieve those development thresholds are prescribed and incorporated to form the scenario. The results are compared with the situation of development thresholds in the DAU scenariol, and implications for carbon emissions are noted.

### *5.1 Well-being indicators and development thresholds*

There are a number of indices and measures, which are currently being used to measure human development across countries. Most popular are the Human Development Index (HDI), multidimensional poverty index and Millennium Development Goals given by the UNDP. The World Bank provides a comprehensive time series of cross-country data on a number of indicators. The UN's department of social and economic affairs (population division) provides data on a number of health- and education-related indicators. In India, the Planning Commission, National Sample Survey and Economic Survey provide national as well as state level data on the progress of well-being indicators.

To realise the VD goals, well-being indicators need to be quantified and measurable targets should be set for each well-being indicator. Hence, a development threshold is defined for each well-being indicator to be achieved by 2050. The methodology adopted to define development thresholds is given below.

For a similar discussion on well-being indicators in a macroeconomic framework see MOSPI (2013a).

### *5.2 Methodology adopted to determine the development thresholds*

The UNDP classifies countries into four categories, as shown in Table 3.

**Table 3: Country classification on the basis of the Human Development Index**

*Source: UNDP (2013a)*

| *Level of human development* | *Range of HDI values (in 2012)* | *Average value of HDI (in 2012)* |
|---|---|---|
| Very high | 0.0805 to 0.955 | 0.905 |
| High | 0.712 to 0.796 | 0.758 |
| Medium | 0.536 to 0.710 | 0.640 |
| Low | 0.304 to 0.534 | 0.466 |

India has a HDI value of 0.554 in 2012 and ranks 136th among 186 countries. It lies in the lower range of medium human development countries. The VD scenario aims to raise India to the 'very high' category by 2050 and increase its HDI value to 0.905, which is the current average HDI of the very high human development countries as per the latest Human Development Report (UNDP, 2013a). The current value for India given in the Report is taken as the baseline for well-being indicators in health and education. The current average value of very high human development countries (including Germany, Sweden, United States, Japan, Israel and Australia in a total of 47 countries) for these categories is taken as the development threshold to be achieved by 2050.

In the case of basic services (water, sanitation) we have followed the definition of indicators given by the World Bank (2013). The data given by the Planning Commission (2010) is taken as the baseline. The target is to achieve 100% access to these basic services as early as possible (not to wait for 2050).For housing, we have used latest Census (2011) data as a baseline and the target is to convert all non-durable houses (kuchha) to durable houses and take care of the additional housing requirement. For clean cooking fuel and electricity, too, we have taken Census 2011 data as the baseline, and the target is to cover the population, which currently lacks access to these services. Halving the population living below the poverty line between 2000 and 2015 was a Millennium Development Goal. Extending this, the target is set to completely alleviate poverty before 2050. Table 4 provides a brief description of each well-being indicator, the present value of the indicator, the development thresholds selected, and the gap between the two.

### *5.3 Determining the factors governing well-being indicators*

To achieve the given development thresholds for various well-being indicators from now to 2050 requires mapping a pathway for each indicator. To understand the factors determining the level of well-being indicators a literature survey was carried out which was followed by extensive regression analysis using eVIEWS to determine the causal relationship between well-being indicators and income and non-income factors. For example, the infant mortality rate is affected by the level of public health expenditure in the country and improved water and sanitation facilities. For this exercise, the cross-country data for year 2011 of the World Bank was used (World Bank, 2013).

### *5.4 Development interventions and policy framework for the VD scenario*

*i) Access to improved water sources and sanitation*

Water and sanitation issues should be tackled togeth-

**Table 4: Selected well being indicators for India in the VD scenario**

| *Description of the indicator* | *Most recent available value of the indicator* | *Development threshold to be achieved by 2050 or before* | *Gap between present and threshold values* |
|---|---|---|---|
| Human development index (HDI)[a] | 0.554 | 0.905 | 0.351 |
| Life expectancy at birth [a] | 65.8 | 80.1 | 14.3 |
| Infant mortality rate [a] | 48 | 5 | -43 |
| Mean years of schooling [a] | 5.48 | 11.5 | 7.1 |
| Households with access to improved water source (%) [b] | 90.5 | 100 | 9.5 |
| Households with access to improved sanitation facilities (%) [b] | 47.2 | 100 | 52.8 |
| Rural households with access to clean coking fuels (%) [c] | 11.9 | 100 | 88.1 |
| Urban households with access to clean cooking fuels (%) [c] | 65.5 | 100 | 34.5 |
| Rural households living in durable houses (%) [c] | 46 | 100 | 54 |
| Urban households living in durable houses (%) [c] | 68 | 100 | 32 |
| Percentage of rural households with access to electricity (%) [c] | 55.3 | 100 | 44.7 |
| Percentage of urban households with access to electricity (%) [c] | 92.7 | 100 | 7.3 |
| Poverty headcount ratio [b] | 29.8 | 0 | -29.8 |

a. UNDP (2013a)
b. Planning Commission of India (2010)
c. Census of India (2011)

er. Water and sanitation facility provision comes mainly under public services and is primarily considered a government responsibility. But according to the twelfth five-year plan, the government of India has spent, during the eleventh plan, only 67% of the plan allocation on water and sanitation (Planning Commission 2012). In VD, government will spend all its allocation on water and sanitation. Rural drinking water and sanitation programmes are converged. Also in urban areas, every water supply project will also have a sewage treatment plant as per the twelfth five-year plan target (Planning Commission, 2012). The problem of drinking water is more acute in rural areas. The 'slipped back' habitations will be covered under the VD scenario. Rural drinking water schemes will be integrated into national aquifer management. Thus, we project that coverage of clean drinking water and sanitation will be 100% by 2015.

*ii) Increase in government expenditure on health and education*

The government spends only 1.3% of India's GDP on the health sector compared to the 8.2% of GDP by very high human development countries (UNDP 2013b). Currently the focus is on expanding public health care facilities as per the twelfth five-year plan (Planning Commission 2012). But VD envisages an equal focus on preventive health care.

Government expenditure on education has improved in recent years, increasing from 2.72% of GDP in 2006–07 to 3.11% of GDP in 2011–12 (Ministry of Finance 2012). But given the mean of only 5.48 years of schooling and a target of attaining 11.6 years of schooling, India needs to boost its efforts to increase the education level. Thus in the VD scenario we increase government expenditure on health and education as a proportion of GDP by 4 percentage points in 2015 to reach a level of 7% of GDP and thereafter the government expenditure on health and education grows at the same rate as government consumption. Many countries with a good record in health and education have public expenditure on health and education at around 7% of GDP. Also the government target is to raise it to 6% of GDP. We have taken a higher level for the VD scenario.

*iii) Housing, electricity and clean cooking fuels*

*Durable houses to all*

The Census of India distinguishes between houses as kuchha (non-durable), pucca (durable) and semi-pucca (semi-durable). According to the 2011 Census, there are 13 million non-durable houses in the country, which are owned by the very poor. Government has launched two schemes for helping the poor to build durable houses: Indira Awas Yojana (scheme for housing in rural areas) and Rajiv Awas Yojana (scheme for housing in urban areas) (MRD 2013; MHUPA 2013). The eleventh five year plan provided about 1.5 million houses under these schemes, implying a rate of 0.3 million housing units being built every year (Planning Commission 2011). VD aims to increase the pace of providing such houses, stepping up from 0.3 to 0.5 million units per year by 2015 and to one million units per year till 2025. So the scenario envisages that apart from the current rate of 0.3 million houses per year, an additional 0.2 million houses will be built each year till 2015 and an additional 0.7 million each year from 2015 to 2025.

Under Indira Awas Yojana, assistance of INR 45 000 is provided to the poor for building houses. At 2003–2004 prices (used in the model), the cost is INR 30 000. Taking into account houses to be built in addition to the government target and per house cost, total costs are calculated as shown in Table 5.

**Table 5: Total costs of building additional houses**

| | *2010* | *2015* | *2020* | *2025* |
|---|---|---|---|---|
| Additional houses (millions) | 0.2 | 0.7 | 0.7 | 0.7 |
| Total cost @ INR 45 000 (2010 price)/unit (INR billions) | 90 | 315 | 315 | 315 |
| Total cost @ INR 30 000 (2003–04 price)/unit (INR billions) | 60 | 210 | 210 | 210 |

The total costs from 2010 to 2015 are thus INR 60 billion each year of building additional houses apart from houses getting built under Indira Awas Yojana. From 2015 onwards, the total costs each year are INR 210 billion. This is what is modelled as the additional demand for construction by government, which they assured in houses for the poor. It is assumed that the income levels will go up with economic development by 2025 and there will be no need to provide government assistance to built durable houses beyond 2025.

*Access to electricity*

India has already made some progress in increasing access to electricity, especially in urban areas. The Rajiv Gandhi Grameen Vidyutikaran Yojana electrification programme had a target to connect all villages by electricity by 2012 and to provide free connection to all households below the poverty line. While there have been slippages, one expects that all but some 25 000 remote villages will be grid-connected soon. However, the power supply is erratic and electricity consumption is low. Access to electricity is a dynamic concept, whereby electricity consumption will go up with an increase in income level as well as lifestyle changes over a period of time. Taking into account these changes, VD aims to give an electricity access of a minimum of 1 kWh electricity per household per day which is adequate to use modern electric appliances like tube lights, fans, refrigerators, etc. In the VD scenario, households consuming less than 1 kWh per day are given the balance amount of electricity by the government which pays for it. The derivation of total value of per capita annual electricity consumption paid by government to poor households is shown in Table 6.

**Table 6: Derivation of subsidy for minimum electricity consumption**

| | |
|---|---|
| Price of electricity (INR/kWh) in 2003–04: | 2.13 |
| Minimum electricity access (kWH/household per day): | 1 |
| Minimum annual electricity consumption per person (kWH): | 73 |
| Total value of per capita annual electricity consumption (INR): | 155.49 |

*Access to clean cooking fuel*

The majority of rural households still depend heavily on firewood as cooking fuel. Thus VD aims to provide a LPG connection to all households in both rural and urban areas. A lump sum subsidy will be given to poor households who cannot afford to buy a LPG connection. A subsidy can be gradually removed when the total income of the poor increases and they can afford clean cooking fuel on their own. Simultaneous innovations in efficient cooking stoves, biogas plants to reduce indoor air pollution and pressure on forests are necessary. The Indian Network on Ethics and Climate Change has compiled eight case studies on such possible micro-interventions at community level (INECC 2011). In the VD scenario the poorer households' expenditure on cooking fuels is supplemented by government so that they have six cylinders of LPG per year.

*iv) Cash transfer to the poor*

In the VD scenario from 2015 onwards, each person in the poorest two household classes in rural and urban areas receives INR 3000(at 2003–04 prices) per person per annum. This cash transfer can be taken as the sum of all kinds of cash transfers received by the poor, for example in the form of cash transfer for food, guaranteed wages received for unskilled labour under an employment guarantee scheme (like MGNAREGA), or some subsidies. It is assumed that the government is able to levy additional tax on the richer classes and is able to target it effectively. Even though effectiveness of targeting is very questionable, a cash transfer instrument is used to get maximum impact on poverty reduction at minimum cost.

### *5.5 Assumptions regarding technology options in the VD scenario*

The scenario focuses on development interventions over and above DAU. Hence, all the specifications in DAU related to energy mix, TFPG, AEEI, energy options and role of renewables remain intact in VD. For example, a target in VD is to attain universal access to electricity, ignoring whether the electricity derives from fossil fuels or renewables.

## 6. Results

The VD scenario has many development interventions in the economy and aims to achieve the development thresholds of well-being indicators latest by 2050 as discussed above. The following section discusses the results of VD. First, it is compared with the DAU scenario for well-being indicators. A cost comparison and the impact on carbon emissions are discussed in later sections.

### *6.1 Achievements in well-being indicators*

Well-being indicators reach the threshold levels by 2050 and some even before then. As one can see in the results given below, DAU itself is a development pathway and makes substantial achievements in many well-being indicators by 2050. However, VD accelerates this development and achieves either better or faster development.

Note that in all the diagrams of well-being indicators the horizontal line shows the targeted threshold value.

*6.1.2 Health indicators*

*Life expectancy at birth*

Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. It is a comprehensive health indicator. According to regression analysis, life expectancy at birth depends on the availability of clean water, sanitation facility, and the prevailing death rates. Table 7 shows the coefficients of regression for life expectancy at birth for a female (see also Figure 1).

**Table 7: Life expectancy at birth (female)**

| | |
|---|---|
| Constant | 54.63 |
| Weighted average of rural and urban availability of water (percentage of population with access) | 0.12 |
| Sanitation (percentage of population with access) | 0.20 |
| Death rate (no. of deaths per 1000 population) | -0.94 |

Regressions are confirmed by cross-checking the value for the base year 2010 with currently available actual values for India. According to the Planning Commission of India (2010), life expectancy at birth for females was 64 in 2010. Given the prevailing rates of availability of water, there will be universal access to water by 2020 in DAU. However, sanitation facilities will reach only 68% of the population by 2050 in DAU. Death rates are already low and projected to go down to 8 by 2050 in DAU. Hence, by 2050 life

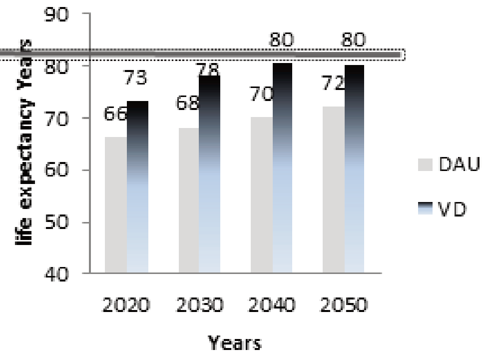


**Figure 1: Life expectancy at birth (female)**

expectancy of females will increase to 72 years in the DAU scenario; in the VD scenario it will reach 80.

Life expectancy at birth for males is generally below that for females. The regression results suggest that life expectancy for males depends on water, sanitation, death rate and income (see Figure 2). According to the Planning Commission (2010), life expectancy at birth for males is 62 years at present. DAU projects it to increase to 69 years by 2050. With additional measures for health, water and sanitation, VD projects life expectancy of males to reach 76 years.

**Table 8: Life expectancy at birth (male)**

| | |
|---|---|
| Constant | 57.81 |
| LOG(GNI/CAP) | -0.24 |
| Death rate (no of deaths per 1000 population) | -1.02 |
| Weighted average of rural and urban availability of water (percentage of population with access) | 0.09 |
| Sanitation (percentage of population with access) | 0.17 |

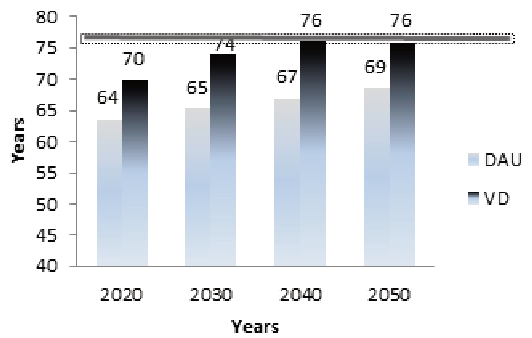


**Figure 2: Life expectancy at birth (male)**

*Infant mortality rate*

The Infant mortality rate is defined as the number of deaths of children before they attain the age of one, per 1000 live births (World Bank, 2011). Currently, infant mortality rates in India are 31 in urban and 51 in rural areas, which are very high. The regression analysis shows that infant mortality depends on female literacy, public health expenditure and water and sanitation.

**Table 9: Infant mortality**

| | |
|---|---|
| Constant | 158.13 |
| Public health expenditure | -0.27 |
| Sanitation | -0.38 |
| Weighted average of rural and urban availability of water | -0.37 |
| Female literacy rate | -0.59 |

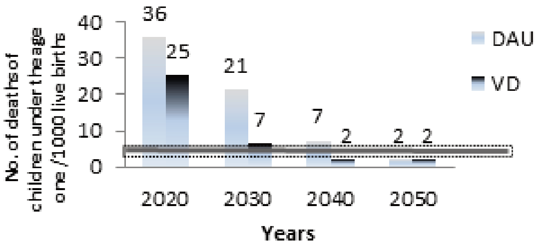


**Figure 3: Infant mortality rate**

DAU makes substantial progress in reducing the infant mortality rate (IMR) by 2050 and achieves the target of five by 2050. However, higher health and education expenditure, universal access to water and sanitation reduces IMR even faster in VD. A threshold of five is almost reached in 2030 itself and by 2040 IMR reduces to two.

*6.1.3 Education*

*Mean years of schooling*

Mean years of schooling is calculated as the average number of years of education received by people aged 25 and older, converted from education attainment levels using official durations of each level. Currently, the mean period of schooling is 5.48 years. DAU projects it to reach the threshold level of 11 years by 2050. However, an increase in expenditure on education in VD is expected to increase literacy levels, school enrolment ratios and reduce dropout rates, and VD achieves 10.72 years of schooling by 2040 and exceeds the threshold level in 2050 to achieve 12 years.

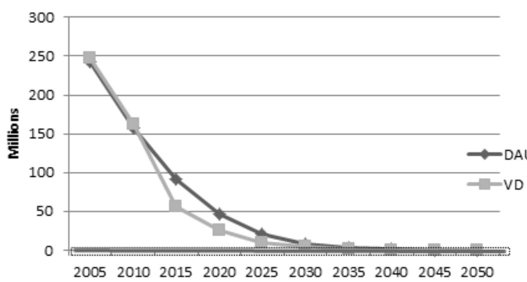


**Figure 4: Mean years of schooling**

*6.1.4 Poverty*

*Population below poverty line*

The poverty line is defined in terms of the class boundary of the second-poorest class in rural and urban areas respectively. The poverty line in rural areas is the upper class limit of RH2, INR 6 800 per annum or INR 227 per month per person at 2003–04 constant prices. In urban areas, the poverty line is the class boundary of class UH2, which is INR 10 800 per annum or INR 360 per month per person at 2003–04 constant prices. Hence, the poverty line and the population below the poverty line are not strictly comparable with the national data. However, they are useful for comparing results of scenarios in a consistent manner.

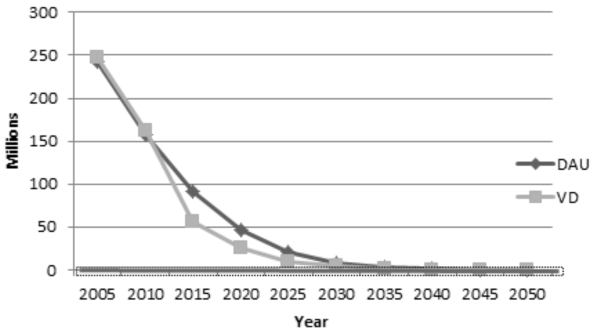


**Figure 5: Rural population earning less than INR 227 at 2003–04 constant prices**

DAU shows the level of poverty as counted by the model, if the trend of poverty alleviation measures taken before 2005 continues. With this definition, there are 242 million persons spending less than INR 227 at 2003–04 constant prices in rural areas in 2005. By 2020, there will be 92 million earning less than INR 227 and by 2050, there will be no one earning less than INR 227 at 2003–04 constant prices. Hence, DAU will shift the majority of rural population to middle class (classes RH3, RH5, RH6) by 2050.

The VD scenario accelerates the process of poverty alleviation by providing cash transfer to the persons falling into the poorest two rural classes. The cash transfer is given until every person enters RH3 or spends more than INR 227 in monthly consumption expenditure. After that, the cash transfer instrument automatically gets eliminated. With a cash transfer of INR 3000 per person per year, poverty is eliminated at a faster rate; by 2020 there will be 25 million poor in rural areas spending less than INR 227 at 2003–04 prices. By 2030 only 4 million, and by 2040 no-one will be spending less than INR 227 in rural areas.

In the Indian scenario, urban poverty is already limited compared to rural areas (both in terms of the absolute number of people below the poverty line and

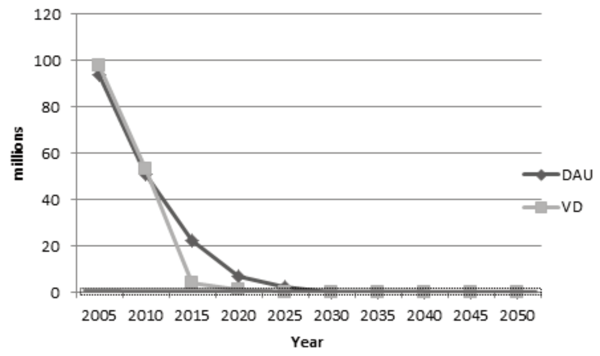


**Figure 6: Urban population earning less than INR 360 at 2003–04 constant prices**

the headcount ratio of poverty). The same is reflected in the trends shown by DAU and VD. In DAU, there are only eight million poor earning less than INR 360 per person per month at 2003–04 constant prices in 2030. By 2040 only one million will be earning less than INR 360 and poverty is alleviated in that sense. In VD, poverty is eliminated faster than in DAU until 2040 and it is completely eliminated in 2040 because of cash transfers.

*5.1.4 Access to services*

*Access to water and sanitation*

According to World Development Indicators, the World Bank's collection of development indicators, access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 litres of water per person per day from a source within one kilometre of the dwelling.

Currently, more than 80% of households have access to clean water. In the DAU scenario, by 2020 the entire population will have access to clean water. VD achieves universal access to clean water by 2015. See Figure 7.

Access to improved sanitation facilities includes access to a latrine facility with water closet or covered pit latrine or public latrine (World Bank 2012). Currently, 67.3% of households do not have access to sanitation facilities and have to opt for open defecation (Census 2011). If this trend follows in the DAU scenario only 68% of the population will have access to sanitation facilities by 2050. In VD, 90% will have access by 2030, and by 2040 universal access to sanitation is provided. See Figure 8.

*Access to electricity*

At present, 67% of households have access to electricity but, even though they are connected to the grid, access is limited due to power cuts (Census 2011). The model shows that poor households (people in household consumption classes of RH1, RH2 and RH3 in rural areas) consume less than 1kWh of electricity per household per day in the DAU scenario. Thus, in the VD scenario, subsidised electricity is provided to poor households in these three classes to increase their electricity consumption above 1 kWh per household per day, or above 365 kWh per annum. Assuming a household size of five persons, it translates to electricity access of 73 kWh per person per annum.

Figure 9 shows that in the DAU scenario the average electricity consumption of poor households from RH1, RH2 and RH3 is merely 13 kWh per person per annum in 2020. By 2040, on average every person in a poor household will consume 79 kWh of electricity per annum, and by 2050 average consumption will increase to 174 kWh per person per annum.

In the DAU scenario, electricity consumption by

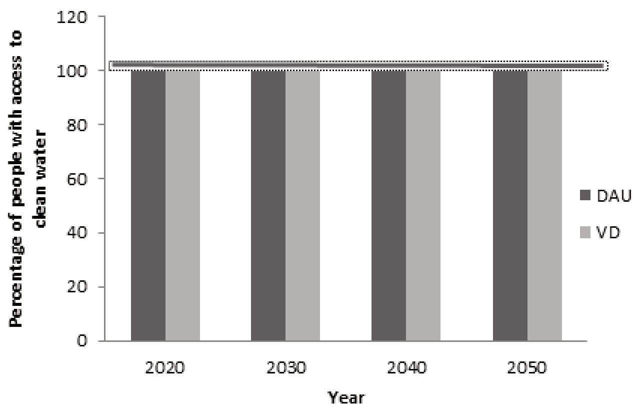


**Figure 7: Access to clean water**

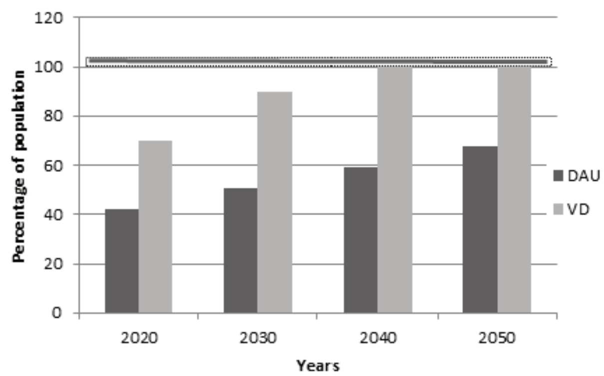


**Figure 8: Access to sanitation**

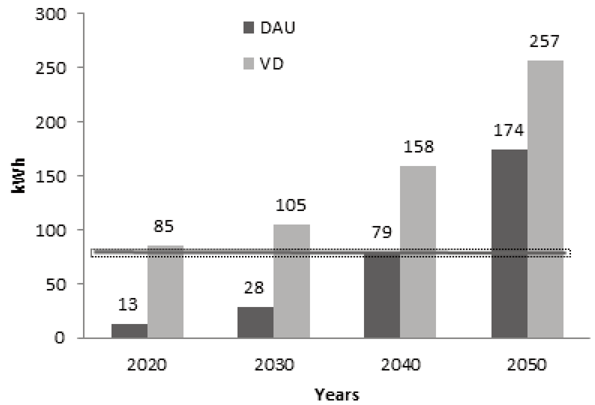


**Figure 9: Per person per annum average electricity consumption in poor rural households**

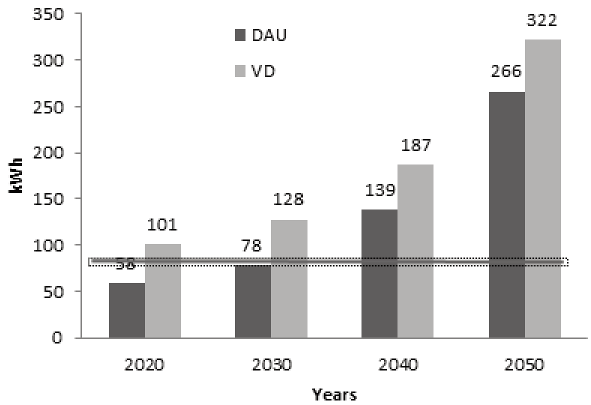


**Figure 10: Per person per annum average electricity consumption in poor urban households**

poor households (UH1, UH2 and UH3 household consumption classes) in urban areas will be 58 kWh per person per annum in 2020. By 2030, every poor household will consume more than 78 kWh of electricity per person per annum. In the VD scenario, the electricity consumption of poor households will exceed 79 kWh per person per annum and will be 101 kWh in 2020; by 2050,electricity consumption will be 322 kWh per person per annum (*see* Figure 10).

*Access to clean cooking fuel*
According to Census 2011, only 29% of households in India use LPG or PNG as a cooking fuel. The rest, mainly in rural areas, depend on firewood, cow dung cake, crop residues, etc. VD aims to provide universal access to LPG and/or PNG. In that scenario, a minimum of six LPG cylinders is provided to all those households that are already not consuming LPG.

VD envisages development in important well-being indicators like health, education, access to various services and poverty reduction. These can be achieved mainly with income growth, targeted assistance/subsidies reaching the poor and increase in government expenditure on health and education, along with good governance. The values of well-being indicators in the VD scenarios are summarised below.

### 6.2 Assessment of the cos of the VD scenario

The VD scenario maximises the per capita consumption expenditure similarly to DAU. However, due to various development interventions, the government consumption increases. Many investments are reallocated to prefer increase in household consumption on health, education, housing, electricity, cooking fuel etc. Figure 11 shows that per capita consumption expenditure remains similar in DAU and VD. While it would seem that income transfer to the poor should have increased average per capita consumption in VD, this does not happen because the transfer is financed by a tax on the richer classes. This would affect the savings of different classes. However, we do not take class-wise savings and the aggregate saving in the economy is endogenously determined in the model to optimise the present discount value of private consumption over time (Chidiak & Tirpak 2008).

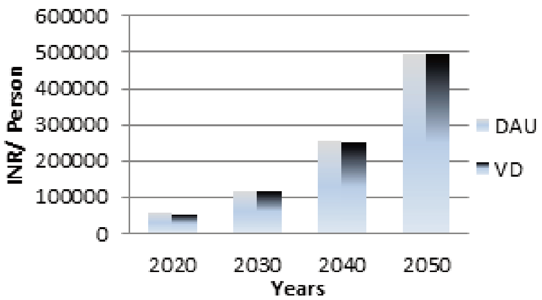


**Figure 11: Per capita consumption expenditure in DAU and VD**

GDP is also comparable in DAU and VD. GDP grows at a slightly higher rate of 7.02% from 2010 to 2050 in the VD scenario. Figure 13 gives the GDP comparison of DAU and VD in constant 2003–04 prices.

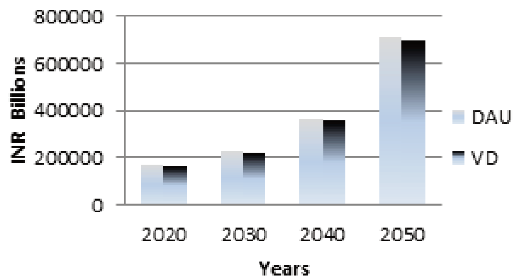


**Figure 12: GDP in DAU and VD**

### 6.3 Impact of VD on carbon emissions

One would expect that development in all fields will lead to significant increases in carbon emissions in VD. However, results show that emissions are in fact similar in both scenarios, mainly because the technology and energy mixes are kept the same. It gives an important message that VD is, in fact, possible, without increasing carbon emissions compared to DAU.

Cumulative emissions grow from 40 to 385 Gigatonnes by 2050 in DAU whereas in VD they increase from 40 to 381 Gigatonnes. Slightly lower emissions in the VD scenario result from the lower electricity consumption of richer classes. Annual $CO_2$ emissions in DAU increase from 4 443 million tonnes in 2020 to 20 072 in 2050. VD has a similar level of annual $CO_2$ emissions. Per capita emissions will reach 13.1 tonnes by 2050 from 3.4 tonnes in 2020 in DAU scenario. VD will have 3.3 tonnes per capita emissions in 2020 and will reach 13.1 tonnes by 2050. See Figures 13–16.

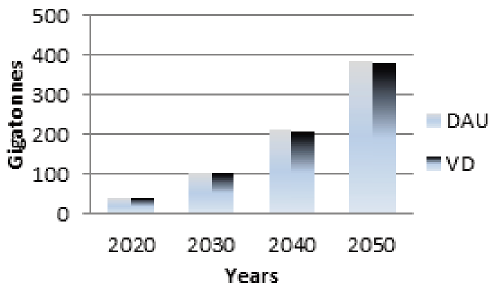


**Figure 13: Cumulative emissions**

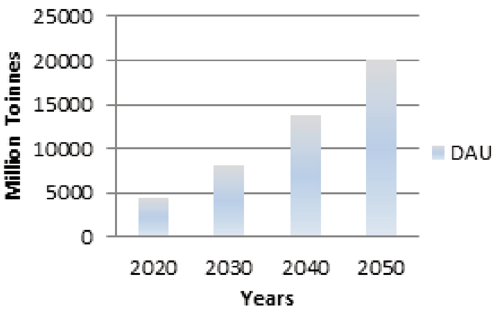


**Figure 14: $CO_2$ emissions per year**

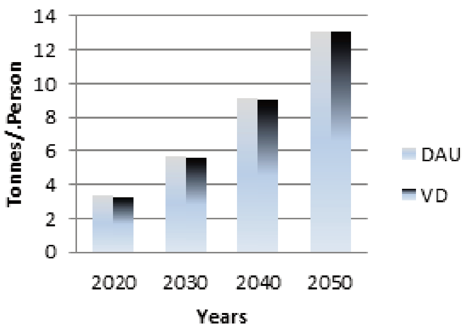


**Figure 15: Per capita $CO_2$ emissions**

## 7. Conclusion

The paper explores the possible interventions for reaching development thresholds by 2050 and analyses its implications on GDP, consumption, emissions vis-à-vis business as usual. These issues were examined with the help of a bottom-up-top-down macro-

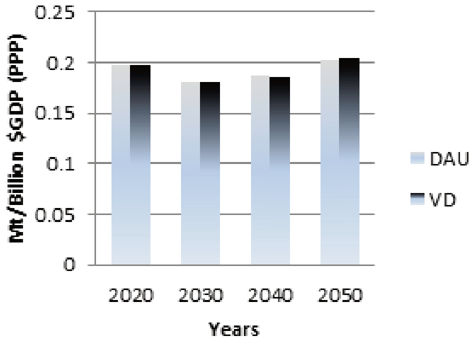


**Figure 16: $CO_2$ Intensity of GDP**

model, which covered the whole economy and provided alternative technologies. This model optimised the present discounted value of household consumption over 2005 to 2050. The main findings of the paper are summarised below.

### *7.1 Dynamics as Usual*

India needs to grow to take care of its human development needs. The DAU scenario that continues the policies of 2003–04 shows that, with compound annual growth rate of 6.96% of GDP and 7.69% of private consumption over 2010 to 2050, per capita consumption per year will exceed INR 490 000 in 2003–04 prices. With this high growth rate and without any special measures to reduce emissions, India's emissions in 2050 will reach about 13.1Gt of $CO_2$. Cumulative emissions in this scenario over 2010 to 2050 will be 385 Gt of $CO_2$.

The shares of different sectors in emissions will change dramatically over time. The share of the energy sector (i.e. coal, gas, oil, petroleum products supply) remains more or less constant at around 5–7% percent. The share of the power sector, however, declines dramatically from nearly 60% in 2007 to 30% by 2050. The share of transport increases from 11% in 2007 to 40% by 2050. The share of industry comes down from around 25% in 2007 to 16% by 2050.

Progress in the well-being indicators of human development will be steady and many of the target thresholds will be reached by 2050.

Electricity generation remains dominated by coal. However, the share of coal for subcritical power plants goes down from 67% in 2010 to slightly more than 20% by 2050 when supercritical coal provides more than 50% of electricity. Renewables such as wind, solar and hydro become important only in later years and in 2050 provide 14% of electricity generation.

### *7.2 Visionary Development*

India's human development index is currently low, below the average of medium human development countries. For the VD scenario, well-being indicator thresholds were set based on the indicators of high human development countries. Then the development thresholds were set for water, sanitation, health, education, housing, poverty, clean cooking fuel, access to electricity. The government's Bharat Nirman target was to have 100% provision of safe drinking water by 2012. The trend shows that even under DAU, safe drinking water will be available to all by 2020.

A number of other government measures are incorporated in the VD scenario:

- Expenditure on health and education is increased by 4% of GDP in 2015 and thereafter it goes by 7% of GDP. This is to ensure better outcomes on health and education.
- 'Pucca' (durable) houses are provided to all by 2020 by Indira Awas Yojana and Rajiv Awas Yojana.
- Government ensures electricity consumption of 1 kWh per household per day by providing a necessary subsidy to poorer households (without regular brown-outs).
- Government provides 90 kg of LPG or six cylinders (for cooking) to every household per year.
- Cash transfer of INR 3 000 per person per year is given to all persons below the poverty line from 2015 onwards.

The cross-country regression analysis has shown that life expectancy and infant mortality depend on per capita GNI, access to clean water and sanitation and death rate, public health expenditure and female literacy rate. The model generates the GDP, water and sanitation accesses from government policies, and as a conservative measure we have assumed the current death-rate trend. Thus, we are able to generate all the well-being indicators. Table 11 shows these indicators' values in the two scenarios in 2050.

It is seen that the VD scenario reaches the threshold values of well-being indicators earlier for indicators like headcount ratio of poverty, access to sanitation, infant mortality rate by 2040. What is important to note is that the GDP values and the per capita consumption levels are virtually the same in VD as in DAU, as are $CO_2$ emissions.

A major conclusion is that VD does not involve any significant cost compared to DAU. All it needs is effectively implemented focused policies as described above. Of course, growth of GDP plays an important role but is by itself insufficient.

## Acknowledgement

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**Table 11: Brief summary of achievements in VD as against DAU in 2050**

| *Well-being indicator* | *VD in 2020* | *VD in 2030* | *VD in 2040* | *VD in 2050* | *DAU in 2050* |
|---|---|---|---|---|---|
| Life expectancy at birth(female) years | 73 | 78 | 80 | 80.31 | 72.16 |
| Life expectancy at birth(male) years | 70 | 74 | 76 | 76 | 68.66 |
| Infant mortality rate | 25 | 7 | 2 | 2 | 2 |
| Mean years of schooling | 6.3 | 8.7 | 10.7 | 12.1 | 11.2 |
| Population below poverty line (rural /urban)[a] | 25<br>1 | 4<br>0 | 0<br>0 | 0<br>0 | 0<br>0 |
| Access to clean water (% of population with access) | 100 | 100 | 100 | 100 | 67 |
| Access to sanitation (% of population with access) | 70 | 90 | 100 | 100 | 100 |
| Average electricity consumption per person per year in poorest three rural classes (kWh)[b] | 85 | 105 | 158 | 257 | 174 |
| Average electricity consumption per person per year in poorest three urban classes (kWh) | 101 | 128 | 187 | 322 | 266 |

a. Poverty line in the model is defined as per capita monthly consumption expenditure of INR 227 in rural areas and INR 360 in urban areas in 2003–04 constant prices.

b. The average of electricity consumption per person per year in three poorest rural and urban classes who mainly benefit from subsidised electricity

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# Supporting Nationally Appropriate Mitigation Actions through the Green Climate Fund: Governance capacities and challenges

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***Abstract***

The Green Climate Fund (GCF), the new operating entity under the Financial Mechanism of the United Nations Framework Convention on Climate Change, is emerging as an innovative multilateral climate finance institution. Among other things, it is commissioned to support developing countries' project-based and programmatic pursuits to address climate change, including Nationally Appropriate Mitigation Actions (NAMAs). Promising as these ambitions may be, the GCF's effectiveness in supporting NAMAs hinges on overcoming significant governance challenges. Using perspectives from international environmental law and governance literature, this paper identifies some crucial governance challenges and analyses the capacities granted to the GCF Board in dealing with them. Developed countries expect that support will lead to measured emissions reductions. Developing countries prefer stringent monitoring of support while hesitating to agree on internationally defined NAMA criteria. The GCF will struggle with this balancing act. Absence of concrete criteria for deciding on NAMA support may prompt potential funders to seek other channels for supporting NAMAs. On the other hand, too-rigid criteria may discourage developing countries from submitting NAMA proposals. For the GCF to be effective in incentivising development and diffusion of NAMAs, we argue that the contracting Parties to the Convention will have to forge an institution that has the capacity to balance diverging expectations on NAMAs. Our analysis indicates that the GCF Board has the governance capacity to efficiently deal with this challenging balancing act. Inability to exercise this capacity may result in establishing a strong but empty shell for supporting NAMAs.

*Keywords:* NAMAs, Green Climate Fund, climate governance, climate finance, international environmental law

## 1. Introduction

Multilateral environmental negotiations have long struggled with balancing national sovereignty against effectiveness of implementing international law (Skjærseth *et al.* 2006). In such negotiations, states strive to maximise legitimacy by achieving consensus agreements, while resisting the dilution of the operative text to a stage where its implementation can become ineffective (Boyle 1991; Biermann & Bauer 2004). Consequently, to safeguard universal acceptance, multilateral environmental negotiations are extraordinarily sensitive to the arguments and interests of all sovereign states participating in the negotiations at hand.

An area of emerging international environmental law where balancing sovereignty, reaching universal agreement and achieving effectiveness are particularly complex is that of encouraging mitigation of greenhouse gases in developing countries. The 1992 United Nations Framework Convention on Climate Change (UNFCCC) allows developing countries to voluntarily propose mitigation actions (UN 1992, Art. 12). It also acknowledges that the extent to which developing countries will effectively implement their commitments depends on financial and technological support from developed countries (UN 1992, para. 4.7). The UNFCCC agreement on the concept of 'Nationally Appropriate Mitigation Actions' (NAMAs) in 2007 builds on these elements in the Convention.[1] Since 2007, there has been intense negotiation as to the more precise meaning of NAMAs (UNFCCC 2008). The 'national appropriateness' inherent in the concept signals the weight given to domestic circumstances, and a strong emphasis on the sovereign right of developing countries to govern their initiatives according to national priorities also when undertaking actions of relevance to global stakeholders. Using the example of Bangladesh Climate Change Resilience Fund where 'the majority of stakeholders were not ready to grant a key leading role to an outside international institution at the expense of national control', Gomez-Echeverri (2013) argues that governance structures for climate change finance are now being challenged. At the same time, developed countries have been reluctant to cover needs for mitigation action support in developing countries channelled through the main operating entity of the financial mechanism of the UNFCCC. They have by far preferred bilateral or more constrained multilateral channels for providing climate finance[2] (Olbrisch *et al.* 2011; Yamineva & Kulovesi 2013), guaranteeing developed country ownership over where and how to spend resources.

In this context, the Parties to the UNFCCC have established the Green Climate Fund (GCF). It serves as an operating entity of the financial mechanism (UN 1992, para. 11; UNFCCC 2011, para. 102). The Conference of the Parties (COP) expects that the GCF will become a key player in the climate finance landscape, including the possibility of it becoming a significant channel for supporting the preparation and implementation of NAMAs (UNFCCC 2012a).

This paper seeks to analyse the challenges for using a multilateral support function – perceived to have potential to impede sovereignty – to effectively support nationally defined mitigation actions in developing countries. To this end the paper analyses the challenges for the GFC in supporting NAMAs – at least potentially – and its governance capacity to overcome such challenges, by asking:

- In relation to support of NAMAs, how will the issue of sovereignty play out in the GCF?
- What constitutes the governance challenges facing the GCF for effective support of NAMAs?
- What form of governance capacity is granted to the GCF to resolve such challenges?

The paper starts by briefly outlining the emergence and establishment of NAMAs, the GCF, and their interrelation in UNFCCC politics (Section 2). Section 3 elaborates on the analytical perspective, as well as on our method for collection and categorisation of empirical material. We provide a definition of the governance capacity that we refer to, and explore its relation to international environmental law literature. The analysis departs from this framework to discuss the governance capacity of the GCF, and how this capacity conditions the ability of the GCF in supporting NAMAs. For the latter discussion, we draw particular attention to the challenge of meeting the expectations of all sovereign member states to the UNFCCC, while maintaining governance capacity to be effective in supporting NAMAs. Although it is too early to evaluate the performative governance capacity of the GCF (Secco *et al.* nd; Arts & Goverde 2006), our analysis highlights that further considerations of options are essential to ensure effectiveness of the GCF as an institution supporting NAMAs. This can only be achieved if states forge an institution that has the capacity to balance different expectations from NAMAs: developed country Parties generally expect measured emissions reductions in return for support, while at the same time being reluctant to strictly monitor the support they extend; developing country Parties are hesitant to agree on internationally defined NAMA criteria and have high hopes for transparent, reliable, predictable and additional support. Inability to manage these varied expectations will lead to creation of a strong but empty shell that will struggle to attract both funds and NAMA proposals.

### *2. Background: Complexity in international support on NAMAs*

Paragraph 1(b) (ii) of the Bali Action Plan (UNFCCC 2007) introduced NAMAs, but provided a very broad reference point (van Asselt *et al.* 2010). Various research initiatives on NAMAs have focused on its definitional and design aspects (Sterk 2010; Torres *et al.* 2012), yet no clear consensus has evolved over these aspects, for two primary reasons. First, the national appropriateness element of NAMAs varies from one country to another and NAMAs as a concept is still subject to varying interpretations (McMahon *et al.* 2010; Linnér & Pahuja 2012). Secondly, the research on NAMAs is still conceptual in nature (CCAP 2012), with very few implementation examples to draw on (Röser & De Vit 2012). Some studies take the voluntary actions announced by the non-Annex I (NAI) parties after COP15 as their point of analysis (Fukuda & Tamura 2010; Sterk 2010). Others studies focus on the supporting framework available at the domestic level and study country specific policy design and institutional arrangements for NAMAs implementation (Höhne *et al.* 2008; Teng *et al.* 2009; van Asselt *et al.* 2010; Wang-Helmreich *et al.* 2011; Tyler, Boyd, Coetzee & Winkler 2013; Tyler, Boyd, Coetzee, Torres Gunfaus *et al.* 2013).

The topic of support for NAMAs has also garnered attention, especially on what is eligible to be counted as support (Sterk *et al.* 2011), and how to link the funding to specific actions and the role of the private sector (Buchner *et al.* 2012; Clapp *et al.* 2012) along with relations with carbon markets (Jung *et al.* 2010; Röser & De Vit 2012; Upadhyaya 2012). Studies have also examined the relationship between specific mechanisms and how specific projects can benefit from being converted into NAMAs (Cocco *et al.* 2011; NOAK-NEFCO 2011; Sutter & Schibli 2011).

The Convention primarily puts the onus of raising finance to address climate change on developed countries (UN 1992, Art. 4). However, there are differences between countries on the following:

- what can be counted as climate finance (Clapp *et al.* 2012; Watson *et al.* 2012);
- its purpose (Buchner *et al.* 2011; Sterk *et al.* 2011);
- climate finance needs in developing countries and the adequacy of the USD 100 billion annually pledged by developed countries from 2020 onwards (Sterk *et al.* 2011; Morel & Delbosc 2012);
- how climate finance can be raised (High-level Advisory Group on Climate Change Finance 2010; Romani & Stern 2011; Clapp *et al.* 2012); and
- its deployment.

There is also lack of clarity on how much climate finance has already been made available to developing countries (OECD 2011; Buchner *et al.* 2012; Kossoy & Guigon 2012). Developed countries argue for flexibility in raising finance whereas developing countries demand new, additional and predictable sources of climate finance.

This means that neither support for nor implementation of NAMAs is well defined. The GCF, established in 2010, is expected to play a key role in channelling finance to developing countries (UNFCCC 2012b, para. 3), not least towards NAMAs. Paragraphs 35, 36 and 40 of the governing instrument for the GCF make clear that the Fund will support agreed full and agreed incremental costs, both project-based and programmatic approaches, as well as readiness and preparatory activities, relating to, *inter alia,* NAMAs (UNFCCC 2012b). Its role is contingent on the amount of finance made available and the agreement of the developing countries to the terms and conditions under which this finance will be made available. The uncertainty surrounding its role is underpinned by the differences between developed and developing countries on various aspects of climate finance. These differences have also been visible in the GCF Board meetings where Parties have frequently differed on the choices presented on the GCF's: a) objectives, results and performance indicators; b) Financial instruments; c) private sector facility; and d) enhanced direct access (Schalatek 2013). In the fifth Meeting of the Board, however, decisions regarding many of these issues have been adopted (GCF 2013a). While developed countries have pledged to mobilise USD 100 billion annually in so called long-term climate finance from 2020 onwards (UNFCCC 2011), linkages between the GCF, long-term finance and NAMAs, and the governance challenges associated with such linkages, have not been explored (Yamineva & Kulovesi 2013).

The USD100 billion annually in long-term finance is pledged 'in the context of meaningful mitigation actions and transparency on implementation' (UNFCCC 2011). It is unclear how much of it will flow through the GCF, which is required to balance its allocation of funds between adaptation and mitigation. For developing countries that are now starting to consider NAMAs as the cornerstone of their domestic mitigation action, it means high uncertainty. Developed countries stress the need for the GCF to 'get on with it', whereas developing countries emphasise 'getting it right' (Schalatek 2013). The impatience with the UN process is also visible in the fact that bilateral arrangements to finance NAMAs have already been initiated. This may lead to proliferation of funds that can result in tension between centralised or decentralised forms of managing finance (Gomez-Echeverri 2013).

Climate finance is a complex issue by itself. New operating entities such as the GCF and the Adaptation Fund, as well as new streams of bilateral and more closed multilateral financing mechanisms, make the picture even more complicated. Partly in response to this, COP16 decided to establish a Standing Committee on Finance (SCF) to assist the COP in dealing with the Convention's financial mechanism (UNFCCC 2011).[3] The tasks of the SCF include improving coherence and coordination in the delivery of climate financing, rationalisation of the financial mechanism, mobilisation of financial resources, and measurement, reporting and verification of support provided to developing country Parties.

The Parties of the UNFCCC, through decision 7/CP.18, specifically requested the SCF and the Board of the GCF to develop arrangements between the COP and the GCF in accordance with its governing instrument and Article 11, paragraph 3, for agreement by the Board and subsequent agreement by the Conference of the Parties at its nineteenth session. Thus, the SCF, without having jurisdiction over the GCF, played a direct role in developing the governance capacity of the GCF (UNFCCC 2013a). The fifth meeting of the GCF Board accepted the report by the SCF on the draft arrangements between the COP and the Fund (GCF 2013b). The arrangement gives the GCF Board full responsibility for its funding decisions but refrains from elaborating on the role of COP in the event of a complaint of a party against a GCF funding decision.

## 3. Governing through international environmental law

Since the early 1980s, international law has been called upon to govern an increasing number of environmental problems. Traditional national and bilateral politics have failed to deal with the increasing severity and complexity of such problems, whose global dimensions have become better understood (McNeill 2000). Thus, international environmental law-making has, since the 1980s, become gradually more multilateral and sometimes even universal (UoJ & UNEP 2007; Muñoz *et al.* 2009). Multilateral environmental agreements (MEAs) have been established in areas such as trans-boundary pollution, desertification, degradation of biological diversity, ozone depletion, climate change, and sustainable development at large, to mention only the most commonly referred to treaty bodies and declarations (Rajamani 2003; Seyfang 2003; Viñuales 2013). The increasing importance of international environmental law makes it tenable to also approach the GCF through this perspective to understand governance capacities of and challenges for the GCF in supporting NAMAs.

### *3.1 Governance capacities*

In this paper, we refer to 'governance as the organization of collective action' (Shawki 2009: 44). Governance entails setting up institutions, with rules, that both constrains and enables actions (Hufty 2011). Institutions can therefore be said to have different governance capacities to act on different kinds of collective problems. Building on this definition, governance capacities refer to the ability of the institution concerned, to operate as a collective actor (González & Healey 2005). With our focus on GCF and its capacities and challenges in supporting NAMAs, we are particularly interested in the capacities of the GCF to support NAMAs. The literature divides governance capacities into indicative and performative capacities (Arts & Goverde 2006). Performative governance capacities refer to the performance of a governance arrangement, in this case, performance of the GCF in supporting NAMAs. As the GCF has still not supported any NAMA, we focus on its indicative governance capacities, by which we mean the *potential* of the GCF to act as a collective actor in effectively governing NAMA support. Thus, when we refer to 'governance capacities' below, we have 'indicative governance capacities' in mind. For indicative governance capacity, 'the key question is whether a certain policy arrangement is such that we can expect a "capacity to govern"' (La Rovere *et al.* 2002, p. 3). As noticed by González and Healey (2005) and in line with our approach to international law, governance capacity is not just defined by formal laws and the mandate that the institutions grants to the organisation, such as the GCF. Governance capacity is equally dependent on what we refer to as different levels of soft law.

In a strictly formal approach to international law, either there is a law or there is not (Vihma 2013). International law normally requires a signed and ratified treaty text, or a rather distinct custom (UN 1969). However, the emergence of a growing collection of MEAs has been paralleled by a change in the literature on international environmental law where governance through law has gradually shifted from a binary understanding of law to a more nuanced continuum-approach (Karlsson-Vinkhuyzen & Vihma 2009). It captures a broader range of options to govern through law, where both soft and hard law are seen to create legal obligations with different levels of precision and delegation. The effectiveness of law is therefore not contingent on its formal status but on the level of legitimacy that it enjoys from the states (Brunnée & Toppe 2010).

Governance through international law thus ranges from strictly legally binding hard law to the much more flexible soft law. As binary categories, hard and soft law do not reflect the more nuanced practice in international law. However, the concepts are well suited to serve as endpoints in a continuum of options for international governance. The level of 'hardness' or 'softness' of international law is often judged based on three criterions (Abbott & Snidal 2000; Abbott *et al.* 2000; Karlsson-Vinkhuyzen & Vihma 2009: Vihma 2013):

- obligation (level of 'bindingness' of a state to a rule or commitment);
- precision (level of unambiguous definition of an obligation, and its modalities and procedures); and,
- delegation (the level of authorisation of third party to implement, interpret, apply, and amend or add rules, as well as serving to arbitrate disputes between states).

On the continuum, the formal character of law matters less than the creation of effects of legal obligations (be they effects of hard or soft law). A COP decision can be more precise and more effective than ratified treaty text (Abbott & Snidal 2000). In fact, the UNFCCC is a good example of precisely this. Under its Kyoto Protocol, for example, there was not enough time before concluding to elaborate on all details required for Parties to feel confident in ratifying the protocol. During the years following on the adoption of the Protocol in 1997, many details had to be clarified before the clause for entering into force was fulfilled. As a result, most of what regulates (for example) compliance, as well as the use of flexible mechanisms, is defined in decisions rather than treaty text. This shows that when approaching the issue of governance capacities, effectiveness is not necessarily only a function of the existence or not of hard law in the formal sense (Brunnée & Toppe 2010).

In the case of the GCF, besides the theoretical arguments, there is also an empirical reason for avoiding the formal distinction between hard and soft law. The GCF is, formally speaking, established through the use of soft law, in COP's capacity as an autonomous decision-making body. The GCF is defined through soft law, and its governing instrument is annexed to soft law. Still, the GCF is set up to perform specific tasks. As such, it can be said to have governance capacities designated to it by the COP. We will address these capacities and their status in terms of obligations, precision and delegation.

### 3.2 Governance challenges: Effectiveness and sovereignty

The discussion of how sovereignty issues play out in the GCF, with consequential challenges for the GCF in supporting NAMAs, relates to the peculiarities of international as opposed to national law. In domestic settings, it is often the case that a legislating body constructs law while police and courts enforce law. This is clearly not how international law functions, nor is it a feasible option for reforming the system of international law (Dryzek & Niemeyer 2006). There is no sovereignty attached to the global community. The international is indeed a realm where states with different interests (Vogel 1997), all of which have sovereign rights to govern over their own territories, must find avenues for cooperation to solve issues of common concern when these cannot be dealt with solely through national politics (Wendt 1992). In the case of international environmental law, there is no equivalence to enforcement institutions such as police. Further, only weak dispute settlement procedures exist. Internationally defined legal obligations therefore heavily depend on their legitimacy among states.

The literature focusing on the procedures at international negotiations – that we engage with here – underscores the significance of states to endorse MEAs with at least a minimum level of legitimacy to foster compliance (Koh 1997; Hurd 1999; Bernstein 2005). The concept of legitimacy interrelates with that of fairness: if an agreement is seen as having come about in a procedurally just manner, it is usually endorsed with legitimacy and therefore a Party to the agreement feels a sense of ownership over, and a responsibility to implement it (Depledge 2005: Bernstein 2012). For the GCF to be effective in its support of NAMAs, it needs to develop governance arrangements that are seen as legitimate by its end users. If not, it may neither be capitalised nor will it receive NAMA proposals – conditions that we believe are vital for the GCF to become effective in supporting NAMAs. We will elaborate on how the GCF is trapped between different expectations on NAMAs, while attempting to effectively support mitigation action in developing countries by matching funds from (sovereign) developed countries with NAMA proposals from (sovereign) developing countries. We will evaluate how the sovereignty issue may play out in the GCF by analysing the willingness of states to delegate some of their sovereignty to a multilateral setting, and the challenges for effective NAMA support that may arise if the delegation of powers to the GCF is done without sensitivity to countries expectations regarding NAMAs.

### 3.3 Scope and data collection

The study is based on document analysis and covers COP, GCF Board and SCF negotiations. Through decision 7/CP.18, the COP requested the GCF Board and the SCF to develop arrangements between the COP and the GCF, negotiations that are significant to understanding the governance capacities of the GCF (UNFCCC 2013a). We focus on the COP since the

Durban decision on the governing instrument of the GCF (UNFCCC 2012a), as well as the SCF and the GCF Board negotiations, since it is in these forums that the details of indicative governance capacities have been developed and agreed. While avoiding a dichotomous distinction between hard and soft law and instead maintaining focus on levels of obligation, precision and delegation, we give precedence to the decisions over ongoing policy developments in submissions, compilations, and consolidated negotiating texts of the COP, the SCF, and the GCF Board. This 'desk-top research' is informed by our longstanding observations of the UNFCCC process, covering more than 15 negotiating sessions, granting us capacity to navigate the various documents coming out of the processes.

### 4. Effective GCF support of NAMAs: Governance challenges and capacity

It is worth recalling that we are indeed quite aware that the GCF is not prompted to support NAMAs in particular; only that it will support mitigation actions that may – as the governing instrument explicitly notices at several instances – include support of NAMAs. However, we think that it could support NAMAs, and should support NAMAs. The analysis we propose below is one where, from a legal perspective, the GCF can expect challenges to effective support of NAMAs. We are also interested in the indicative governance capacities that the GCF already has, as well as is expected to be bestowed with to resolve such challenges. Our conclusions underscore the need for further analysis of governance options available to the GCF for effective (performative) support of NAMAs.

#### *4.1 Sovereignty, and the governance challenges facing the GCF*

To address how the issue of sovereignty is played out in the GFC in relation to support of NAMAs, we focus on its obligation and precision functions, which in this particular case means the level of 'bindingness' of a state to an agreement by the GCF and its accompanying level of unambiguous definition of an obligation. (The context of delegation, will be explored below in relation to governance capacities.) From this perspective, the GCF faces a 'balancing act'. It needs to act as a weighbridge between developed and developing countries' expectations on how NAMAs should be governed. Developed countries argue for greater access to information regarding mitigation for providing higher NAMA support. At the same time, developed countries have not been fond of measuring, reporting and verifying the support they provide, or to commit to certain levels of support. In absence of reliable and predictable support, developing countries are reluctant to take on NAMAs (Yamineva & Kulovesi 2013). At the same time, they would like to view emissions reduction as add-on to other overriding priorities such as development and poverty eradication. The GCF must accommodate both perspectives. The balancing act must be carried out both in relation to support being provided and to mitigation actions that are being proposed.

First, on support: The GCF Board must build criteria, including on how to select one NAMA over another, that make developed countries trust the GCF. The crux is that 'wise spending' means different things to different Parties, with a general divide between developed and developing countries. Having developed countries trust in the GCF will capitalise it at higher volumes, and could possibly check the tendency to influence decision making, over their money. At the same time, developing countries must be convinced that the level of support provided, as well as its transparency and reliability, is adequate. As expressed by a representative for New Zealand in relation to discussing NAMA support during the UN Climate Change Conference in Warsaw: 'When you're dealing with taxpayers money, there's a certain amount of discipline required' (Friman 2013a).

Second, and contrary to the first, on mitigation action: The GCF, to be effective in supporting NAMAs, must be designed to instil confidence in developing countries to agree on internationally defined criteria for deciding to support one NAMA and not another. If developing countries are not convinced that these criteria are good, they will either not agree to them or they will simply not file NAMA proposals to the GCF. During the meeting referred to above, a representative for Vietnam raised concerns that 'the eligibility criteria is impossible for us to fulfil', resulting in missing out on possible mitigation actions that are seen by multilateral development banks as, strictly speaking, not bankable (Friman 2013a). A Brazilian representative cautioned that the Parties must make sure that further elaboration on methodologies of NAMAs does not interrupt the ability of developing country Parties to propose mitigation actions. Instead, they argued that it is due time to focus more on how to match mitigation actions with support (Friman 2013b).

The governance challenges for the GCF in supporting NAMAs essentially has to do with balancing the sovereign right of countries to decide over their national resources and priorities against the benefits of entering into an agreement that provide, on the one hand, mitigation actions in developing countries, and, on the other hand, a redistribution of international support from developed to developing countries. If this balancing act is unsuccessful, it cannot be expected that GCF support to NAMAs will be effective.

Building a consensus that is seen as legitimate among all Parties will provide at least three benefits. First, it will foster a sense of responsibility within the GCF; secondly, the implementation of commitments related to the GCF will be taken seriously; and, thirdly, the GCF will be actually put to use as it will be able to attract both support as well as NAMA proposals. Developed Parties are collectively obliged to provide support to developing Parties, but the Convention does not specify individual commitments. Support provided is therefore based on voluntary contributions. The developed Parties joint pledge of mobilising USD100 billion per year, from 2020 onwards, in so called 'long-term finance' is still not linked to the GCF. The level of precision in terms of how much money will be made available to the GCF is therefore low, currently based on voluntary contributions rather than commitments tied to finance targets for individual countries. The COP also encourages developing countries to submit NAMA proposals, also on a voluntary basis. However, the GCF Board is working on regulating both eligibility criteria for deciding which NAMAs to fund and which not to fund. Funding decisions will be taken based on, *inter alia*, how a NAMA proposal contributes to the performance of the fund, which in turn is evaluated using performance indicators. These indicators will guide how the fund disburses its support (GCF 2013c, 2013d).

Currently there is nothing to indicate that either the provision of certain volumes of support or the submissions of a certain level of NAMA proposals will become binding by international law. The GCF Board must therefore focus on the challenge to preserve sovereignty of countries to build trust and foster agreements that are seen as legitimate and that evoke a sense of responsibility to act accordingly. At the same time, it needs to ensure the precision of obligations to the extent that the actions of the institution maintain efficacy. Precision and obligation are important, but striking the balance is essential for any precise obligation to become effective. Since legality of the GCF Board decisions cannot be enforced, the decision has to be built on mutual trust; a perception among states that the GCF is a legitimate broker of perspectives will encourage using the multilateral mode provided by GCF for supporting and implementing contracts emerging out of the GCF. We therefore turn to the question of whether the GCF has the governance capacity required to deal with these challenges.

### *4.2 Governance capacities of the GCF*

Having established that challenges the GCF faces in effectuating its task to support NAMAs, we turn to the issue of capacity of the GCF to solve such challenges. To understand what governance capacity that are being granted to the GCF, we focus on the level of *precision,* particularly in regards to *delegation* of decision-making powers to the GCF. To understand delegation, we pinpoint the legal status of the GCF, a status that determines to what extent it operates as an independent public international organisation or as an organ dependent on its mother organisation, the COP to the UNFCCC. Given that the GCF is an operating entity to the Convention's Financial Mechanism, this might seem a clear-cut case of a thematic body within the UNFCCC regime. The direction in which the GCF seems to be evolving raises questions with respect to its independence and the consequent governance capacities that the level of independency is granting the GCF in relation to its birthplace – that is, the COP.

The GCF is currently not defined through, and is only partly regulated by, international law in the formal sense; it is defined through a COP decision rather than through ratified treaty text. Yet it is indeed an operating entity under the Financial Mechanism of the UNFCCC, which is defined through treaty text (hard law) in Article 11 of the Convention. In other words, the GCF is defined through soft law but intertwined with hard law. As a result of constituting it through soft law, states' obligations in relation to the GCF become non-enforceable. The COP may change this by inscribing core functions and capacities of the GCF in future treaties or, although much less likely, through amending the Convention, making ratifying states bound by international law to perform according to such operating paragraphs. On the other hand, the flexibility that is granted to states by defining the GCF through soft law can indeed make its operation smoother. As long as the GCF is defined through a decision, and not established in ratified treaty text, the flexibility for compromise between states is, relatively speaking, high. The fact that the GCF is linked to, and structured under, ratified treaty text also provides the institution some weight.

The GCF is established as an operating entity of the Financial Mechanism. However, besides the fact that states are not bound by decisions even if they are expected to follow the same, the legal status of the GCF is less clear. It is unclear whether the GCF is more of an independent intergovernmental organisation (IGO) or more of an organ under the COP. On the one hand, it makes the GCF more free-floating in the realm of international environmental law. Given that the COP, though the GCF's governing Instrument (UNFCCC 2012b, para. 7, 8), provides the GCF with legal personality and privileges and immunities of the GCF and to its officials, the GCF is one step closer to becoming a formal and more independent IGO with far-reaching abilities to take decisions. Judging by this, the indicative governance capacity of the GCF, in terms of delegated powers, is rather high. In fact, the GCF fulfils all formal criteria to be judged as an IGO (Schermers & Blokker 2011): first, it is founded on international agreement; secondly, it has an organ with a will of its own; and, thirdly, it is established under international law. This indicates that the delegation of power to the GCF and its independence from the COP is quite high.

Before turning to why this is significant for our analysis, let us further nuance this picture. The fact that GCF is to be 'accountable to and function under the guidance of the COP' (UNFCCC 2012b, para. 4) points to it being more of an organ rather than an independent public IGO with a will of its own. The agreement between the GCF and the COP on arrangements between the two bodies indeed specifies that the 'GCF shall receive guidance from the COP, including on matters related to policies, programme priorities and eligibility criteria' (UNFCCC 2013b: Annex 2). Article 11 of the Convention regulates such decisions. The agreement on arrangements between the COP and the GCF indeed reaffirms that the Board has full responsibility for funding decisions (UNFCCC 2013b, para. 6). However, this is not the same as saying that the Board is free to decide. It functions under guidance by the COP, including on, for example, programme priorities and eligibility criteria. The financial mechanism determines that the arrangements between the COP and operating entities of the financial mechanism shall include modalities to ensure that funded projects are in conformity with the policies, programme priorities and eligibility criteria established by the COP (UN 1992: Article 11.3(a)). The arrangements, however, do not address details of such modalities; they instead rely on specification through the Convention itself and clarification of it by COP decision 11/CP.1 (UNFCCC 1995). Neither of these decisions (that is, relating to such modalities and arrangements between the COP and the GCF) specifies what to do in the event of conflict between the COP and the GCF. Nor can the arrangements between the COP and the GCF be changed or terminated without agreement by both the COP and the GCF (UNFCCC 2013b, para. 23–25). Depending on the composition of the Board, the situation may indeed occur where the COP and the GCF Board have differing opinions. Still, the GCF does not automatically draw the short end of the stick in such cases.

Any recommendation of COP decisions by the GCF Board would require sanction by the COP to become effective. Such recommendations will run into the same procedural wrangle that the COP finds itself in. This is mostly relevant in cases where the GCF Board may want to recommend the COP to govern through formal law. However, this is an unlikely strategy. For decisions by the Board itself, which constitutes soft law, the GCF is not granted the ability to adopt any far-reaching decisions on matters of substance without clear guidance from the COP. And if it does, the COP, to which the GCF is held accountable, can revisit such decisions. If the COP wants to, they have the capacity to demand from the GCF to revise its decisions in the light of further guidance by the COP. Thus, for substantive decision coming out of the GCF, the GCF, only in part relies on the sanction of the validity of their decisions by the COP.

Firstly, the GCF Board is indeed, granted full responsibility for funding decisions, although questions relating to the potential or not of using COP as an arbitrator of last resort in the case of conflict between individual Parties and the GCF Board over specific funding decisions remain unresolved (UNFCCC 2012b, para. 5–6). Addressing the so-called Independent Redress Mechanism that would regulate procedures relating to appeals on funding decisions remains an issue for future sessions.

Secondly, the independence of the GCF is strengthened by the fact that it has been allowed by the COP to have its own independent Secretariat, with its own budget, separated from that of the UNFCCC Secretariat's budget. In summary: the fact that the GCF Board is functioning as a decision making organ with at least a certain will of its own, even if somewhat limited by guidance from the COP and having its own legal personality, clearly distinguish the GCF from being merely an organ under the UNFCCC. Whether an organ or an IGO (we treat it as an hybrid), what the GCF is in fact developing into is similar to what Eckersley (2012) labels as 'inclusive minilateralism'; a multilateral body with constrained membership representing the universal membership of the UNFCCC. As a body with constrained membership and a potential future possibility to vote, the GCF Board can be procedurally much more efficient than the COP.

Thus it is fair to say that the indicative governance capacity of the GCF, to address governance challenges related to support of NAMAs, is high. The GCF is defined more or less as an independent public IGO. Its relation to the COP puts theoretical constraints on its ability to decide on matters of substance. However, in practice, the GCF is designed in a way that gives it an advantage. As an example of inclusive minilateralism, the GCF Board is procedurally more efficient. In the event that the GCF Board and the COP disagrees on an issue of substance agreed by the Board, there will be representatives of member states in the Board that also have representatives in the COP. Agreeing in consensus on further guidance from to COP to the

GCF Board on the matter of disagreement is likely not an easy exercise, therefore the GCF Board trumps the COP. In short: large powers are currently being transferred from the COP to the Board with regards to funding decisions, but also in practice in regards to all other decisions of substance.

If the GCF is later sanctioned through a treaty, hopefully by the COP21 in 2015 (Paris), confirming these rather far reaching delegations of powers from the COP to the GCF, the stage is set for a more clearly defined public IGO with independent powers; i.e. testing ground for an indicatively speaking, procedurally efficient IGO in the UN MEA-family. It could develop into a testing ground for a new kind of minilateralism, with universal representation, for effective environmental governance. The current analysis of the indicative governance capacity of the GCF indicates that it will likely have quite some scope for manoeuvring among various governance options. The precision by which it is granted this capacity is high, and so are the delegated powers. However, what is lacking is agreement on states' obligations in relation to the GCF. Currently, developed countries should capitalise it on a voluntary basis and developing countries should submit NAMA proposals on equally voluntary basis, without internationally defined guidelines. The criteria for decision making on supporting NAMA proposals is still unclear. Under such circumstances, it is uncertain if NAMA proposals will start flowing to the GCF. Funding from developed countries towards GCF, however, is less likely to be particularly high in the absence of clearer guidelines or criteria for evaluation of proposals.

To sum up the discussion thus far and to direct attention to the tentative discussion on governance options available for the GCF, we conclude that:

- As long as the GCF is not established through hard law (defined through a treaty), it does not formally withdraw any exercise of powers from the sovereignty of states. The decisions are guiding with Parties expected to comply. However, states' obligations in relation to the GCF cannot be enforced. We presume that development in the current UNFCCC negotiations, through soft law, may be used to encourage broader adhesion to decisions and eventually to inscribe GCF (at least parts of it) into a legally binding international agreement by 2015.
- Secondly, behind the veil of granting the GCF legal personality, privileges, and immunities, it is clear that the sovereign members of the GCF remain visible. The membership of the GCF Board, and provision of observer participation, is based on a very traditional, state-centric model (Abbott & Gartner 2011; UNFCCC 2012b; GCF 2013e). The GCF cannot be expected to function as a strong institution in itself with the ability to affect an individual state's behaviour. It will do so only to the extent that actions are sanctioned by its member states. As such, it is to be viewed as a platform for negotiations between states on how to cooperate on issues under its mandate. However, as we have shown, it fulfils all the fundamental requirements to become an unusually efficient negotiating platform in comparison to multilateral environmental negotiations in general. As such, its capacity to be performative on NAMAs seems high.

Both of these facts place the GCF in a position where states can be quite flexible, while the GCF Board is granted quite high leeway to govern through soft law. Perhaps even more importantly, the delegation of powers to the GCF (UNFCCC 2012b; 2013a) and the rules of procedure for the GCF (UNFCCC 2012b; GCF 2013f) give the Board a greater say in decision-making compared to the COP. The GCF Board decisions do not have to be acceptable by all Parties in the COP. This puts the Board in a position to be much more flexible than the COP; the Board can take decisions that are favoured by the majority of the contracting Parties to the UNFCCC without having to convince all Parties in the COP. As such, it can raise ambition above the least common denominator of environmental multilateralism while still maintaining close to universal support and legitimacy, paving the way for its operation to become more effective. On voting, the rules of procedures that are additional to those set out in the governing instrument for the GCF makes clear that 'the Board will adopt voting rules' (GCF 2013f, para. 2). If such are agreed, the governance capacity to agree will be even higher compared to the COP. Reaching agreement on voting procedures, though difficult, would be still easier in the GCF than in the COP.

Currently, however, it should also be noted that the president of the COP has more leeway to interpret the concept of consensus than does the chair of the Board. In the Board, 'consensus exists when no objection is stated by any Board member or alternate member acting on behalf of a Board member' (GCF 2013f, para. 1). In the COP, it is possible, but highly contested, to use so-called flexible consensus to adopt a decision despite an outspoken objection by a Party (Friman 2013c). This is strictly speaking impossible in the GCF. As long as voting procedures are not agreed, the GCF will have to agree by clearly defined consensus among its 24 members. The impossibility for the GCF chair to exercise flexible consensus still grants the GCF higher capacity to agree than the COP but, at least on the margin, nuances the picture of the GCF as having higher capacity to agree than the COP.

The high governance capacity granted to the GCF Board places it in a good position to resolve governance challenges. However, as our analysis also shows, a huge task still lies ahead of the GCF Board: to design the GCF in a way that successfully balances the expectations of developed and developing countries, particularly for NAMAs. This is no easy task, as the expectations highlighted in this analysis continue to remain contentious.

## 5. Conclusions

The fact that Parties to the UNFCCC have the sovereign right to govern their own initiatives poses challenges for the GCF in supporting NAMAs. It needs to be seen if the GCF can strike the balance to attract both funding and NAMA proposals to become effective on a performative basis. To capitalise the fund, developed countries require some comfort that the money will be well spent. Such comfort may be granted by clearly defined eligibility criteria for funding. On the other hand, developing countries stress the *national appropriateness* of NAMAs, and want to avoid too much international regulation of what can be eligible as a NAMA. If the GCF Board manages to strike the balance between *most* of developed and developing country Parties' diverging expectations on its support of NAMAs, it can indeed develop into an exciting and promising innovative multilateral climate-funding agency for NAMAs. If not, it will likely remain in the margins of the multilateral landscape of supporting NAMAs.

The issue of matching design and support of NAMAs through a multilateral setting has been difficult to resolve through the COP to the UNFCCC. The lack of adopted voting procedures, the inability of Parties to file reservation, and poorly developed conflict resolution mechanisms makes this particular issue, with highly diverging interests, particularly challenging for the COP. On the other hand, the indicative governance capacity of the GCF to address the governance challenges arising from matching design and support of NAMAs seems to be high. In a traditional perspective from international law, effectiveness is a function of the existence of law. We argue that if this perspective is applied to the GCF, it will be viewed as having weak governance capacities that in turn limits its likelihood of being successful in effectively supporting NAMAs. Of course, all aspects of the GCF could become an integral part of the upcoming 2015 agreement. Aiming for such an approach, however, is likely to impede on the possibility to agree on the GCF with a great level of precision in defining obligation and delegation. Hence, instead of a binary divide of soft and hard law we seek to understand the level of 'hardness' or 'softness' of the GCF based on the three criteria of obligation, precision and delegation.

We suggest that the GCF is defined more or less as an independent public IGO as it meets all formal criteria of an IGO; that is, it is founded on an international agreement, it has an organ with a will of its own, and it is established under international law. This indicates that the delegation of power to the GCF and its independence from the COP is quite high. As the GCF will operate under guidance of and be accountable to the COP, its relation to the COP puts theoretical constraints on its ability to decide on matters of substance. However, in practice, the GCF is designed in a way that gives it an advantage over the COP in ultimate decision-making. In case of conflict between Parties on a GCF Board decision that does not relate to a funding decision, the GCF currently has the governance tools needed to wrangle a way out. On funding decisions, the relationship to COP is still unclear. The extent to which the COP will function as the arbitrator of last resort, for judging in conflicts between Parties that appeal a funding decision and the GCF Board, will ultimately depend on the redress mechanism that it is expected to be set up. As an example of inclusive minilateralism, the GCF Board is procedurally more efficient. It can take decisions under agreed rules of procedures including the possibility to vote. This in no way makes the challenge redundant. However, it does provide a setting where most but not all Parties can agree. Such a setting paves the way for more efficient decision-making processes and thus forms the foundation for effective NAMA support provided that the expectations of developed and developing countries can be addressed. GCF is on its way to becoming the strong shell needed to tackle challenges of climate change, but the threat of it becoming a strong empty shell still exists.

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## Notes

1. By NAMAs we refer to policies, programmes as well as specific project that a developing country undertakes or intends to undertake, in order to address its domestic challenges while contributing to reduce its greenhouse gas emissions.

2. By climate finance we refer to the financial support flowing from developed to developing countries, with primary objective of supporting climate change mitigation and adaptation activities in developing countries.
3. COP16 defined a 'Standing Committee' renamed by COP18 to the 'Standing Committee on Finance'.

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# Whither multilateralism? Implications of bilateral NAMA finance for development and sovereignty concerns of developing countries

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***Abstract***
The concept of sovereignty has been considerably redefined by the environmental challenges, particularly those with global implications. While the sovereign right of countries to exploit natural resources (and protect the environment) within national boundaries has been recognised, how this right may be exercised by countries has been facing increasing threat of restrictions on account of the possible negative impacts it may have on other countries and global environment. For developing countries a multilateral regime to address global problems is better suited than a bilateral regime on account of sovereignty concerns. Space to bargain for legitimate space for determining national development agenda, as well as for negotiating a capability enhancing non-intrusive arrangement towards contributing to the global solutions, is relatively wider under multilateral processes – more so, because developing countries can benefit from collective bargaining power. These options are either not available or restricted in a bilateral setting. In the context of climate change, provision of financial support to developing countries under the UNFCCC is one such capability-enhancing non-intrusive arrangement. However, the many bilateral channels of climate finance have reduced the effective bargaining space for developing countries. Many of the terms of these bilateral channels to support Nationally Appropriate Mitigation Actions are in conflict with the long standing negotiating positions of developing countries on climate finance. Hence, implementation of bilaterally supported climate action puts developing countries' negotiating stances in a contradictory position. Moreover, these terms may be influencing the development agenda in favour of mitigation over development.

*Keywords:* climate finance, multilateralism, bilateral initiatives, NAMAs, sovereignty

## 1. Introduction

Recognition of national sovereignty and the derivative right to develop is embedded in all international environmental agreements, to the effect that the right to develop comes across as a manifestation of sovereignty (Tarlock 1997; Weiss 1993). Broadly, the story of climate change negotiations could be summarised as countries trying to maintain their freedom to decide upon domestic climate actions and development pathways while ensuring that the aggregate impact does not hinder global interest. The global nature of climate change has put two types of demands on countries. The first, of course, is to alter their development pathways in line to meet the ultimate objective of the Convention. The second is an implicit demand to redefine sovereignty. Principle 21 of the Stockholm Declaration (UN 1972) recognises that countries have sovereign rights over their natural resources but that, at the same time, all countries need to be watchful of the impacts of their decisions on the global environment.

It is important to note that for the newly independent third world countries, sovereign rights over their natural resources were integral to their new-found freedom and struggle to self-determination (Anand 1987). Reducing and avoiding any form of dependence on, and interference from, Western countries in matters of domestic policy making hence became a core strategic goal, which broadly manifested in building domestic technological capabilities (Parthasarthi 1987). They did not want the industrialised world to dictate the terms of their development. It is not surprising, therefore, that developing countries made it clear during the preparation of the 1972 United Nations Conference on Human Environment at Stockholm that it would be impossible for developing countries to participate in a global initiative on a purely environmental basis and that for them environmental degradation is always integral to their development challenges (Strong 2001).

The concern of sovereignty was again at the centre of debate at the UN General Assembly on the issue of how the negotiations to develop a framework for global climate policy should be organised. Developing countries opposed the idea of negotiations for climate convention being organised under the auspices of the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) carrying forward the IPCC process, and argued for negotiations under the UN process. Here the concerns of sovereignty were expressed in terms of ability to participate in the global decision-making process. Developing countries believed that they would have equal say in decision-making under the United nations General Assembly process, based on equality of sovereign states as compared to a process under the WMO and UNEP where technical expertise played an important role. Overall, developing countries, which felt excluded from the scientific work by the Intergovernmental Panel on Climate Change (IPCC), argued that climate change is a political and not merely a technical issue (Bodansky 1994). It is important to note that the language of Principle 21 of the Stockholm Declaration, particularly the relationship between the scope and limits of sovereignty, development and global environmental concerns, was echoed in the various UN resolutions that led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), as well as the UN Conference on Environment and Development in 1992 at Rio.[1] These resolutions laid the foundation of the core principles of the Rio Declaration as well as the UNFCCC, particularly the principle of equity and common but differentiated responsibility and respective capabilities.

At the core of these debates was the question of control over resources and choices of actions. During negotiations under the Intergovernmental Negotiating Committee (INC) towards drafting the UNFCCC as well as towards the Kyoto Protocol, countries insisted, particularly the developed countries, that a 'menu of options' be listed as part of the agreement instead of prescriptions. Driving the concern for this insistence was that countries wanted to keep their sovereign rights intact in deciding which options they wanted to implement in line with their 'national circumstances'. Of course, many countries were also concerned that such sovereign actions might have negative impacts on their national development. Particularly, the oil exporting countries were concerned that unilateral actions by countries might affect their fossil fuel exports, primary source of their economic growth. Hence, as precaution, they demanded compensation for any losses caused by unilateral actions (Shrivastava 2012; Rowlands 1995). The questions of control, and implications for developing countries, were more pronounced in the discussions that went into the structure of the Global Environment Facility (GEF). At the Rio Earth Summit, developing countries were not in favour of giving the World Bank control of the GEF, raising concerns over the legitimacy of World Bank's governance structure (Najam 2005). Over the years, the disbursement of GEF funds by the World Bank in the form of combining the GEF grants with World Bank Loans has received sharp criticisms.[2] Current debates on the issues surrounding the 'pledge and review approach', 'international consultation and analysis' (ICA) and 'measurement, reporting and verification' (MRV), also resonate similar concerns regarding control and judgement.

Arguably, the concept of sovereignty has been considerably redefined by the environmental challenges, particularly those with global implications. While the sovereign right of countries to exploit natural resources (and protect environment) within national boundaries has been recognised (UN 1972), how this right may be exercised by countries has been facing increasing threats of restrictions on account of the possible negative impacts it may have on other countries and global environment (Shue 1995). The extent to which the global community can ask a country to limit its sovereign right to make national decisions is at the heart of any attempt to draft a global climate regime. The principles inscribed in Article 3 and commitments listed in Article 4 of the UNFCCC provide a framework for defining global claims on individual countries. From the developing countries' point of view, the principle of equity and common but differentiated responsibilities and respective capabilities and the obligation of developed countries to provide financial, technological and capacity building support to developing countries are extremely important. Particularly 'new', 'additional' and 'predictable' finance which is broadly captured by the phrase 'full agreed incremental costs' in the Article 4 and 11 of the UNFCCC is considered fundamental in full and effective implementation of the Convention. Although negotiations are still grappling with the definition of climate finance, a lot is already under progress in the name of bilateral climate finance, most of which may not be 'new' or 'additional'.

This paper examines the recent developments related to finance for nationally appropriate mitigation actions (NAMAs) in light of the conceptual linkages 'climate finance' has with the idea of development and sovereignty. It argues that recent developments may not be in line with the idea of development and sovereignty that climate negotiations, particularly the UNFCCC, have been respectful of. The rest of the paper is organised as follows. Section 2 outlines a general framework explaining relationship between the idea of development, sovereignty and need for finance in the context of climate change. Section 3 summarises the negotiations on climate finance and discusses briefly the recent developments. Section 4, analyses the current landscape of climate finance in light of the discussion in section 2. General conclusions are drawn in section 5.

## 2. Climate finance, sustainable development and sovereignty

From developing countries' perspective, the idea of sovereignty, the objective of sustainable development, and the provision of climate finance are inseparably linked through the operational significance of 'capabilities' to follow a desired development path, as well as through meeting the ethical demands of 'equity' and 'freedom of choice'. This relationship is deeply grounded in the principles of the Convention, particularly the principles of equity, common but differentiated responsibility and respective capabilities, and the right to promote sustainable development. However, as Sen (1999) argues, the recognition of equality in principle may remain hollow if the 'real opportunities' set remains unequal. The term 'real opportunity' implies that an agent not only has a set of opportunities available but also possesses necessary capabilities to exploit those opportunities. The choices are not free if the 'real opportunities' are restricted on account of limited capabilities. In international politics, the demand for sovereignty is also a demand for equal treatment and freedom of choice. It is not surprising, therefore, that the right to development in international law is grounded either in the concept of 'exclusive territorial sovereignty' or in 'the duty of equity' that developed countries owe to developing ones (Weiss 1993). Arguably, this demand for the right to development, and claims on developed countries to support enhancement of the 'real opportunities' for development, is a negotiated arrangement to protect and enhance the sovereignty of developing countries so as to enable them to fulfill the imperatives of national development while simultaneously attuning to the needs of increasing scope of, and responsibilities towards, global governance regimes.

Access to unconditional and enhanced finance is one of the prerequisites for developing countries to meet the general obligations under the Convention. Access to finance depends upon the strength of domestic financial markets and the attractiveness of an economy to foreign finance. While the former is an integral component of the level of development, the latter is a function of the former, at least partially. However, experience shows that the conventional flow of finance from industrialised countries comes with a potential sovereignty cost. A major policy concern for developing countries, particularly in the post East-Asian crisis, has been to not only attract global finance but also to ensure that it is not volatile (Grabel 2003). Financial liberalisation has resulted in a considerable amount of influence and negotiating power accruing to international investors in national policy making. A recent example is Nokia threatening to withdraw its investment in opposition to the Indian government's tax policies (*India Times* 2013), an area which is the sovereign right of national governments. A more explicit violation of sovereignty was experienced by some developing countries during the early 1990s when they had to accept a range of 'conditionalities' in return for financial support from the

International Monetary Fund (IMF) as part of a 'structural adjustment programme' (Vreeland 2004). Recent initiatives of the BRICS countries towards setting up a USD 100 billion fund to protect them from financial shocks (Castro 2013), is being interpreted as a strategic step by these countries to avoid the sovereignty costs that came with IMF support.

It is in this context that climate finance has been, and remains, a core issue in climate change negotiations. It continues to be a problematic issue in the negotiations because of different readings by developed and developing country parties of its objectives and functions. In our understanding of climate finance, we refer to the finance that developed countries are expected to provide to developing countries so as to enable the latter to meet their obligations under Article 12 of the UNFCCC (1992). This definition locates the understanding of climate finance in the north-south context.[3] Article 4 provides the contours within which the specific aspects of delivering climate finance and other means of supporting developing countries need to be negotiated and agreed upon. Paragraph 4.3 refers to new and additional financial resources as well as adequacy and predictability in the flow of the funds. Paragraph 4.7 further underlines the importance of international support by explicitly stating that 'The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources'. It also acknowledges the overriding priorities of developing countries. Article 11 of the Kyoto Protocol also referred to these provisions of the convention (UNFCCC 1998). Subsequently, the Bali Action Plan in 2007 recognised finance as one of the four building blocks for the future climate regime and suggested that mitigation in developing countries can be enhanced by means of Nationally Appropriate Mitigation Actions (NAMAs), to be 'supported and enabled … in a measurable, reportable and verifiable manner' (UNFCCC 2007). The Bali Action Plan also acknowledged the different social and economic conditions of parties.

Whether a global agreement on climate regime will successfully deliver the ultimate objective of the Convention is critically dependent upon the magnitude of financial flows from North to South. More than the argument of historical responsibility, this critical role underlines the fact that the developing world cannot change their course of economic progress, in a way conducive to avoiding climate change, on its own. Immediate development imperatives, and concurrent domestic political pressures, do not allow the governments of most countries to give priority to climate action. Poverty eradication from the global south is already on top of the global political and economic agenda. The terms of financial flows, however, have been the subject of fierce debate in climate change negotiations. These debates have taken a more concrete shape ever since developed countries pledged to provide USD 100 billion by 2020. Estimates indicate that this figure is much less than the finance actually needed for effective adaptation and mitigation in developing countries (Sterk *et al*. 2011). Differences also exist on what is eligible to be counted as climate finance, who is to provide this finance, and by what means can this money be raised (Clapp *et al.* 2012). The various suggestions offered for mobilising this volume of financial support have included a range of options blurring the distinction between 'climate finance' and any other mode of financial flows. Broadly, developing countries consider grants provided by the developed countries through budgetary provisions, over and above their overseas development assistance (ODA) commitment disbursed through a multilateral arrangement under the Conference of Parties (COP) as climate finance, whereas developed countries tend to include and report, commercial lending, ODA and other financial flows as climate finance (Fransen *et al.* 2012).

The longstanding position of developing countries that climate finance should flow from developed countries in the form of grants, over and above ODA commitments, has been justified by the historical responsibility argument. However, the emphasis on flow of climate finance from developed to developing countries and various qualifications of the mitigation actions by developing countries are grounded in the principles of equity and common but differentiated responsibilities and capabilities (arguably more than in historical responsibility considerations) and considerations of varying national circumstances. Asking developing countries to do more than their contribution to the problem, as well as their capabilities to do so, is perceived to be unfair. True, the developing world too is equally vulnerable, or perhaps more so, to the impacts of climate change, but asking them to assign climate change a priority over their other domestic political and economic pressures is akin to interfering with their freedom of 'choice', telling them what is more important for them and hence infringing upon their self-determination.

In this context, the provision that actions by developing countries are dependent upon the extent to which developed countries provide financial support appears to be a fair contract between two or more sovereign parties. Of course, other forms of support which may have financial implications, such as technological and capacity-building support, are also acceptable. The operational aspect of it remains the non-willingness to pay or acquiring these capacities in the absence of support. In that case, this is an interesting example of exercising freedom of choice for developing countries to not take actions which are not 'real' for them and, at the same time, an expression of willingness to give global concerns equal priority if the 'sovereignty gap' is reduced by means of adding to their financial capabilities, directly or indirectly.

From this perspective, the overriding priority given to social and economic development in Article 4.7 of the Convention does not necessarily imply neglect of climate concerns but a strategic promise that, once the 'capability gap' is closed through enhanced financial resources, a higher sustainable development trajectory would become a real opportunity for developing countries and climate change would automatically become a priority concern. It is interesting to note that in the Convention, 'promotion of sustainable development' has been treated both as an objective (Article 2), the right of all Parties (Article 3), and the obligation of all parties (Article 4), whereas social and economic development is recognised as the 'overriding priority of developing countries' (UNFCCC 1992). The language of 'right' for sustainable development makes it imperative that countries can claim compensation if their path to sustainable development is obstructed. But, at the same time, the language of obligation for all and explicit lesser priority to the environmental arm of sustainable development in the context of developing countries allows developing countries to claim support to bridge the 'capability gap'.

### 3. Status of 'climate finance'

Despite continuous emphasis on the element of support in the agreed outcomes and an acknowledgement of the developmental prerogatives of the developing countries, climate finance continues to be a contested topic. The High-level Advisory Group on Climate Change Financing (AGF) undertook an assessment of climate change financing. However, by categorically stating that it 'did not seek consensus on all issues and concepts' (AGF 2010) it acknowledged the complexity and difference in opinions on various issues surrounding climate change. Instead, the AGF report provides a platform for presenting various perspectives without taking any sides.

Buchner *et al.* (2012), in their overview on the landscape of climate finance, estimate that the annual global climate finance flows at USD 343–385 billion in 2010/2011. This figure includes funding from both public (USD 16–23 billion) and private (USD 217–243 billion) sources and funding into both developed countries (USD 193 billion) and developing countries (USD 172 Billion). Public and private financial institutions contribute by raising and channelling some USD 110–120 billion in this estimate. Most of the finance (USD 330.7–369.3 billion) was aimed at mitigation activities, with adaptation failing to attract any sort of private finance. An important point which the study makes is that domestic private actors contributed up to 83% of private investments in developing countries, and private investors from OECD countries contributed for 15% of the remaining investment. As highlighted in section 2, our understanding of climate finance differs from this particular definition. Nevertheless, as one of the most comprehensive studies on climate finance flows, this provides an important point for our argument.

The study indicates that public intermediaries such as multilateral, bilateral, national development banks and dedicated climate funds distributed some USD 77 billion in total, out of which multilateral and bilateral funds accounted for USD 34 billion.[4] National entities accounted for USD 42.7 billion and majorly invested in the country where such institutions were based. Although the study indicates that multilateral and bilateral agencies account for only 10% of overall climate finance, it is important to note that this data comes with a greater degree of confidence. It is much more difficult to provide information about the private sources of finance with this degree of confidence (Stadelmann *et al.* 2013; Pereira *et al.* 2013). Indeed, there is a need to go beyond just reporting the numbers (Stadelmann *et al.* 2013) to get a better understanding of how climate finance is evolving and whether it has implications for changing geopolitics and vice-versa (Gomez-Echeverri 2013). It is, however, clear that the focus of climate finance at the moment is primarily on mitigation. Another useful source of information is the website Climate Funds Update (CFU) (Heinrich Böll Foundation & ODI 2013). The website tracks the international climate finance initiatives that have been designed to address the challenges of climate change. The data maintained by CFU indicates that bilateral and multilateral funds have pledged close to USD 30 billion, of which Japan's 'fast-start finance' fund alone accounts for USD 15 billion. The data confirms that most of the money is spent on mitigation, particularly in Asia and the Pacific region. Most of the initiatives reported by CFU are bilateral in nature. Differences in the figures provided by these oft-cited reports also point to the inconsistency in the various estimates, and hence the uncertainty inherent in quoting any study on climate finance. Evidently, the flow of finance from developed countries to developing countries has been far lower than needed and promised.

In the context of the relationship that climate finance has with sovereignty and sustainable development, as discussed above, the issue of volume of climate finance, its use and terms and conditions of access to it are critical. However, with reference to volume of climate finance, 'what is to be counted as climate finance?' (Watson *et al*. 2012) is the central issue which has been delved into in a number of studies (Sterk *et al.* 2011; Buchner *et al.* 2011; Buchner *et al.* 2012; Stewart *et al.* 2009; Haites 2011). Still the debate is far from settled. Due to the definitional ambiguity on climate finance it is difficult to reach a consensus on key issues such as: a) climate finance needs in developing countries; b) sources of finance; c) amount of finance made available to developing countries; and d) the potential uses that climate finance can be put to (Clapp *et al.* 2012; Sterk *et al.* 2011; Stadelmann et al. 2011). Questions such as whether USD 100 billion is to be treated as gross or net flow; usage of the same terms to mean different things, or different terms to mean same things (Upadhyaya *et al.* 2012) make it difficult to reach consistency on how the term climate finance can be used. In the Green Climate Fund (GCF) discussions, terms such as capital/total investment, incremental investment, and incremental costs have been used to clarify what the GCF should focus on. This ambiguity originates from different readings of the texts in the different UN documents that provide broad context for climate finance and avoids getting into its specific aspects. One expects that operationalisation of the GCF would clarify issues to some extent. But the ongoing negotiations to finalise the Business Model Framework for the GCF have been slow to reach agreement on such crucial aspects (Schalatek 2013). As of now, while the volume of finance is settled in principle in the form of USD 100 billion by the 2020 pledge taken by developed countries at Copenhagen, how that 100 billion is to be mobilised is not the concern of the GCF. But tension was visible in the Fourth Board meeting in Songdo, where Parties differed on the choices presented on GCF's: a) objectives, results and performance indicators; b) financial instruments; c) private sector facility; and d) enhanced direct access.

In its fifth meeting, the GCF Board finally managed to resolve many of these key issues (GCF 2013b).Some of these agreements concerned the principles and factors for the terms and conditions of grants and concessional loans (GCF 2013a) and arrangements between the COP and the GCF (GCF 2013c).

### *3.1 NAMA finance: Emerging trends*

NAMAs are expected to be a crucial vehicle to enhance mitigation in developing countries. How NAMAs can be supported is still not agreed. The NAMA registry, developed by the UNFCCC, was expected to establish matchmaking between support available for NAMAs and the NAMAs seeking support. Although the registry now hosts substantial information on NAMAs seeking support, the same cannot be said about the support being made available. Based on the information that is available on the registry it seems that most of the action is taking place outside the UNFCCC domain. Annexure 1 presents a snapshot of the information made available at the NAMA registry website on the support available for NAMAs (UNFCCC, 2014). To date, seven initiatives have provided information regarding NAMA support. None of these initiatives are part of the NAMA registry but use it as a platform to share information about their scope, sectors targeted, funding channels, purpose of the support and the principles or criteria for selecting a NAMA to be financed, whether for preparation or for implementation.

All of these initiatives originate in European countries and target different developing countries. Initiatives such as EU-Africa Infrastructure Fund, Latin America Investment Facility (LAIF) and Neighbourhood Investment Facility (NIF) are regional in nature, whereas the GEF, climate-related ODA funding, International Climate Initiative and NAMA Facility focus on almost all developing countries. Out of all these initiatives only GEF – by virtue of being under UNFCCC – is multilateral in nature. The rest of the initiatives are primarily bilateral initiatives. The regional initiatives provide limited information, if any, on the type of actions they support, the organisations that will channel the support they provide and the extent of country consultation that is promoted. But they do provide information on the number of projects that they have supported or the finance that they have made available to date. Some of the initiatives provide support for preparation of NAMAs, whereas others provide information on their implementation; only GEF provides support for both preparation and implementation.

The most important development that is reflected in the information collated in Annex 1 is that all the different funds have their respective selection criteria. It is also important to note that none of the funds provides any information on the extent of financial, technological or capacity-building support that would be made available for supporting NAMAs. Without providing any information on the extent of support made available, it is expected that developing countries would spend resources in designing NAMAs while taking into account different criteria for accessing NAMA support. This complicates the process to access support for NAMA implementation and can create avenues for developing countries to become intellectually dependent on developed countries to meet these requirements. All these funds have substantial overlaps in terms of sectors and type of actions being supported as well as the means by which the support is being provided. Due to substantial overlaps, it should not be difficult to agree on and follow a common funding channel for supporting NAMAs.

On the contrary, there are certain features where these criteria vary from one to another. Some criteria do not exclude any specific country from accessing support, as in the case with the GCF; yet some are regional in nature and expect support of existing priorities, for example with the NIF; whereas some expect the projects to meet the ODA eligibility criteria, as is the case with climate-related ODA funding, International Climate Initiative and NAMA Facility. The latter three funds are bilateral mechanisms, designed to reach out to all the developing countries. By insisting that the funded projects should meet ODA eligibility, these funds broadly violate the condition of being 'new and additional' as most of this support can be easily relabelled as ODA money and used to meet multiple commitments. This in our understanding is a serious issue and needs to be addressed so as to ensure additionality of climate finance and to ensure that multilateralism is followed in word and spirit.

## 4. Implications for developing countries

The financial flows supporting climate action, by and large flowing through bilateral initiatives and private support, may affect developing countries in three ways. Firstly, the acceptance of bilateral support for actions, particularly with explicit and stated mitigation objectives, weakens the negotiating stance of developing countries for 'new' and 'additional' finance. It has been observed that developed countries have reported all types of financial flows, including commercial loans and ODA, as fulfilment of their commitment of USD 30 billion during 2010-2012 as fast-start finance. This has been acknowledged also in the decision taken at COP 18. Acceptance of such financial flows may imply that even commercial flows and ODA can be treated as 'new' and 'additional' and are equivalent to meeting financial obligations by developed countries as per the principle of the Convention, which is not correct. In fact, a corollary to this development is that flow of such finance for mitigation is not bound to follow the principles of the Convention. The most important deviation is from the notion of 'self-determination' and choice of actions for which 'full agreed incremental cost' is to be provided by developed countries as climate finance. Since these funds are not 'new' and 'additional' but a re-labelling of ODA, those developing countries that choose to stick to their longstanding position on climate finance are excluded by design from access to these resources. This support then comes at the cost of compromising countries' independent foreign policy on climate change, arguably the strongest indicator of a country's sovereignty in international matters, reflected in contribution to the conceptual understanding of the terms of the global agreement.

The second way in which the proliferation of bilateral mitigation support may affect developing countries is by way of implicitly suggesting that developing countries align their low-carbon development strategies, of which NAMAs are one component (Lütken *et al.* 2011), to the criteria as defined by the channel delivering climate finance. Although details of the criteria and their application are yet to unfold, the broad structure of it is in direct conflict with the negotiating positions of developing countries that have manifested their sovereignty over determining developmental priorities. For example, the criterion of the NAMA facility regarding the 'ambition' level of a proposed NAMA is in clear conflict with the COP 16 decision on international consultation and analysis (ICA) of mitigation actions, which clearly notes that the purpose of ICA shall not be to adjudge ambition level of actions being analysed. Further, the criterion of 'transformation' has the potential of being 'intrusive'. In fact, when a South African negotiator questioned the NAMA Facility representative at the technical workshop organised by the SBI during COP19 on why the same money could not be put into the GCF, the representative of the NAMA facility categorically mentioned that through the NAMA facility they were seeking clear control over how the money is used by the host countries.[5]

Along the same lines, it has also been argued in justifying the NAMAs outside UNFCCC process that these experiences will give empirical evidence of how NAMA mechanisms should look, one of the key features of which is a donor-driven MRV framework.[6] This is in clear violation of the idea of climate finance as defined under the Convention. In addition, a likely corollary of such support to mitigation actions is diversion of bilateral aid away from traditional social development sectors such as education, health and water. One may argue that the development co-benefits approach for supporting NAMAs is likely to also take care of traditional lines of bilateral support. While this may be true in many instances, it locks social sectors with 'ambitious' mitigation potential and by implication excludes the regions from receiving support where mitigation potential is low. Moreover, this support also requires that the proposed activity has some level of financial commitment from other sources. Collectively, it may add to the already existing regional developmental inequalities within individual developing countries by encouraging convergence of financial flows to certain areas and sectors. Together, it amounts to setting the agenda for developing countries, which, contrary to the developing country assertion, prioritises mitigation over development.

The third route through which the proliferation of bilateral flow of finance of climate action can undermine sovereignty of developing countries is the possibility that the commitments for bilateral support also leave the GCF empty. This does not have to be necessarily true, but so far this has been the case. Currently, the progress on building the corpus to operationalise the GCF does not seem promising. It has been reported that both France and EU have retreated from their respective commitments of Euro 110 million in 2014 and Euro 100 million in 2020 (EurActiv 2013). In sharp contrast stand the proliferation of bilateral commitments and its rather fast delivery. The German and United Kingdom governments launched the NAMA Facility with up to Euro 15 million support early in 2013. This is in line with what has been referred to as 'get on with it' sentiment in the GCF negotiations (Schalatek 2013). An empty GCF along with a concrete, although ambiguous, flow of climate finance through bilateral channels leaves both multilateralism as well as the collective negotiating power of developing countries weakened in three ways. Firstly, the explicit requirement of the NAMA Facility that this support be recognised as ODA support invites developing countries to give up their longstanding negotiating position that ODA support should not be part of climate finance (UNFCCC 2012). Secondly, and most importantly, developing countries have no say in determining the governance and terms and conditions of disbursement of these resources as they have in case of the GCF or any other mechanisms under the UNFCCC. Thirdly, it delays the operationalisation of the GCF, which can play an important role in developing a more inclusive mechanism which eliminates the negative consequences of proliferation of large number of funds, and provides a focal point through which the efforts to address climate change can be amplified, more so if it engages developing countries at the national level, and engages with parties at a partner level (Gomez-Echeverri 2013). Operationalisation of the GCF can possibly result in finding the middle ground between a highly centralised system and a decentralised system that will be crucial to ensure highest ownership of the GCF's governance structure balancing national sovereignties with global imperatives.

## 5. Conclusion

For developing countries, a multilateral regime to address global problems is better suited than a bilateral regime on account of sovereignty concerns. Space to bargain for legitimate space for determining a national development agenda as well as negotiating a capability-enhancing, non-intrusive arrangement towards contributing to the global solutions is relatively wider under multilateral processes; more so, because developing countries can benefit from collective bargaining power. These options are either not available or restricted in a bilateral setting. In the context of climate change, provision of financial support to developing countries under the UNFCCC is one such capability-enhancing, non-intrusive arrangement. However, the many bilateral channels of climate finance have reduced the effective bargaining space for developing countries. Many of the terms of these bilateral channels to support NAMAs are in conflict with the longstanding negotiating positions of developing countries on climate finance. Hence, implementation of bilaterally supported climate action puts developing countries' negotiating stances in a contradictory position. Moreover, these terms may be influencing the development agenda in favour of mitigation over development. While one can only hope that capitalisation of the GCF will counterbalance this trend, it is difficult to conceive that developed countries will contribute to the GCF along with the bilateral channels.

## Annexure 1

See pages 88–89.

## Notes

1. See United Nations General Assembly Resolutions A/RES/42/186 (Environmental Perspective to the Year 2000 and Beyond, adopted on 11 December 1987); A/RES/ 42/187 (Report of the World Commission on Environment and Development, adopted on 11 December 1987); A/RES/43/53 (Protection of global climate for present and future generations of mankind, adopted on 6 December 1988); A/RES/ 44/228 (United Nations Conference on Environment and Development, adopted on 22 December 1989); A/RES/45/211 (United Nations Conference on Environment and Development, adopted on 21 December 1990); and A/RES/45/212 (Protection of global climate for present and future generations of mankind, adopted on 21 December 1990).
2. Personal communication with Dr Prodipto Ghosh, former climate negotiator for India.
3. We use north-south and developed-developing terminologies interchangeably. The latter is more frequently used in the UNFCCC context than the former but the north-south framing is important to provide historical context.

4. Multilateral finance institutions (USD 21.2 billion); Bilateral finance institutions (USD 11.3 billion).
5. Personal notes.
6. Laura Würtenberger during a side-event presentation on NAMAs at COP18.

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## Annexure 1: Sources of finance for NAMAs as listed on NAMA Registry (2014)

| *Title* | *GEF Trust Fund* | *Climate related ODA Funding* | *International Climate Initiative* | *NAMA Facility* | *EU-Africa Infra-structure Trust Fund* | *Latin American Investment Facility* | *Neighbourhood Investment Facility* |
|---|---|---|---|---|---|---|---|
| **Part of Registry** | No. GEF has funded NAMAs in Azerbaijan, Kazakhastan, Peru and Tunisia outside the Registry. | No. No information is provided on support provided outside of Registry. | No. IKI has initiated 365 projects until October 2013 with funding totaling EUR 1.15 bn. About half of the projects contribute to mitigating greenhouse gas emissions. | No. No information is provided on support provided outside of Registry. | No. The cumulative total of grant operations approved by the ITF by Sep 2013 outside Registry is EUR 385 m. | No. LAIF has approved 20 operations in Latin America (LA) outside the Registry, granting a total of EUR 160 million (end 2012). | No. NIF has supported 66 projects in the region outside the Registry (end 2012). In total, it contributed EUR 590 m out of which EUR 332 m have contributed to 41 low-carbon and climate resilience projects. |
| **Funder(s)** | Multilateral. | Germany. | | Germany and the United Kingdom. | European Commission and certain European Union Member States. | Multilateral and/or bilateral public European Development Finance Institutions and regional LA banks. | European Economic Community. |
| **Regional scope** | Africa, Asia Pacific, Eastern Europe, LA and the Caribbean, LDCs, SIDS, Middle East and North Africa, member countries. | Africa, Asia Pacific, Eastern Europe, Latin America and the Caribbean, LDCs, SIDS, Middle East and North Africa. | | | Africa. | LA and the Caribbean. | Eastern Europe, Middle East and North Africa. |
| **Sector** | Energy supply, residential and commercial buildings, agriculture, waste management, transport and its infrastructure, industry, forestry | | | | Energy supply, transport and its infrastructure | | Energy supply, waste management, transport and its infrastructure, industry and forestry |
| **Type of action** | National/sectoral goal, Strategy, National/sectoral policy or program, Project: Investment in machinery, Project: Investment in infrastructure. | | | Project: Investment in machinery, Project: Investment in infrastructure. | Not specified. | | |
| **Channel** | World Bank serving as the GEF Trustee. | Bilateral. | Through implementing organisations only. | Through GIZ and KfW. | Not specified. | | |
| **Principles/ criteria** | Contribute to overall objective of the UNFCCC (Article 2). Applies the overall criteria of GEF: 1. Undertaken in eligible country, consistent with national priorities and programmes; 2. Addresses one or more of the GEF focal areas; 3. Consistent with the GEF operational strategy; 4. Seeks GEF financing only for agreed- | Development needs, governance performance, the relevance of Germany's contribution compared with other bilateral and multilateral donors, political factors, regional aspects and established ties. Should meet criteria for ODA eligibility. | Two step selection process. Main criteria to fund project proposals are: 1. Designing an international climate finance architecture; 2. Innovation and multiplier effect; 3. Transparency and coherence; 4. Sustainability of projects. Funded projects must meet the criteria for | *Step 1, General Criteria:* 1. Maturity for immediate implementation; 2. Time frame; 3. ODA eligibility; 4. Financing volume € 5-15 m; 5. Feasibility and (preliminary) implementation plan; 6. Concept for phase-out of support. *Step 2, Ambition criteria:* 1. Contribute to transformation of na- | ITF grants are always connected with loan investments provided by one or more financiers. It is only the financiers that are entitled to submit grants requests for infrastructure projects that may be eligible for ITF support. Projects eligible for ITF support must be able to demonstrate both financial sustainability | Strategies and priorities are fixed by the LAIF Strategic Board, which is chaired by the European Commission and the European External Action Service, and composed of representatives from the EU member states. Projects are presented by the European Lead Financial Institution to the Finance Institutions Group which appraises and dis- | Project must be located in an European Neighbourhood Policy (ENP) partner country which has signed an Action Plan with the EU. Projects must support the priorities of the ENP Action Plans or related thematic policy priorities, avoid replacing private financing (additionality), and be complementary to corresponding regional, |

| *Title* | *GEF Trust Fund* | *Climate related ODA Funding* | *International Climate Initiative* | *NAMA Facility* | *EU-Africa Infra-structure Trust Fund* | *Latin American Investment Facility* | *Neighbourhood Investment Facility* |
|---|---|---|---|---|---|---|---|
| | on incremental costs on measures to achieve global environmental benefits; 5. Involves the public in project design and implementation; 6. Is endorsed by the government(s) of the country/ies in which it will be implemented. Supported NAMAs are expected to contribute towards achieving economy-wide emission goals. | | recognition as ODA. | tional/ sectoral development; 2. additional development co-benefits beyond GHG emissions; 3. Substantial funding contribution from other sources; 4. GHG emission reductions. Funded projects must meet the criteria for recognition as ODA. | and a development impact. | burses funding for projects. | national and local strategy and measures. To receive a grant contribution from the NIF, a project must be financed by an eligible European Finance Institution. |
| **Country consultations** | Support through its regular financing of mitigation projects endorsed by developing parties. | Yes. | No, decision on support made by IKI. | Need endorsement by respective national government/national ministry. | Not specified. | | |
| **Support for** | Preparation and implementation of NAMas. | Preparation of NAMAs. | | Implementation of NAMAs | | | Preperation of NAMAs |
| **Financial support** | No amount provided; Support by means of grant. | No amount provided; Support by means of grant, concessional loan. | No amount provided; Support by means of grant, loan (private). | No amount provided; Support by means of grant, concessional loan. | No amount specified, EUR 746.4 million pledges since 2007; grant, guarantee and equity. | No amount specified; Support by means of grant and loan (private). | No amount specified; Support by means of grant, guarantee, equity. |
| **Technological support** | No technology specified. | No technology specified; not a necessarily component. | No technology specified; follow an integrative concept for acceleration of transformational processes. | No technology specified. | | | |
| **Capacity building** | No information provided. | | | | | | |

# The socio-economic implications of renewable energy and low-carbon trajectories in South Africa

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***Abstract***
South Africa is one of the top twenty emitters in the world and, like many middle-income countries, is facing the challenge of pursuing low-carbon policies in the context of high levels of unemployment, inequality and poverty. Renewable energy investments and the implementation of a carbon tax are two key issues on the low-carbon policy agenda for South Africa. This paper uses a dynamic-recursive general equilibrium model to evaluate the potential implications of these mitigation actions for economic growth, emissions, employment and inequality in South Africa. Results indicate that both the implementation of a carbon tax and investment in greener energy options are unlikely to have a 'devastating' impact on the economy. The introduction of renewable energy has a positive impact on direct employment in the electricity sector, although indirect job losses, mostly by low-skilled workers, drown out this effect and lead to a slight decrease in overall employment growth and a negative impact on income distribution. This study finds that the introduction of a carbon tax is an effective mechanism for emissions reduction. The proposed tax-level, however, even coupled with an aggressive renewable energy build plan, is still too low to allow South Africa to reach its emissions reduction target of 42% by 2025. If South Africa is to meet the challenge of decreasing emissions as well as decreasing inequality and eradicating poverty a higher carbon tax should be introduced, along with a revenue-recycling mechanism that would result in increased welfare.

*Keywords:* Renewable energy, employment, carbon tax, mitigation, economy-wide, CGE

## 1. Introduction

A number of developing countries have realised the importance of reassessing their energy demand, hoping to benefit from 'green growth' in the renewables sector. South Africa is amongst the top twenty emitters (in tonnage of $CO_2$) in the world and, with the target of peaking emissions by 2025, is in the process of implementing greener energy options. The electricity sector is heavily reliant on coal-fired generation, contributing to over 90% of the country's current generation capacity. South Africa has committed to an emissions reduction of 34% by 2020 and 42% by 2025 relative to a business-as-usual (BAU) baseline (RSA 2010). In order to reach these targets, alternative energy options need to be explored. The country's Integrated Resource Plan (IRP) shows a move in the right direction with a decrease in the reliance on coal-fired plants and an increase in renewable energy generation capacity.

The current process of the IRP is influenced by a number of policy goals, including emissions reductions; these policy goals act as 'inputs' into the operational process. The intention of the IRP is to address these and propose an electricity supply plan that is aligned with these policy goals and that also ensures the supply of affordable, reliable electricity to the region. Three easily quantifiable indicators form the basis of decision-making in the IRP, namely investment cost, emissions reduction and water usage. There are, however, a number of important economic and social policy goals that should also form an integral part of the decision-making process, namely: (1) economic growth or GDP growth; (2) employment; (3) regional development; (4) localisation; (5) good terms of trade; (6) and low electricity price. The modelling approach used in the IRP is limiting in terms of analysing the plan's ability to address some of these policy goals. This is a major gap in the planning process, as these policy goals are important considerations for economic growth and development nationally as well as regionally. An interim attempt was made during the IRP process to quantify the possible effects of scenarios on these policy goals. The process followed a multi-criteria decision-making methodology informed by various stakeholder meetings. An important drawback of this method is that it is difficult to prove that there is solid theoretical backing for the results and that these results are not influenced by subjectivity. However, under time and budget constraints it was difficult to include a thorough economic analysis in the IRP process, and the need for this type of analysis was mentioned in the draft report for the IRP (DoE 2010)

This paper aims to fill this gap in the literature by using a highly disaggregated economy-wide model to analyse the potential socioeconomic implications of introducing renewable energy and implementing a carbon tax in South Africa; addressing the impacts on two of the policy goals in the IRP, namely, economic growth and employment. The chosen methodology is appropriate for the analysis as it is theory-based and consistent with the current structure of the South African economy.

There are a few existing studies that use similar methodologies to simulate mitigation actions in South Africa. Pauw (2007), Devarajan *et al.* (2011) and Alton *et al.* (2012) explore issues surrounding a carbon tax in South Africa. Devarajan *et al.* find that the implementation of a carbon tax in South Africa is likely to lead to a decrease in welfare but is, however, more efficient than other tax instruments in curbing energy use and emissions. An important limitation of this study, highlighted in Alton *et al.*, is that there is no differentiation between energy technologies or inclusion of the country's long-term electricity investment plan. Pauw, on the other-hand, distinguishes between different types of energy technologies and uses a partial-equilibrium energy model to derive an optimal electricity investment schedule. This study finds smaller welfare reductions from the introduction of a carbon tax in comparison to Devarajan *et al.* Alton *et al.* follow Pauw by including detailed energy technologies and deriving electricity investment paths from an energy sector model. Secondly, they address a number of limitations of the aforementioned studies: the use of a dynamic computable general equilibrium model to overcome the lack of time dimension; industries are allowed to invest in less energy-intensive activities in response to higher energy prices; labour and capital market rigidities are captured; a number of tax-recycling options are simulated. A carbon tax of R12 per ton of $CO_2$ is introduced in 2012 and projected to rise linearly to a value of R210 per ton in 2022, sufficient to meet the national emissions reduction target. This study highlights the importance of both the design of the carbon tax and the method of revenue-recycling. In comparison, the use of tax revenues to fund corporate tax reductions is favourable for economic growth and high-income households but results in decreased welfare for the majority of the population. An alternative option of expanding social transfers, intuitively, improves welfare for low-income households but results in less economic growth.

The methodology used in this paper follows on from that used in Alton *et al.* (2012). The model design is extended to include a highly disaggregated renewable energy sector. Three scenarios, based on scenarios derived from a partial equilibrium energy sector model used in the IRP process, are simulated in this paper. They depict different levels of renewable energy investment and, since they are derived from an energy model, are consistent with South Africa's electricity system requirements. The results will include a comparison between potential impacts of these scenarios on economic growth, inequality, employment and emissions reduction.

## 2. Electricity generation options in South Africa

### *2.1 Description of the model scenarios*

The IRP broadly describes the process of modelling and decision-making for the future of South Africa's electricity generation. The main objectives are to, first, estimate the long-term future demand for electricity and secondly, to identify possible scenarios of generation capacity that are able to meet this demand (DoE 2011). The long lead times and high investment costs associated with electricity generation capacity provide obvious motivation for the importance of integrated resource planning. A number of other concerns accompany these in the case of South Africa; economic uncertainty due to the long time horizon, pending emissions reduction targets, and security of supply concerns due to the country's dominant reliance on coal, to name but a few. (DoE 2011)

The scope of the IRP spans over the total demand and supply for electricity in South Africa, and includes Eskom as well as non-Eskom sources of generation capacity. The foundation of the plan is built on a number of policy recommendations, such as cost-minimisation and emissions constraints. The initial stage of the IRP requires the generation of a base case, or reference scenario. This base case represents the least-cost option and is considered the optimal option in terms of meeting capacity needs when the only limitation is the cost factor (DoE 2011). There are a number of other scenarios that are then compiled in light of explicit policy and the consideration of risk adjustments that eventually lead to the determination of a proposed electricity build plan for South Africa.

A number of policy requirements govern the IRP. These form the foundation on which the IRP is built. Three particular elements of policy are crucial to the determination of the plan. Firstly, the Energy White Paper (DME 1998) specified a preference for the movement away from reliance on coal and towards a more diverse electricity generation mix with the inclusion of nuclear, natural gas and renewable options. Secondly, in light of potential future international climate change obligations, the IRP is considerate of South Africa's climate change policy. With regard to this, the importance of accounting for the environmental impacts of electricity generation technologies is noted and should be accounted for in the IRP. Thirdly, there is a considerable amount of political pressure to ensure that electricity provision remains at the least possible cost to the consumer. In light of this, the purpose of the IRP is to provide additional capacity through a build plan in order to meet the expected demand growth at the minimum social cost; the cost should include the costs associated with the impact of externalities.

The ultimate goal of the IRP process is to present a build plan that is accepted by the Ministry as the most optimal scenario taking into account a number of constraints and policy interests. The plan is not fixed and it should be revised every two years in an attempt to mitigate the effects of the uncertainty and allow the plan to evolve to meet revised demand growth and include any technological developments that may occur over the period. The current scenario is the policy-adjusted plan; considered to be a compromise between the least-cost scenario (Base-case) and the scenario with the strictest emissions target, but is also the most costly - the Emissions 3 scenario. The use of these three scenarios in this paper allows an appropriate contrast between employment projections under a low-carbon trajectory and under a BAU trajectory, where there is no need to reduce emissions. Figure 1 provides a graphical representation of the total new capacity builds under these scenarios over the period of analysis, 2010 to 2030.

The least-cost technology option in South Africa is coal, with coal-fired plants now supplying over 90% of its electricity. This is apparent in the baseline scenario, where capacity for coal-fired electricity generation almost doubles over the period to 2030. There are a number of capacity build plans that are considered 'firm commitments' and are either in the process of being built or in the final stages of planning. Two large coal-fired plants, Medupi and Kusile, make up the bulk of the committed builds and are planned to add 8760 MW of capacity by 2020 (dependent on delays). A number of small renewable electricity generation plants are also considered 'committed', but their contribution is minor in comparison, with an estimated 2400 MW by 2030.

The Policy-adjusted scenario displays a more diversified electricity build plan, with the inclusion of 9600MW of nuclear power, and 8400 MW each of wind and solar photovoltaic (PV). There is also an increase in peaking capacity, open-cycle gas turbines (OCGT) and closed-cycle gas turbines (CCGT), with 6280 MW of capacity in total. The Emissions 3 scenario relies heavily on the use of renewable energy, contributing to approximately 60% of total electricity capacity by 2030. As with the policy-adjusted scenario, 9600MW of nuclear power is planned to come online during the period, with no additional base-load capacity from coal-fired plants. The emissions reduc-

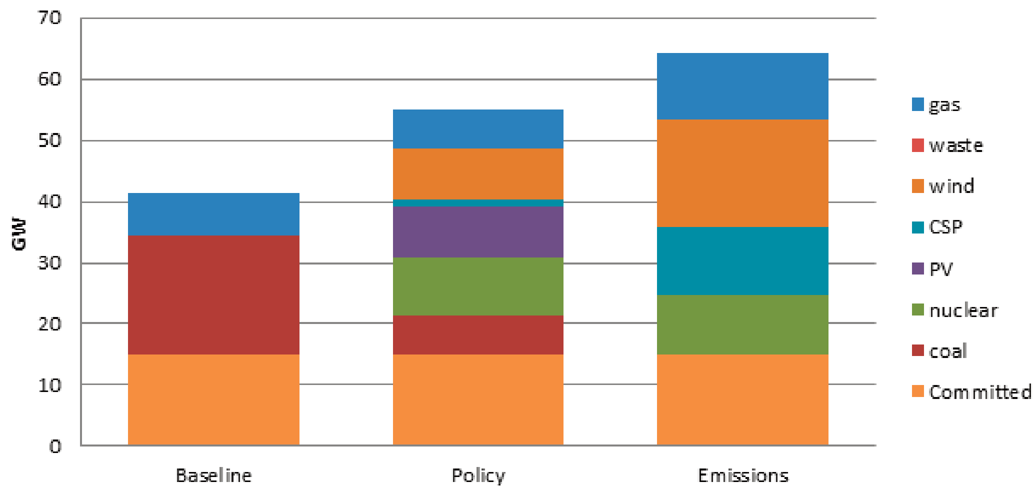


**Figure 1: The planned capacity builds for all three scenarios (GW)**
*Source: Based on the IRP (2011)*

tions in this scenario, although substantial with an annual emissions limit of 220MT $CO_2$-eq, still will not get South Africa to the targeted emissions reduction of 42% from baseline by 2025. Alton *et al.* (2012) estimate that, given domestic demand forecasts and production quotas, at least an additional R0.46 trillion of investment would be needed for South Africa to reach its emissions reduction target. The emissions pathways for the three scenarios is given in Figure 2.

In order to ensure that the scenarios are comparable, we simulate the same total electricity supply in GWh for all scenarios. Renewable options for electricity generation currently have low capacity factors, in comparison to nuclear power and coal-fired plants. The rest of this section will expand on the technology options available in the IRP.

### *2.2 Technology options for electricity generation*

There are a number of alternative electricity generation options outlined in the IRP. Each option produces the same good, electricity, but with different technology coefficients – i.e., they have different factor and intermediate inputs. Table 1 provides a summary of the technology options in terms of cost, demand for intermediates and factor demand.

## 3. Measuring economy-wide impacts

*3.1 Structure of South African economy and labour markets*

Table 2 outlines the structure of the South African economy and labour market in 2007. South Africa has a dominantly services-based economy, with serv-

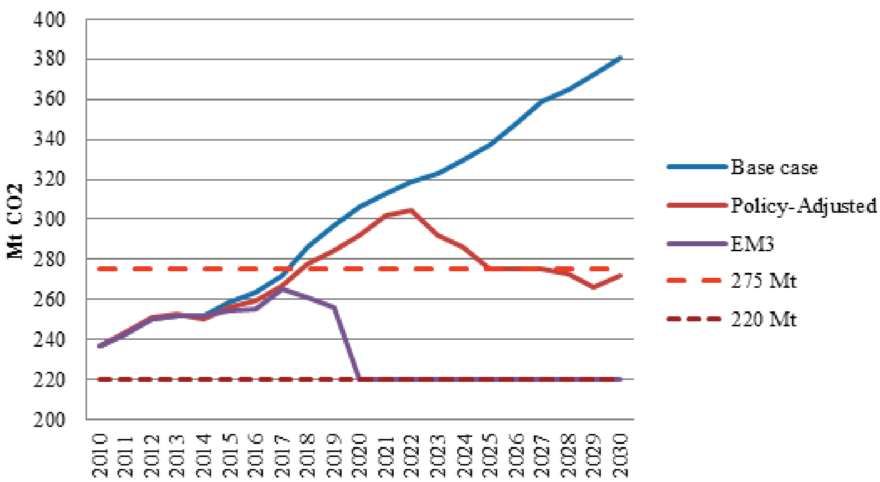


**Figure 2: Emissions pathways for the Base-case, Policy-adjusted and Emissions 3 scenarios**
*Source: Based on IRP calculations*

**Table 1: Intermediate and factor estimates for electricity generation technologies**
*Source: Based on EPRI (2010)*

| | *Coal* | *Nuclear* | *Hydro* | *PV* | *CSP* | *Wind* | *Waste* | *Gas* | *Diesel* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *Base year 2007* | | | | | |
| *Electricity supply (GWh)* | 229 571 | 11 317 | 5 845 | 213 | 319 | 32 | 204 | 1 | 86 |
| *Gross operating surplus[a] (ZAR mil)* | 55 749 | 2 480 | 1 369 | 140 | 103 | 8 | 76 | 0 | 16 |
| *Total employment (people)* | 33 014 | 2 071 | 2 063 | 64 | 96 | 7 | 56 | 0 | 12 |
| *High-skilled (people)* | 15 054 | 795 | 990 | 32 | 48 | 3 | 26 | 0 | 6 |
| | | | | *Assumptions[b]* | | | | | |
| *Build cost (ZAR mil/GWh)* | 17 785 | 26 575 | 9 464 | 37 225 | 37 425 | 14 445 | 9 464 | 4 868 | 4 868 |
| *Levelised cost[c] of plant (ZAR mil/GWh)* | 0.40 | 0.74 | 0.13 | 1.43 | 1.42 | 0.70 | 0.54 | 0.96 | 2.25 |
| *O&M (jobs/GWh)* | 0.14 | 0.18 | 0.35 | 0.30 | 0.30 | 0.22 | 0.27 | 0.14 | 0.14 |
| *Construction/installation (job years/MW)* | 10.40 | 10.80 | 19.40 | 52.30 | 10.80 | 4.50 | 6.90 | 6.20 | 6.20 |
| *Manufacturing (job years/MW)* | 1.50 | 1.20 | 0.90 | 16.80 | 7.20 | 22.50 | 0.80 | 0.07 | 0.07 |
| *Imported content (%)* | 35 % | 35 % | 35 % | 70 % | 50 % | 70 % | 50 % | 35 % | 35 % |
| *Value[d] (ZAR/GWh)* | 6 225 | 9 301 | 3 312 | 26 058 | 18 713 | 10 112 | 4 732 | 1 704 | 1 704 |
| *Fuel (ZAR mil/GWh)* | 0.08 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 2.39 |

*Notes:*

a. Gross operating surplus is the portion of income that is earned by the capital factor from production by incorporated enterprises.
b. These assumptions are based on the lifetime of the plant and are based on EPRI (2010) and, for renewable energy options, REIPPPP announcements (DoE 2013).
c. Levelised cost of plant is the unit cost of electricity generation over the life of the plant. It includes all the costs needed to build and operate a power plant over its lifetime, normalised over the total net electricity generated by the plant.
d. The portion of investment assumed to flow out the economy through imported content requirements during the build phase. Based on weighted averages for imported content over the first 2 bids (DoE, 2013).

**Table 2: Structure of South Africa's economy and labour market**
*Source: South Africa 2007 social accounting matrix (own calculations)*

| | *Share of total (%)* | | | | *Exports/ output (%)* | *Imports/ output (%)* |
|---|---|---|---|---|---|---|
| | *GDP* | *Employment* | *Exports* | *Imports* | | |
| Total GDP | 100.00 | 100.00 | 100.00 | 100.00 | 11.21 | 15.28 |
| **Agriculture** | 3.11 | 3.74 | 2.64 | 0.95 | 11.14 | 5.65 |
| *Industry* | 30.77 | 29.08 | 83.73 | 84.22 | 21.49 | 27.53 |
| Mining | 8.83 | 8.79 | 33.41 | 10.47 | 65.07 | 40.75 |
| Coal-mining | 1.59 | 1.61 | 4.49 | 0.21 | 43.82 | 4.31 |
| Manufacturing | 16.83 | 15.88 | 48.75 | 72.47 | 16.55 | 30.04 |
| Petroleum | 1.15 | 0.20 | 2.17 | 3.67 | 8.41 | 21.84 |
| Electricity | 1.81 | 0.31 | 1.57 | 1.29 | 15.22 | 14.43 |
| Coal-fired | 1.63 | 0.28 | - | - | - | - |
| Nuclear | 0.15 | 0.02 | - | - | - | - |
| Hydro | 0.02 | 0.01 | - | - | - | - |
| Services | 66.12 | 67.18 | 13.63 | 14.83 | 3.11 | 3.91 |

ices accounting for over 66% of gross domestic product (GDP) and approximately two-thirds of employment. The electricity sector is a relatively small sector, with a contribution of around 1.8% of GDP and 0.3% of employment. Historically cheap electricity prices coupled with a mineral-rich country has aided the development of energy-intensive sectors in the economy. For this reason, we believe that the importance of the electricity sector is understated when looking at the direct contribution to GDP; the indirect effects of changes in the electricity sector are more pronounced given the forward linkages associated with the sector.

Eskom is the state utility and runs a monopoly in the electricity sector, generating approximately 95% of the electricity used in South Africa and an estimated 45% of the electricity used in Africa (Eskom 2011). Electricity generation is highly reliant on the use of coal, which remains the cheapest generation option given that South Africa is a coal-rich country. There was not much diversity in terms of electricity generation in 2007, with approximately 93% of electricity generated by coal-fired plant, 1.8GW (5%) generated by Koeberg, Africa's first nuclear power station; and the remainder mainly from hydropower (Eskom, 2011).

### 3.2 Description of the static E-SAGE model

A number of CGE models have contributed to the local policy-making process in areas including trade strategy, income distribution, and structural change in low-income countries. There are several features of this class of models that make them suitable for this type of analysis (Arndt *et al.* 2011). Firstly, the structure of CGE models ensures that all economy-wide constraints are respected and provide a theoretically consistent framework for welfare and distributional analysis (Arndt *et al.* 2011). Secondly, CGE models simulate the functioning of a market economy, and provide a platform for analysis on how different economic conditions affect markets and prices (Arndt *et al.* 2011). One of the drawbacks of this type of modelling, however, is that the credibility of the results is highly dependent on the accuracy of the data and assumptions made when calibrating the model. It is possible to mitigate this limitation through transparency and disclosing the assumptions made and data used in building the economy-wide model.

The South African General Equilibrium (SAGE) model used in this analysis is derived from neoclassical tradition originally presented in the seminal work by Dervis, de Melo and Robinson (1982). A number of extensions and adaptations have been made to this framework, including the ability for producers to produce more than one commodity and the explicit treatment of transaction costs (Lofgren *et al.* 2001). The dynamic-recursive energy extension to the SAGE model, developed by Arndt *et al.* (2011) is used in this paper. The SAGE model was extended to reflect the detailed structure and workings of South Africa's energy sector – the E-SAGE model. In addition, the model was developed further to capture a detailed factor demand for the electricity sector. The SAGE model is a dynamic recursive model; in simple terms a sequence of static model runs that are solved to simulate the passing of time. The static model is solved 'within-the-period' with the use of non-linear equations that are solved simultaneously to capture linkages that exist in the real economy. This is followed by a 'between-period' run where a number of parameters are updated according to exogenous behavioural changes over time as well as the results from the previous static run. The E-SAGE model simulates the period between 2010 and 2030 and each static run represents one year.

There are 46 productive sectors, or *activities*, identified within the model; as well as six factors of production including, capital, crop land and labour. Labour is disaggregated further into four factors by level of education – primary, middle, secondary, tertiary.

The production schedule for a sole producer is provided for simplicity, although in reality, the SAGE model contains 46 sectors, each of which are assigned a representative producer. The behaviour of the representative producer is such that they will maximise profits subject to a given set of input and output prices (Thurlow 2004). The model follows neoclassical theory, and assumes constant returns to scale and hence a constant elasticity of substitution (CES) function is used to determine production (Arndt *et al.* 2011):

$$QA_i = \alpha_i^p \left( \sum_f \delta_{if}^p \cdot QF_{if}^{-p_i^p} \right)^{-1/p_i^p} \quad (1)$$

where *QA* is the output quantity of sector *i*, $\alpha^p$ is the shift parameter reflecting total factor productivity (TFP), *QF* is the quantity demanded of each factor *f* (i.e., labour and capital) and is a share parameter of factor *f* employed in the production of good *i*. The elasticity of substitution between factors σ is a transformation of $\rho^p$.

The use of a CES function allows producers to respond to changes in relative factor returns by smoothly substituting between available factors to derive a final value-added composite (Thurlow 2004).

Profits π in each sector *i* are defined as the difference between revenues and total factor payments (Arndt *et al.* 2011):

$$\pi_i = PV_i \cdot QA_i - \Sigma_f(WF_f \cdot QF_{if}) \quad (2)$$

where *PV* is the value-added component of the producer price, and *WF* is factor prices (e.g., labour wages and returns on capital). Profit maximisation implies that factors will receive an income where marginal revenue is equal to marginal cost, based on endogenous relative prices (Thurlow 2004). Maximising sectoral profits subject to Equation 6, and rearranging the resulting first order condition provides the system of factor demand equations used in the model (Arndt *et al.* 2011):

$$QF_{if} = \propto_i^{p^{\frac{p_i^p}{1+p_i^p}}} \cdot QA_i \left( \delta_{if}^p \cdot \frac{PV_i}{WF_f} \right)^{1/(1+p_i^p)} \quad (3)$$

According to Arndt *et al.* (2011), the SAGE model assumes a Leontief specification for technology when calculating the intermediate demands of individual goods as well as when merging aggregate factor and intermediate inputs. This use of fixed shares is due to the belief that technology, and not the decisio-making of producers, determines the mixture of intermediates per unit of output, and the ratio of intermediates to value-added (Thurlow 2004). In light of this, the complete producer price PA is (Arndt *et al.* 2011):

$$PA_i = PV_i + \Sigma_j(PQ_j \cdot io_{ij}) \quad (4)$$

where $io_{ij}$ represents the fixed input-output coefficient used in the demand for intermediates, which defines the quantity of good *j* used in the production of one unit of good *i* (Arndt *et al.* 2011).

The SAGE model represents an open economy and hence the model recognises the two-way trade that exists between countries for similar goods (Arndt *et al.* 2011). Substitution possibilities, governed by a CET function, exist between the production for domestic and for foreign markets (Thurlow, 2004). A CET function is used to allow the distinction between domestic and imported goods in terms of differences in time and/or quality that may exist between them (Thurlow 2004).

Producers are driven by profit-maximisation and therefore choose to sell in the market that offers the highest returns. Exported commodities are disaggregated further using a CES according to the specific region under a CES specification. The assumption that the substitution between regions is governed by a CES specification is fair as one would expect that producers would react to changes in relative prices across regions. This would therefore change the geographical composition of their exports accordingly (Thurlow 2004).

The import market is treated in the same regard. Substitution possibilities exist between imported and domestic goods under a CES Armington specification (Armington 1969). This is true in the use of both final and intermediate goods (Arndt, Davies & Thurlow 2011).

The SAGE model distinguishes between different institutions in the South African economy, namely, households, government and enterprises. Households are disaggregated according to income deciles, with the top decile divided into five income categories (Thurlow 2004).

The factor income generated from production forms the primary source of income for households and enterprises (Thurlow 2004). In addition, due to the model representing an open economy, household incomes consist of transfers from the government, other domestic institutions as well as from the rest of the world. Factor returns in South Africa have been found to differ across both occupations and sectors. In this light, the SAGE model utilises a fixed activity-specific wage-distortion term combined with the economy-wide wage to generate activity-specific wages that are paid by each activity (Thurlow 2004). There are a number of assumptions governing the factor market. Firstly, the supply of capital is fixed over a specific time-period, i.e. fully employed, but is considered immobile across sectors (Thurlow 2004). Energy capital, however, is treated as fully employed and activity-specific. There is assumed to be unemployment for the unskilled workers, however, the other three labour categories are assumed to be fully employed and mobile. Remittances are also received by factors from the rest of the world and therefore also contribute to factor incomes (Thurlow 2004).

The SAGE model follows general equilibrium theory in that households within a certain income category are assumed to share identical preferences, and are therefore modelled as ‘representative consumers’ (Thurlow 2004). According to this theory, equilibrium is reached when the representative household maximises their utility subject to a budget constraint. In the model, each representative household has its own utility function, in which *QH* is the level of consumption is income-independent and constrained by the households’ marginal budget share (Arndt *et al.* 2011). Utility is maximised for the consumer subject to a budget constraint, in which *PQ* is the market price of each good, *YH* is total household income, and *sh* and *th* are marginal savings and direct income tax rates, respectively (Arndt *et al.* 2011). By maximising the above utility function subject to a household budget constraint, a linear expenditure system (LES) of demand is derived (Arndt *et al.* 2011).

The LES of demand represents the consumer preferences captured in the model, given prices and incomes. These demand functions define households’ real consumption of each commodity. The LES specification is used in the model as it allows the identification of excess household income and therefore ensures a minimum level of consumption (Thurlow 2004).

The government is considered to be a separate agent with income and expenditure, although it is not considered to have any behavioural functions (Arndt *et al.* 2011). Most of the income earned by the government is from direct and indirect taxes and its expenditure is assumed to be on consumption and household transfers (i.e., grants) (Thurlow 2004).

Household and enterprise savings are collected into a 'savings pool' from which investment in the economy is financed (Thurlow 2004). It is assumed in the model that government borrowing can diminish this supply of loanable funds and that capital inflows from the rest of the world are able to increase it (Thurlow, 2004). There is no specified behavioural function governing the level of investment demand in the model, although the model assumes that the total value of investment spending must equate the total amount of investible funds TI in the economy (Arndt *et al.* 2011).

The SAGE model assumes full employment and factor mobility across sectors at an aggregate level. Thus the following factor market equilibrium holds (Arndt *et al.* 2011):

$$\Sigma_i QF_{if} = QFS_f \quad (5)$$

where *QFS* is fixed total factor supply. Assuming all factors are owned by households, household income *YH* is determined by (Arndt *et al.* 2011):

$$YH_h = \Sigma_{if} \omega_{hf} (1 - tf_f) \cdot WF_f \cdot QF_{if} \quad (6)$$

where $\omega$ is a coefficient matrix determining the distribution of factor earnings to individual households, and tf is the direct tax on factor earnings (e.g., corporate taxes imposed on capital profits).

The model is set up with a number of closures that govern macro adjustments. The selection of appropriate closures should ensure that the model reacts to shocks in a way that is representative of the real economy under investigation. There are considered to be three broad macroeconomic accounts in the SAGE model: the current account, the government balance, and the savings and investment account (Thurlow 2004). The macroeconomic balance in the SAGE model is governed by a number of closure rules, which provide a mechanism through which adjustments are made to maintain this balance, or equilibrium (Arndt *et al.* 2011).

According to Arndt, *et al.* (2011), the current account is considered to be the most important of these macro accounts. A substantial amount of research pours into this topic, although in this case, due to the single-country open economy CGE model, it is considered an exogenous variable (Arnd *et al.* 2011). It is assumed that a flexible exchange rate adjusts in order to maintain a fixed level of foreign borrowing for the current account macro closure rule (Thurlow 2004). South Africa's firm commitment to a flexible exchange rate system and idea that foreign borrowing is unlimited ensure that the chosen closure rule is realistic (Thurlow 2004).

The second closure rule concerns the government balance. Government consumption spending in the SAGE model is considered to be exogenous. In response to this the fiscal balance, or government savings are flexible and adjust accordingly (Arndt *et al.* 2011).

The third closure rule, perhaps the least obvious, involves the choice of a savings-investment closure (Thurlow 2004). The relationship between savings and investment continues to be a highly debated and controversial topic in macroeconomics (Nell, 2003). Neo-classical theory, along with new endogenous growth theory, maintains the view that it is former savings that decide an economy's investment and output (Thurlow 2004). Conversely, from a Keynesian perspective it is investment that is exogenous and savings that adjust accordingly (Thurlow 2004). Although, according to Nell (2003), recent works have established that, in the case of South Africa, the long-run savings and investment relationship is associated with exogenous savings and no feedback from investment.

Along with these three macroeconomic accounts, there is a factor market closure in the model. The various factors in the economy require specification in terms of how they are to be treated in the model. The SAGE model assumes full employment for high-skilled labour and unemployment amongst low-skilled labour with labour being mobile across sectors - a suitable closure for the South African context (Pauw 2007). Capital stock is assumed to be fully employed and activity-specific for the electricity sector, as the simulations impose a structural shift on production capacity. Land is assumed to be fixed and immobile as it is generally treated.

The consumer price index is assumed to be the numeraire in the SAGE model. In other words, all prices are considered relative to the weighted unit price of household's initial consumption bundle (Arndt *et al.* 2011).

### *3.3 The energy sector and carbon tax simulations*

Electricity is defined as a single commodity in the SAGE model, comprised of the separate supply of each electricity subsector (nuclear, hydropower, etc) to the national grid. The model assumes that each of these subsectors has its own distinctive production technology, based on estimates from an earlier study by Pauw (2007). It is also assumed that each subsector requires a different mix of factor inputs (Arndt *et al.* 2011). Hence, there are a number of different electricity 'activities' and a sole electricity commodity. This is a realistic assumption, as consumers in South Africa are not able to demand certain 'types' of electricity as it all comes from the national grid; electricity subsectors have very different supply processes and costs.

There are a number of adjustments that were made in order to allow multiple energy subsectors to produce the same commodity. The updated production functions are adapted to:

$$QAS_{is} = \alpha_{is}^{p}\left(\sum_f \delta_{isf}^{p} \cdot QF_{isf}^{-p_{is}^{p}}\right)^{-1/p_{is}^{p}} \quad (7)$$

$$QF_{isf} = \alpha_{is}^{p\frac{p_{is}^{p}}{1+p_{is}^{p}}} \cdot QAS_{is}\left(\delta_{isf}^{p} \cdot \frac{PV_{is}}{WD_{isf} \cdot WF_f}\right)^{1/(1+p_{is}^{p})} \quad (8)$$

$$PAS_{is} = PV_{is} + \sum_j PQ_j io_{ijs} \quad (9)$$

where *QAS* is the output of subsector s within aggregate sector *i, PAS* is the subsector producer price, and *io* reflects each subsector's unique production technology. Factor demands *QF* are also defined at sector level.

A high elasticity of substitution is assumed to exist between energy subsectors in order to replicate their product homogeneity. However, switching between different energy subsectors is constrained by the fixed installed capital in each subsector, due to the immobility of this capital. The speed at which South Africa can exchange between energy sources is determined by new capital investment as installed capital is assumed to depreciate at a fixed rate. In the current extension to the SAGE model, new investment in each subsector is determined exogenously and follows the IRP (Arndt *et al.* 2011).

Energy is treated as an intermediate input in the E-SAGE model, aggregated with other intermediates using a Leontief production function. Producers are, however, able to respond to energy price changes by the use of a 'response' elasticity ($\rho$). The energy product input coefficient ($io_{ij}$) falls either when energy prices rise (provided there is some new investment) or when the new investment share ($s_j$) is positive (provided the price rises). This relationship is:

$$io \downarrow ij,t+1/io \downarrow ijt =$$
$$1-(1-P \downarrow jt/P \downarrow j,t-1 \uparrow -\rho) \cdot s \downarrow i$$

The carbon tax simulations were applied domestically, similarly to an *ad valorem* tax placed only on fossil fuels burned within the South African borders. We assumed that there was a uniform reduction in indirect sales tax rates to have a less severe, distribution neutral simulation. An important next step would be to model tax recycling options, especially in light of the findings from Alton *et al.* (2012) that show that the choice of revenue-recycling is a main driver of the economic impact of a carbon tax in South Africa. The modelling of alternative recycling options was not conducted in this paper because of time constraints; however, based on the results from Alton *et al.*, mention will be made of the potential impacts of these alternative options on our results.

The carbon tax design proposed by the National Treasury for South Africa is highly complex (RSA 2013). At first glance, the proposed ZAR 120 per ton of $CO_2$ seems to be a significant tax allocation, although it is only half of the carbon tax value estimated by Alton *et al.* (2012), if South Africa is to reach emissions reduction targets. The Treasury proposed an initial phasing-in period from 2015 to 2019 with the rate increasing at 10% annually until the end of 2019. The rate of increase for the second period, 2020 to 2025, will be announced in February 2019. All sectors will benefit from a 'basic tax-free threshold' of 60% of emissions as well as a number of complex exemptions for energy-intensive users. The electricity sector will benefit from an additional 5% to 10% exemption whilst the petroleum sector will be exempt from an additional 15% to 20% for being a trade-exposed sector. Energy intensive sectors – such as chemicals, glass, cement, iron and steel, ceramics and fugitive emissions from coal mining – will benefit from exemptions of up to 85%. The effective tax rate is therefore much lower, at between ZAR 12 and ZAR 48 per ton of $CO_2$ – likely to be too little to transform South Africa's emissions pathway.

The carbon tax simulated in this analysis is designed in a more simplistic manner. The carbon tax is also assumed to phase in between 2015 and 2019, increasing linearly over the period until a total of ZAR 120 per ton of $CO_2$ is levied on all sectoral emissions. Given that the effective tax rate is significantly lower than this, the scenarios will overestimate the proposed carbon tax. The decision not to include the exemptions is, first, to simplify this initial analysis and, secondly, because existing literature suggests that an effective tax rate of between ZAR 12 and ZAR 48 per ton is not enough to have a significant impact on South Africa's emissions trajectory.

## 4. Results and discussion

The simulations were run under two conditions: one without a carbon tax and a second with a simplified carbon tax. The next step would be to model the exact tax design proposed by the Treasury and compare the socioeconomic implication with this simplified version of the tax; an interesting modelling exercise for the future. As previously noted, alternative revenue-recycling options have not been modelled in this paper, and are also on the agenda for future work.

Table 3 presents the results for the simulations run without a carbon tax. All three scenarios fare quite favourably in terms of growth in South Africa, with a slightly lower average growth rate for the Policy-adjusted scenario and more so for the Emissions 3 scenario. It should be noted that the assumptions governing the financing of the electricity build plan might be resulting in an overly optimistic economic growth projection. It is assumed that the build plan is financed by a foreign loan, of which an annual interest payment of 5% is made; none of the principal payment is made over the modelling period to 2030. This may be a contentious assumption. However, given that economy-wide models are not predictive but rather are a valuable tool for comparing possible futures, the relative burden on the economy should be sufficient for our analysis. It would be interesting to explore different financing options and analyse the potential impacts of these on the economy - a topic that should be noted for future work.

**Table 3: Simulation results without a carbon tax**

| | *GDP growth* | *Inequality* | *Emissions reduction* | *Employ-ment* |
|---|---|---|---|---|
| Base | 3.90% | 1.10% | 0% | 1.32% |
| Policy-adjusted | 3.82% | 1.01% | -11% | 1.31% |
| Emissions 3 | 3.67% | 0.85% | -18% | 1.29% |

The Emissions 3 scenario requires significantly more investment in comparison to the Base-case and to a lesser extent the Policy-adjusted scenario. This is shown in the slight contraction of the economy relative to the base case; economic growth is still positive, but the higher investment cost results in a decrease in the investment funds available for other, more profitable sectors in the economy.

The second indicator is titled '*inequality*'; in this instance, the values refer to the relative increase in income growth for poorest decile in comparison to the richest decile.[2] In the base case, the income of the poorest decile increases by 1,1% over the simulation period, in relation to the richest decile; the income gap is narrowing slightly and therefore inequality is decreasing. The Policy-adjusted and Emissions 3 scenarios are less favourable for income distribution. There are a number of reasons for this. The first relates to a higher cost of investment, the relative decrease in growth of other sectors in the economy has an impact on employment and, ultimately, household income. There is a negative impact on the growth of all sectors, except the electricity sector (as one would expect) and natural gas mining; driven by the increase in demand for gas turbines in the two alternative scenarios (Policy-adjusted and Emissions 3). Coal-mining, for instance, contracts by 1,14% relative to the base; as a sector with a high employment multiplier, especially for low-skilled labour, this would detract from the gains in the electricity sector. The second reason is directly linked to the decrease in employment of the various labour groups over the period. Renewable energy options are more labour-intensive, per GWh of electricity, in comparison to baseload coal, although they do require a larger proportion of high-skilled labour. There is a slight decrease in overall employment from the investment in the alternative plans, relative to the base case, with most of the impact falling on low-skilled workers. In the Emissions 3 case, there was a reduction of 5% in employment of low-skilled labour, compared to the base, while high-skilled labour remained fully employed. This, in turn, has a negative impact on income distribution.

The reduction in emissions, as one would expect, is significantly higher for the Emissions 3 scenario, with a reduction of 18% compared to the base.[3] As previously mentioned, at least ZAR 0.46 trillion would be required for the electricity sector to reach its emissions plateau by 2025, in addition to the ZAR 1.3 trillion already estimated for the Emissions 3 scenario. The relatively high allocation of renewables in the policy-adjusted scenario does make a dent in South Africa's emissions, however, with a reduction of 11% compared to the base.

**Table 4: Simulation results with a carbon tax**

| | *GDP growth* | *Inequality* | *Emissions reduction* | *Employ-ment* |
|---|---|---|---|---|
| Base | 3.90% | 1.06% | -29.26% | 1.31% |
| Policy-adjusted | 3.79% | 0.97% | -39.66% | 1.30% |
| Emissions 3 | 3.64% | 0.81% | -43.62% | 1.28% |

The simulation results with a carbon tax are shown in Table 4 and indicate that the tax is likely to have a slightly contractionary effect on the economy, with some sectors actually becoming more profitable given the changes in relative prices that occur as a result of the tax. Biomass, for example, grows by 2.38% with the introduction of a carbon tax in the Base-case scenario. We found a similar result for growth in other less energy-intensive sectors, with lower growth for the Policy-adjusted scenario, and even less for the Emissions 3 scenario. This is an intuitive result, given our assumption that all investments are funded from the savings pool; the higher the investment required for the electricity sector, the less funds available for the rest of the economy. Given that the effective tax rate is overestimated in these simulations, a conclusion can be made that the tax may not have a detrimental effect on the economy and could incentivise growth in 'cleaner' sectors; highlighting the potential benefit of moving to a low-carbon trajectory.

The reduction in emissions is significantly increased for all three cases, with approximately a 44% reduction in emissions in the Emissions 3 scenario by 2030, relative to the base. The tax is also very effective in reducing emissions in the Base-case scenario, with a reduction of 30%. The results echo those found in previous studies, that even at the full ZAR 120 per ton of $CO_2$ and with a very costly electricity build plan based on a carbon limit for the sector, South Africa is unlikely to reach their target of a 42% reduction in emissions by 2025, relative to a BAU baseline. One can conclude that the proposed tax level, even without the 'basic tax-free threshold' and complex exemptions for energy-intensive users, is still too low and needs to be revised if South Africa wants to reach its emissions targets.

The distributional impact of a carbon tax is not as favourable; however, the income gap is still narrowing. Employment also remains positive, albeit less than the employment growth rate without a carbon tax. The slight decrease is attributed to the marginal contraction of the economy due to increased energy prices.

There are a number of tax-recycling mechanisms that are available to increase the distributional impact of the carbon tax – referring back to Alton *et al.* (2012) where it was found that the revenue recycling option is an important driver of the economic impact of a carbon tax. Given the findings of their study one would expect that the distributional impact of the carbon tax would be more favourable if the revenue was recycled to fund social grants and less favourable if it were coupled with a decrease in corporate tax. A complete analysis of potential revenue recycling options has been noted for future work.

## 5. Conclusion

In conclusion, the introduction of renewable energy and low-carbon trajectories is likely to have a slightly negative impact on employment and a marginally contractionary impact on the economy. This is a key finding, as it indicates that the implementation of these mitigation actions is not likely to cripple the economy and that there are benefits that South Africa should capitalise on.

Renewable energy options, unfortunately, still have relatively high investment costs; this is the main driver for the results in this study. The higher cost of renewables causes a slightly contractionary effect on the economy from the decrease in the investment funds available to other more profitable sectors. This impact ripples into employment where, even though some renewable energy options have higher job years per MW (approximately 52 job years per MW for PV compared to 10.8 for coal-fired plants), the positive impact on direct employment is drowned out by the negative impact on indirect employment. The loss of low-skilled jobs dominates this effect, which results in higher income inequality.

In terms of emissions reduction, one can conclude that the introduction of renewable energy, even to the extent proposed in the Emissions 3 scenario, is not sufficient for South Africa to meet its emissions reduction target of 42% against a 'business-as-usual' baseline by 2025.

The implementation of a carbon tax is likely to have less of a 'devastating' impact than was previously thought. Higher energy prices might incentivise the development of 'cleaner' sectors such as the biomass industry. The addition of a carbon tax proves quite effective in terms of lowering total emissions; however, the tax level (even without the exemptions) is still too low and will not be enough to get emissions down to the target trajectory. Modelling a carbon tax of around ZAR 12 to ZAR 48 per ton of $CO_2$, the effective tax rate taking all proposed exemptions into account, would have even less of an impact on the emissions. The argument that an increased tax level will cripple the economy seems unjustified and South Africa should capitalise on the growth of sectors that could become profitable with the introduction of a carbon tax.

The distributional impact of a carbon tax is not favourable in this case, albeit the income gap is still narrowing and employment is still positive. Revenue-recycling options are a key driver of impact of a carbon tax on the economy. Designing the carbon tax with a revenue-recycling option to fund social grants is likely to lead to more favourable welfare effects, but less economic growth.

In conclusion, this paper shows that current renewable energy plans and the proposed carbon tax level are not enough to allow South Africa to reach its emissions reduction target of 42% by 2025. Both of these mitigation actions are found to have a less 'devastating' impact on the economy than was previously thought. If South Africa is to meet the challenge of decreasing emissions as well as decreasing inequality and eradicating poverty, a higher carbon tax should be introduced along with a revenue recycling mechanism that would result in increased welfare.

## Notes

1. The IRP has recently been criticised for being 'out-of-date', especially in terms of the demand forecasts and the cost assumptions for the technology options; the Renewable Energy Independent Power Producer Procurement Programme provides more realistic employment, local content and cost data. The estimates given in the table will be updated to reflect these in the near future.
2. The use of this form of inequality measure may be criticised for being over-simplified and vulnerable to the effects of outliers. For the purpose of this paper it is sufficient and more complex inequality measures could be used in future modelling exercises.
3. These are economy-wide emissions, not only for the electricity sector.

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# Energy poverty and climate change mitigation in Ghana: An economic assessment

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***Abstract***

Ghana's economy, though energy-poor, consistently grew over the past two decades, reaching 14.4% in 2011. This growth far exceeded the global average during 2011 of about 4%, from about 5.1% in 2010, making Ghana one of the fastest-growing economies in the world at that time. The Ghana Shared Growth and Development Agenda (2010–2013) projects further growth to a per capita income of USD 3000 by 2020, which is more than double the current per capita income. Since traditional biomass accounts for over 60% of total energy consumption in Ghana, attaining this target through a business-as-usual household energy approach assumes insensitivity of economic growth to energy poverty, a deceptively harmless development issue. Diversification of energy supply and demand should, however, be inevitable in the wake of climate change shocks and low-carbon development requirements. This paper assesses climate change-induced energy behaviour of households in Ghana, who contribute 32% of total energy sector emissions of greenhouse gases. It also assesses climate change-induced welfare change for households in a low carbon-development scenario as against business as usual. The net welfare effect for the scenario to switch from fuelwood to mitigate climate change was negative. The results indicate that Ghana is in an energy poverty trap, providing mixed effects for climate change mitigation. To effectively mitigate climate change under energy poverty, Ghana should promote the cultivation of energy forest plantations, introduce and use improved charcoal stoves and improved charcoal production kilns. These could lead to greater efficiency in the energy sector and create jobs for rural communities involved in the plantations for sustained growth, while at the same time delivering benefits from mitigation funding.

*Keywords:* Climate change mitigation, economic welfare, energy poverty, fuelwood, Ghana

## Introduction

Wood-based biomass is the dominant source of energy for sub-Saharan Africa, and fuelwood consumption per capita in Africa is higher than any other continent. In Ghana, the bulk of energy consumption is based on fuelwood, and 90% is obtained directly from natural forests. The demand for fuelwood is thus a major driver of forest degradation and the release of greenhouse gas (GHG) emissions (UNEP Risoe 2013). Reducing the demand for fuelwood as a low-carbon development (LCD) measure is, therefore, an important strategy to reduce drivers of deforestation and forest degradation to mitigate climate change, while generating financial flows from forest carbon activities under the Clean Development Mechanism, REDD+ (Reducing Emissions from Deforestation and Forest Degradation), and Nationally Appropriate Mitigation Activities (NAMAs).

Ghana's energy sector shows signs of high susceptibility to climate change (World Bank 2009), an indication that achieving its targeted middle-income status of US$3000 per capita income by 2020 (NDPC 2010) would require a reorganization of generation, processing and use of energy resources due to climate change shocks. In line with projections for attaining and sustaining middle income status by 2020, total energy requirements have been growing from about seven million tonnes of oil equivalent in 2004 and are expected to reach 22 million tonnes of oil equivalent by 2020 (Ghana Energy Commission 2006). Current trends in energy use show that this energy requirement is to a large extent met through traditional biomass sources, accounting for about 63% of total energy consumption (NDPC 2010). Ghana has one of the strongest economies of sub-Saharan Africa, due to its wealth in natural resources, coupled with political stability. However, the exploitation of resources through subsistence agriculture and cutting fuelwood has resulted in significant deforestation and degradation of the country's forests (UNEP Risoe, 2013). Gillis (1988) also found that one of the two principal sources of deforestation in Ghana was fuelwood harvesting, driven by rural and urban poverty.

Energy poverty can be defined as 'the absence of sufficient choice that allows access to adequate energy services, affordable, reliable, effective and sustainable in environmental terms to support the economic and human development' (Reddy 2000). It concerns people that have low income, low energy consumption and no access, or limited access, to modern energy fuel (petroleum products and electricity). Approximately 1.6 billion people do not have access to modern energy fuels globally (Chevalter & Ouedraogo 2009). The high dependence on fuelwood therefore shows the prevalence of energy poverty in Ghana, since such a trend appears highly unsustainable for continued economic growth, particularly in the wake of recent and projected climate change shocks and persistently high levels of deforestation. Also, the threat to climate change mitigation is expected to be high under such circumstances.

Ghana's greenhouse gas (GHG) emissions represent about 0.05% of the total global emissions and rank 108 in the world. This represented a total per capita emission of nearly $1tCO_2e$ as at 2006. At the continental level, Ghana ranks equally with Senegal and Mali as the 21st most GHG-emitting country in Africa (Ghana EPA 2010). Though GHG emission levels appear relatively low compared to other major developing economies, Ghana's Environmental Protection Agency (2010) cautions that the emission trends clearly indicate a strong peaking potential in the near-to-medium-term horizon, as the economy continues to grow. Also, the EU Emissions Trading Scheme, one of the world's largest carbon markets, considers Ghana to be one of Africa's largest potential emitting countries (Hanrahan & Morton 2012). Thus, the development of new frontiers dominated by agriculture, forestry and the oil and gas industry are expected to pose further challenges for climate change mitigation efforts in Ghana. This paper therefore assesses the limiting consequences of energy poverty on climate change mitigation and development in Ghana.

## Energy poverty and development

Even though modern energy has been accepteded as necessary for economic growth and development, several reasons can be given to explain why it took so long to identify energy poverty as a major developmental challenge. For a long time the real impact of energy poverty was not assessed because of several misleading indicators. This was further reinforced by the largely non-market nature of most of the biomass used for energy purposes, being essentially environmental commodities and as such taken for granted. One main misleading indicator was that energy poverty-endemic countries did not seem to show serious signs of de-development through energy poverty. Some of these countries, like Ghana, had for the past two decades recorded commendable gross domestic product (GDP) growth rates and had actually been commended as doing well by the standards of development partners. Ghana's impressive GDP record over the past two decades were achieved while traditional biomass accounted for over 60% of total energy consumption and over 80% of energy for cooking. Table 1 shows the relationships among key macroeconomic variables and fuelwood consumed in Ghana since 2002.

**Table 1: Some major macroeconomic variables and fuelwood consumed in Ghana for 2002–2012**
**Sources: GSS (2012); NDPC (2011); Energy Commission (2007)**

| *Years* | *Per capita GDP (USD)* | *Population* | *Nominal GDP (million US)* | *Real GDP growth rate* | *Fuelwood onsumed (million tonnes)* |
|---|---|---|---|---|---|
| 2002 | 310.86 | 19.9 | 6 184.81 | 4.5 | 15.05 |
| 2003 | 372.54 | 20.41 | 7 604.6 | 5.3 | 15.6 |
| 2004 | 423.84 | 20.94 | 8 876.67 | 5.8 | 15.85 |
| 2005 | 497.39 | 21.49 | 10 687.9 | 5.9 | 17.3 |
| 2006 | 923.1 | 22.03 | 20 331.5 | 6.4 | 17.31 |
| 2007 | 1091.07 | 22.58 | 24 631.9 | 6.5 | 17.94 |
| 2008 | 1218.85 | 23.14 | 28 204.7 | 8.4 | 18.9 |
| 2009 | 1095.67 | 23.1 | 25 962.7 | 4.7 | 19.9 |
| 2010 | 1235.97 | 24.24 | 29 960.8 | 6.6 | 19.91 |
| 2011 | 1384.34 | 24.8 | 34 329.2 | 14.4 | 22.93 |
| 2012 | 1478.1 | 24.34 | 37 460.6 | 7.1 | 31.9 |

The growth rate of 14.4% in 2011 made Ghana one of the fastest-growing economies in the world in that year (ISSER 2012). Figure 1 indicates an overall positive correlation between fuelwood use in Ghana and GDP growth rates. This trend is also confirmed by data from the Food and Agriculture Organisation in the United Nation's *State of the world's forests* report of 2009.

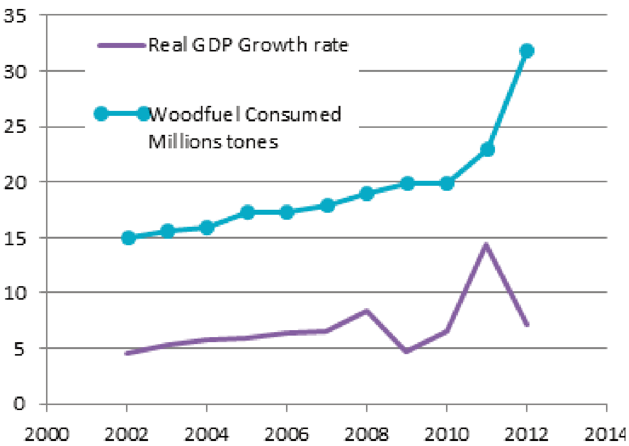


**Figure 1: Relationship between real GDP growth rate and fuelwood consumed in Ghana for 2002–2012**
*Source: Based on Table 1*

The most recent development agenda of Ghana, the Shared Growth and Development Agenda (GSGDA) projects a per capital income of US$ 3000 by 2020, without targeting the over-dependence on fuelwood in the economy. This confirms the treatment of the fuelwood variable for the period 2012-2020 as operating on a business-as-usual basis as the case has been since time immemorial. It is also worth noting that Ghana's energy outlook for 2012 did not discuss fuelwood. The fact is that if in the midst of over-dependence on biomass the economy was making substantial progress then there would be no incentive for change, particularly if change was going to mean more government expenditure from already scarce monetary and material resources. Thus, energy poor-countries like Ghana for a long time did not realise the direct economic welfare effects of their energy poverty due to growth in GDP, which most of these countries and their assessors considered the most important indicator of progress. This probably contributed to these countries not making a big issue of energy poverty as they had of income poverty.

Another misleading indicator has been the overly open-ended definition of energy 'access' which is the sole baseline for determining energy poverty. The United Nations Development Programme/World Health Organisation (UNDP/WHO) define energy access as 'access to various forms of modern energy' comprising access to electricity, modern fuels, mechanical power and improved cooking stoves (Legros et al 2009). Although the UNDP/WHO further recognise the need to include measures related to quality, quantity, appliances and equipment, services provided, socioeconomic profiles of users and affordability, these elaborate measures were left to the discretion of each country. If in a country electricity was extended from the national grid to a community which afterwards realised that it could have electricity only two days in a week on aggregate through energy rationing, this surely falls below energy access. However, no developing country left to determine energy access will consider this scenario as lack of access. Thus through various arrangements like the above, global reports about energy access have been seen to be encouraging. What the case now shows is that the overly open definition is producing negative feedback. While efforts to provide access to modern energy should be commended, the baseline must be clearly established such that a commendable effort is not mistaken for 'access', to the eventual detriment of the welfare of the energy poor. The omission of energy poverty as one of the world's leading developmental issues until 2012 was one of the greatest oversights in the history of development.

### Energy poverty and carbon dioxide emissions

One way to assess the implications of fuelwood use for the global environment is to estimate the associated GHG emissions. Though combusting wood emits carbon dioxide ($CO_2$) into the atmosphere, regrowth of wood captures $CO_2$ from the atmosphere, showing that fuelwood use is $CO_2$ emissions-neutral. Arnold *et al.* (2003) explain that this assertion holds in two ways. First, with fuelwood from forest and non-forested lands the same amount of $CO_2$ emitted by wood combustion is recaptured from the atmosphere by regrowth of wood. Second, leftovers from non-sustainable logging and land conversion, if not used as fuel would simply decompose by natural processes, and lead to the same amount of carbon emitted into the atmosphere if the woody material were to be combusted. If fuelwood were not utilised, some alternative energy source like fossil fuels and in a few cases hydro power would be required and used with accompanying $CO_2$ emissions. This, however, does not imply that energy poverty is $CO_2$ emissions-neutral. As a result of decreased access to fuelwood, the incomes of fuelwood users, their livelihoods and forest conservation can be adversely affected (Arnold *et al.* 2003), making low-carbon development activities relevant towards energy poverty reduction and vice versa.

The adverse impact on poor subsistence users arising from reduced access to fuelwood is mainly a rural issue and predominantly relates to fuelwood, as charcoal is not a subsistence fuel (Arnold *et al.* 2003). In urban areas, diminished access to supplies can negatively affect many poor households. However, this relates largely to purchased rather than gathered supplies. In most rural areas on the other hand, gathered supplies of fuelwood still constitute the main source of domestic energy for rural households (Barnes & Floor 1996) and hence these users are more vulnerable to changes that affect their ability to access fuelwood. Where access to fuelwood supplies is reduced for some reason, this implies a welfare loss for those affected. How serious this is depends on each household's ability to adapt to the new situation (Arnold *et al.* 2003).

Most of the fuelwood trade among the energy poor is on a small scale, accessible to the urban poor and is a major source of income. Townson (1995) found that in the forest zone of southern Ghana, approximately 258 000 people were involved in the fuelwood trade from 38% of the households in the region. However, many instances are recorded where fuelwood-gathering and -trading activities are associated with land clearance and the formation of farms, and therefore this declines as the farmers involved move beyond that phase in the farm cycle (Townson 1995; Wunder 1996).

The application of location theory in explaining spatial patterns of agriculture and other land uses indicates that woodfuel demand in large and growing urban areas is likely to lead to large-scale tree removal in periurban zones, spreading progressively further out into a given city's hinterland as the population increases (Arnold *et al.*. 2003). The analysis in the ESMAP study (Barnes *et al.* 2001) of data from 46 cities shows a pattern of forest depletion that is initially heavy near urban areas but this slows down as cities get larger and wealthier. The periurban areas in which fuelwood production is likely to be concentrated in the early stages of urban growth are likely to be areas that are also under pressure from clearance of agriculture. Therefore the patterns of deforestation could be explained just as much by this as the growing urban demand for fuelwood which may not be depleting wood stocks beyond what would have been cleared anyway (Arnold *et al.* 2003). However, growing population pressure on dwindling forest resources near energy poor communities definitely raises the risk of forest degradation on a daily basis. The annual rate of change in the forested areas of Ghana over the period 1990–2010 has been negative, with a deforestation rate of –1.99%. The deforestation rate increased between 2005 and 2010, reaching 2.19% (FAO 2010). Forest and grassland conversion through deforestation activities has been the major cause for the declining $CO_2$ removal capacity (sinks) and increased emissions in the forestry sector of Ghana (UNEP RISO 2013).

### Climate change and energy behaviour in Ghana

A major piece of evidence of Ghana's energy sector's susceptibility to climate change has been the effect of highly variable precipitation patterns on hydropower production. In recent times over 65% of electricity generation in the country has come from hydropower and 33% from petroleum-fired thermal generation (Ghana Energy Commission 2006), with a contribution of less than 1% from small-scale solar systems. The drought of the early eighties (1980 to 1983), and also recent times, not only affected export earnings through crop losses but also caused large-scale human suffering and called into question the nation's continued dependence on large hydroelectric power systems. As a result, the development of petroleum-fired thermal plants is now viewed as an energy security necessity in Ghana. The current rate of electrification presents the challenge of providing energy in a suitable form to a large population, primarily rural but increasingly urban, while at the same time minimising greenhouse gas emissions (low-carbon development) to contribute to global climate change mitigation efforts.

System losses in electricity distribution are about 25%, with wastage in the end-use of electricity also estimated at about 30% (Ghana Energy Commission 2006). Losses in energy supply and inefficient use of energy contribute to the high levels of energy consumption. Higher ambient temperature levels due to climate change are a contributing factor to the increased transmission losses. Under a changed climate, lower precipitation, enhanced evaporation, and more frequent droughts will diminish water availability in the Lake Volta reservoir. In addition, the Akosombo Dam, which typically provides about 70% of the country's electricity needs, produces only 30% during periods of low water levels in the dam, which poses serious implications for industrialisation and private sector development. These periods of drought result in high $CO_2$ emission levels as Ghana resorts to thermal systems for electricity.

The residential sector was the second-largest contributor to total energy emissions between 1990 and 2006, contributing 32% of the total energy sector emissions (Ghana Energy Commission 2006). This is due to the increasing population and subsequent increase in consumption of biomass to meet domestic energy needs. Thus mitigation strategies for the energy sector will have to be closely linked with measures taken in the forestry sector. Broadhead *et al.* (2009) suggest that achieving climate change mitigation through forestry requires that forests are managed in ways that fundamentally reduce carbon emissions. The simplest way to mitigate climate change in this case would be to reduce all the uses of the forest that make it lose its reservoir and sink capacities unsustainably. Mitigation practices include maintaining or increasing forest land area, reduced deforestation, increased forestation and reforestation, reduced degradation, wildfire management, and increased use of wood products from sustainably managed forests. For society to benefit fully, forests must be managed for both mitigation and adaptation purposes. To effectively mitigate climate change in the context of energy poverty, Ghana would need to promote the cultivation of forest plantations, introduce and use improved charcoal stoves and improved charcoal production kilns. These could lead to greater efficiency in the energy sector and massively create jobs for rural communities involved in the plantations for sustained growth while at the same time delivering benefits from mitigation funding.

## Energy poverty and climate change in Ghana

Household energy consumption in Ghana is primarily for lighting and cooking. About 67% (24 890 GWh/yr) of total energy consumption in the household is used for cooking (Ministry of Energy 2008). The UNDP (2011) estimates that 90% of households in Ghana rely on traditional biomass (fuelwood and charcoal). It further estimates that every person in Ghana currently uses around 1 cubic metre or 640 kilograms of fuelwood per annum. The statistics indicate a strong attachment to fuelwood by households in Ghana, which must have contributed strongly to the activities responsible for the rate of economic growth recorded so far. The repercussions of such a fuelwood consumption pattern on forest resources are immense. High deforestation and forest degradation have resulted in a loss of biomass in Ghana and depleted the capacity for carbon sequestration as a means of combating climate change through the natural forests. Sustainable economic growth, however, requires a growth policy that also mitigates climate change.

Users of natural resource goods like fuelwood often find it difficult to adjust to potential reductions in their availability, because of the lack of affordable substitutes. Thus even though in Ghana fuelwood use should have been sensitive to availability, there is currently little tendency to switch to other sources of energy for cooking, even in the wake of climate change shocks. Land is directly affected by temperature increases and drought, floods leading to erosion, loss of fertility, and crop and resource damage. Vegetation, particularly forests, is thus affected, accounting for shortages in the availability of fuelwood or at least increasing the difficulty of accessing it. Biomass is a climate-sensitive renewable source of energy. This makes it more vulnerable to climate variability than other renewable sources of energy like solar and wind. The inelasticity of fuelwood use in relation to the cost of acquisition will mean a loss of welfare as the cost of acquiring fuelwood continues to increase for the average Ghanaian household through climate change shocks. This means breaking out of energy poverty could become more difficult than ever for Ghana unless very determined measures are employed to mitigate climate change through the forestry sector.

## Importance of low-carbon development to Ghana

The evidence of climate change vulnerability indicated above has rendered Ghana's development more complicated than ever before. It is expected that GHG emissions can be reduced at a much lower cost than the cost of energy poverty caused by business-as-usual actions. This requires a change in the way development policies are made, to include low-carbon development (LCD) strategies towards climate change mitigation. Specifically, a LCD plan which must be the starting point for LCD implementation is important to Ghana because it will: provide an effective tool to examine realistic climate change mitigation options; help policy makers identify low-carbon growth scenarios and opportunities; and facilitate informed decision-making in LCD. Afforestation and reforestation (A/R) of degraded forest lands and mangrove restoration present significant potential for climate change mitigation in Ghana, while generating financial flows from forest carbon activities under the CDM, REDD+, and possibly NAMA projects.

However, A/R CDM activities have remained underdeveloped compared to other CDM sectors, mainly as a result of the complexity of the A/R CDM procedure and the limited market demand for A/R CDM credits. Nonetheless, Africa holds a significant share in the global CDM forestry sector by hosting 30% of all A/R CDM activities, which represents 8% of CDM activities in Africa (UNEP Risoe 2012), altogether reflecting the continent's potential for abatement in the land use, land-use change and forestry (LULUCF sector. Despite efforts to enhance forest biomass, activities in agriculture and forest sectors are showing increasing trends in emissions. Avoiding just deforestation in Ghana has the potential to contribute approximately 38 million tons in $CO_2$ emission reductions every year. Reversing the trend, and adding reforestation to these estimates would increase this number even more (UNEP Risoe, 2013). The cumulative total cost of climate change adaptation from 2012 to 2050 is estimated to be $2.7 billion with real GDP projected to decline from negative 5.4% per annum (Global dry) to negative 2.1% per annum (Ghana wet) by 2050 (Ghana EPA 2010).

Thus, mitigation strategies in the forestry sector will to a large extent lead to a reduction in the cost of adaptation and ultimately address energy poverty. It is always true that forest conservation actions to mitigate climate change will reduce the cost of adaptation. For instance, in the case of soil erosion prevention due to floods, even if others decide not to cooperate, we would still be better off having implemented forest mitigation measures than not. Thus forest resource-based mitigation will always be beneficial, no matter what the outcomes of climate change-related actions of various actors.

For the household sector, the primary option for LCD is energy efficiency, making the sector a potential source of LCD in Ghana. The following areas can be potential LCD points for action in households in Ghana:

- switching to energy-saving light bulbs;
- replacing inefficient appliances with more energy efficient appliances;
- designing houses in such a way as to lower the need for cooling; and
- a cooking fuel switch from biomass to a low-carbon alternative.

It is worth noting that, among the action points identified, only cooking fuel-switching is directly related to energy poverty, making it the preferred example in the forestry sector based economic welfare analysis in the following sections. Fuelwood constitutes about 80% of the energy demand for cooking in Ghana. In rural areas the demand for fuelwood can be as high as 90% in some cases. These allow for reductions in the fuelwood needed for energy consumption, thereby having both positive economic welfare and GHG reduction effects (UNEP Risoe, 2013).

The Ghana Energy Commission (2006) estimated the average life cycle cost per annum for using fuelwood in Ghana to be USD 53.00. Ghana Statistical Service (GSS) (2008) data shows that 80% of households in Ghana use fuelwood, which translates to about 4.4 million households. This brings the household expenditure on fuelwood to USD 233.20 million per annum (ie.USD 53 × 4.4 million households). Since the expenditure expresses the revealed monetary value of the demand for fuelwood, if all the fuelwood is collected very close to consumers' homes, then the USD 233.2 million is the monetary value which fuelwood users place on the commodity per annum. (A travel cost model approach has been used to derive an alternative value for fuelwood in Ghana, and is provided as an appendix to this paper.) This is also a measure of the benefit they will lose per annum if they cannot have access to fuelwood. Thus any policy which seeks to move fuelwood users from fuelwood use must be in the position to compensate them with this amount of money to ensure their welfare does not decrease.

### Household switching from fuelwood

In considering a switch from fuelwood to more modern and efficient energy forms for the Ghanaian economy, two key sectors will be crucial – the informal and commercial/service sectors and households. The discussion is therefore based on these two sectors because they constitute over 95% of the users of fuelwood for energy in Ghana. All the official data in this section were obtained from Ghana Energy Commission (2006) publications, the only body mandated by the Government of Ghana to produce such data for official purposes.

For the household sector, cost considerations and availability seem to be the most prominent issues in a shift from firewood to charcoal and then to other cooking fuels such as LPG, kerosene and electricity. Costs involved in the various cooking modes as computed by the Ghana Energy Commission are indicated in Table 2.

**Table 2: Costs of using various cooking devices in Ghana**
*Source: Ghana Energy Commission (2006)*

| *Device* | *Initial investment cost (USD)* | *Total annual cost (USD)* |
|---|---|---|
| Three stone – mud firewood stove | 0 | 44–62 |
| Traditional charcoal stove | 1.5–3 | 67–80 |
| Improved '*Ahibenso*' charcoal stove | 10 | 37–43 |
| LPG (1-2 burner) cooker | 30–50 | 83–98 |
| Electric (one-two burner) cooker | 20–50 | 81–93 |
| Kerosene (1-2 burner) cooker | 17–25 | 138–161 |

Even though there is no initial capital investment in making a three-stone or mud firewood stove, particularly in rural areas, it is more expensive to use when compared with improved charcoal stove in the case where firewood is purchased. Otherwise, the three-stone or mud firewood stove is the least expensive cooking device and has the lowest life-cycle cost as well. For health reasons, however, it will be wise to encourage a switch from firewood stove to charcoal stove usage, but that involves an initial capital investment of about USD 10.00.

On the environmental front, charcoal usage consumes more wood than firewood does, and is not an attractive option for CDM and other large climate change-related financial facilities. Charcoal usage leads to higher GHG (methane) emissions because it takes between four and six units of wood to make a unit of charcoal, whilst firewood is used directly from the field.

A switch from fuelwood usage to kerosene for cooking is the most expensive option in terms of annual expenses. Secondly, kerosene is a fossil fuel and so the shift is not environmentally attractive. A switch from fuelwood to electricity for cooking presents the cleanest option in terms of indoor pollution. However, it is not climate change-neutral if the electricity is a product of thermal-based generation. Carbon dioxide emission from fuelwood is neutral in terms of global warming whilst emissions from fossils are non-biogenic. There is also the issue of availability, since national electricity access is still less than 55% in real terms (UNEP Risoe, 2013). The most advocated option is the switch from fuelwood to liquefied petroleum gas (LPG), since the latter is quite 'environmentally' friendly. LPG is a cleaner fuel in terms of indoor pollution, with far less emissions of particulate matter, acidic and other pollutants. Other renewable sources of energy are not viable yet due to cost and technical reasons, and hence are not discussed.

The LPG required to substitute for fuelwood in a LCD scenario will be 750 000–1.9 million tonnes by 2012–2015; and 950 000–2.8 million tonnes by 2020 (Ghana Energy Commission 2006). This additional LPG demand is likely to put a lot of pressure on the crude oil refining capacity of the country, unless the LPG shortfall is imported. This can create an opportunity to increase the refinery capacity of the country and boost gas cylinder manufacturing in the country. Introducing LPG to rural users will, however, require an efficient distribution network and back-up support to control potential gas accidents associated with it and occasional shortages due to distances from retailing centers. Mobile LPG retailers exist but have higher premium than stationary retailers. For rural areas (where the effect may be greatest), it will be a significant extra payment to make, unless rural supplies are targeted and subsidised.

The switch from fuelwood use to LPG for residential cooking and heating has probably been the boldest step taken so far to mitigate climate change in the energy sector of Ghana. Such a policy had the capacity to reduce deforestation and forest degradation. It also led to the creative and increased use of LPG as fuel in the road sector. Many commercial drivers rapidly converted their gasoline-based commercial passenger vehicles to LPG, realising it was more cost-effective. However, the adoption of LPG for commercial vehicle use has of late created some shortages for household users and has tended to defeat the purpose of promoting LPG use. Net benefit comparisons are made for the switch from fuelwood to LPG as a demonstration of the net welfare effect of an energy poverty-based LCD initiative in Ghana, in the next section.

## Welfare analysis: Net benefit comparisons for LCD

Even though the switch from fuelwood has been analysed for various energy sources in the previous section, the switch from fuelwood to LPG is considered the most feasible alternative (Ghana Energy Commission 2006) due to cost and technical issues. It is, however, worth assessing whether the net benefit of LPG use as a LCD measure surpasses that of fuelwood (business-as-usual) in Ghana. Ghana's LPG programme was initiated in 1990 to promote the use of LPG as a substitute for charcoal and firewood in order to slow down the rate of deforestation caused partly by the production and use of wood fuels (Damptey & Mensah 2008). The programme has, however, been derailed to a large extent as a result of cost, organisational and structural deficiencies. Nonetheless, the net benefit implications are relevant to inform policy on the possible way out, which can ensure continued growth in the face of climate change challenges.

The use of fuelwood does not come with any installation cost, since the tripods used are moulded out of common clay found in abundant quantities in Ghana. The total cost of use per year, as computed by the Ghana Energy Commission (2006), in cases where fuelwood is bought as shown in Table 2, is a maximum of USD 62 per annum. LPG (with a one-two burner cooker) however has a maximum initial installation cost of USD 50 and then a cost of use of USD 98, making a total of USD 148. Thus the cost difference in switching from fuelwood to LPG is about 239% of the cost of using fuelwood. This will be higher in cases where fuelwood is collected near consumers' homes and not bought.

Since the expenditure on fuelwood in the business-as-usual case derived earlier is USD 233.2 million per annum, the expenditure on LPG will be 239% of USD 233.2, which is equal to USD 557.35 million per annum. This means for LCD action to provide the same benefit as fuelwood in a business-as-usual case a subsidy of USD 324.15 will be required annually to ensure households use LPG instead of fuelwood in Ghana. This subsidy will excessively add to the already heavy government subsidy burden in the energy sector, which the government is trying to offload to consumers to improve efficient use of available energy resources.

The current subsidy for LPG of USD 110 million from the government of Ghana (IMANI Ghana 2011) is for all users of LPG. Based on use patterns, it has been estimated that USD 80 million of this subsidy goes to urban and peri-urban users, whose use of it is of less LCD value than for those who will need to switch from fuelwood (IMANI Ghana 2011). Thus, only about USD 30 million of the subsidy goes to supplement LPG for a supply that meets only about 45% of the domestic need. To meet the full domestic need, the remaining LPG must be imported, considering the current operational challenges of refinery activities in Ghana. This comes with a huge cost to growth, with the potential of creating a worse situation of export dependency. Currently the greatest problem with LPG use even by the affluent in Ghana is the lack of availability. The uncertainty that has come to be associated with LPG shortages in Ghana has not been a good sign for the switch from fuelwood to LPG. Clearly the net benefit of switching to LPG from fuelwood is negative given the current income and energy situation in Ghana. This implies a switch imposed on the status quo will lead to a decrease in welfare. Ghana appears trapped in a fuelwood energy trap and therefore energy poverty in the short-to-medium term. The only alternative left is to continue to use biomass; this compounds the issue of GHG emissions through persistent deforestation and degradation of forest resources, posing a serious threat to climate change mitigation.

## Conclusion

Forest and grassland conversion through deforestation activities has been the major cause for the declining $CO_2$ removal capacity (sinks) and increased emissions in the forestry sector of Ghana. The drought of the early eighties (1980 to 1983), and also in recent times, not only affected export earnings through crop losses but also caused large-scale human suffering and called into question Ghana's continued dependence on large hydroelectric power systems. As a result, the development of petroleum-fired thermal plants is now viewed as an energy security necessity in Ghana. This trend, which will increase due to climate change, remains one of the threats to LCD in Ghana's energy sector.

Mitigation strategies for the energy sector will have to be closely linked with the forestry sector. This makes policy coordination essential between the forestry and energy sectors of Ghana's economy, to prevent deforestation while simultaneously supporting better energy security.

There is currently no competitive alternative to fuelwood as the most important household fuel in Ghana. A subsidy worth three times the current subsidy will be needed to ensure fuelwood users switch to LPG and remain as well off as they were before the switch, so as to mitigate climate change. Such a measure will also serve the purpose of getting the country out of energy poverty. However, Ghana's practical situation shows it is not prepared enough to eradicate energy poverty. This means the high dependence on fuelwood by households is bound to continue. Growth policy projects an increase in fuelwood use as incomes and population increase. This trend makes the Ghanaian energy sector very vulnerable to climate change shocks, a major contributor to forest degradation, an increasing contributor to GHG emissions, and eventually a source of decreasing welfare. Promoting cultivation of energy forest plantations, introduction and use of improved charcoal stoves and improved charcoal production kilns could lead to greater efficiency in the energy sector and create massive jobs for rural communities involved in the plantations for sustained growth while at the same time delivering benefits from climate change mitigation funding.

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## Appendix: The travel cost model

A travel cost model was used to determine the economic value of fuelwood (though other methods like the contingent valuation method, the loss of productivity and the hedonic price models could have been used to derive this value). This could subsequently be used to derive the net welfare change for households switching from fuelwood as a potential LCD policy. The use of the travel cost model yields a welfare value for fuelwood based on fuelwood collected for use - the most practical way of capturing the value of current fuelwood demand in Ghana. For LCD policy purposes, a similar study needs to be done for charcoal, which potentially has an equally devastating effect on LCD actions, particularly in urban Ghana. For a fuller appreciation of the drivers of household energy consumption, further research is suggested using the contingent valuation method, which captures total economic value unlike the travel cost approach which reveals only use value (which was the most relevant value concept for this paper). The following sections provide the travel cost model application.

### *The model*

The travel cost model portrays a simple concept of the cost of fuelwood collection. This concept is embedded in the fact that every collector and or user of fuelwood pays a price measured by his/her travel costs (Johansson 1987).Thus a change in travel cost to collect fuelwood results in a change in economic welfare due to changing costs that the household has to bear. This principle was first used by Clawson (1959) after being proposed by Hoteling to the director of the US Park Service in 1947 (Johansson 1987). The model is widely used by government agencies in the United States and increasingly in the United Kingdom, for example, by the Forestry Commission (Willis & Benson 1989).

The travel cost model is technically and essentially an example of a conventional household production function model (Garrod & Gillis 2001). These models investigate changes in the consumption of commodities that are substitutes or complements for each other. The application of this principle for evaluating preferences for fuelwood in Ghana over and above more efficient alternatives allows the use of the travel cost model. The early literature on valuation of non-market resources abounds with the use of travel cost models for recreational values, but that was a very limited use of the travel cost principle. With improved understanding of the model, recent literature has several uses of the model for valuing clean water, fuelwood, health care demand, etc. In principle, the model can be applied to any good whose consumption involves travel-related costs.

### *A methodological framework*

The travel cost model seeks to place a value on non-marketed environmental goods by using consumption behaviour in related markets. It is a survey technique. A questionnaire is prepared and administered to a sample of visitors at a site in order to ascertain their place of residence, necessary demographic and attitudinal information; frequency of visits to sites; and trip information such as purposefulness, length and associated costs. From these data, visit costs can be calculated and related, with other relevant factors, to visit frequency so that a demand relationship may be established.

In the simplest case, this demand function can then be used to estimate the value of the commodity that attracted the consumer to the site or the value of the whole site. Also, in more advanced studies, attempts can be made to develop demand equations for the differing attributes of sites and values evaluated for these individual attributes. The demand function estimated by the model is an uncompensated ordinary demand curve incorporating income effect, and the welfare measure obtained from it will be that of Marshallian consumer's surplus (Bateman 1992).

However by Willig's approximation, specifically, the costs of consuming the services of the environmental asset which attracted a consumer to the site are used as a proxy for price of consuming the commodity. These consumption costs will include travel costs, entry fees, on-site expenditures and outlay on capital equipment necessary for consumption. The Model cannot estimate non-user values. An implicit assumption made in most travel cost studies is that the representative visitor's utility function is 'separable' in the activity being modelled. This means that, if the activity of interest is fishing, then the utility function is such that demand for fishing trips can be estimated independent of demand for say hunting trips (alternative leisure activities). Travel costs (C) depend for a given site 'j' on several variables.

$$C_{ij} = c(DC_{ij}, TC_{ij}, F_i)$$

Where $i=1,\ldots,n$, $j=1,\ldots,m$. $DC_i$ are distance costs in cedis for each individual 'i', dependent on how far he/she has to travel to visit the site and the cost per mile of travelling. TC are time costs in cedis: these depend on how long it takes to get to the site and the value of an individual's time. F is the fee if any, which is charged for entrance to site j. Travel costs (C) are included in a trip generating function (TGF) which predicts how may visits (V) will be undertaken by any individual i to site j. Also included in the TGF for an individual would be socio-economic characteristics such as incomes, education and age level, as well as variables giving information on the type of trip.

The alternative to the individual travel cost model as described above is the zonal travel cost model. This was the version employed by Wood and Trice (1958) and Knetsch and Clawson (1966). The zonal approach entails dividing the area surrounding the site to be valued into 'zones of origin'. These may be concentric rings around the site, but are more likely to be selected with regard to local government administrative districts (such as counties and states). Measuring the area under the obtained demand curve gives an estimate of consumers' surplus per visit. Travel cost models are often estimated for particular sites, such as Hanley's (1989) study of Achray Forest in Central Scotland. However, the approach can also be applied to groups of sites, for example, Willis and Benson's work on UK forests (1989). The literature reveals a few basic problems. These include the choice of Dependent Variable. Two basic options exist for choosing the dependent variable. These are (i) visits from a given zone; and (ii) visits made by a given individual. Option (ii) is usually implemented by collecting data on visits per annum for each respondent (VPA). Option (i) is frequently expressed as visits per capita V/pop. There is no consensus in the literature as to which option is preferable on theoretical grounds. Brown *et al.* (1983), for instance, advocate V/Pop, while Common (1988) advocates VPA.

Hanley and Spash (1993) used the model in a study of a wildlife site in eastern England particularly valued by bird watchers. They converted distances into travel costs using a marginal cost per kilometre. Time cost both on-site and travelling were set at zero. Their regression equation which was a log- linear function showed that the travel cost variable was significant at 95% level and correctly signed (that is negative).

Smith and Kaoru (1990) examined 77 US travel cost studies for which consumer's surplus per visit figures were obtainable. To give an econometric explanation of the figures obtained they related them to the treatment given to substitute sites, opportunity cost of time, type of activity, type of site and functional form. They were able to explain 43% of the variation in consumer's surplus figures and could also predict the effect of the employment of a particular functional from or treatment of travel time on consumer's surplus.

### *Distance costs*

After data has been collected on the distance travelled by respondents to the site in question, this variable is converted into a 'cost of distance travelled' variable. This involves setting a price per mile, which requires choosing between two options:

- use of petrol costs only as an estimate of marginal cost, or
- use of 'full cost of motoring', figures to include an allowance for depreciation and insurance.

Consumer's surplus figures will depend on the choice. It is assumed that Individuals, in maximising utility, compare the marginal utility with marginal costs of consumption; this makes option (1) more attractive, since option (2) is a measure of average costs. In an Achray forest study by Hanley (1989) when full cost data was used he obtained a total consumer's surplus of GBP 402 023 per annum, while the use of petrol costs only gave GBP 160 744 (Hanley & Spash 1993).

### *The value of time*

In the household production function approach to recreation demand modelling, consumers combine several inputs to 'produce' recreation service flows. Principal among these inputs are visits, equipment and time. Time is expended both in travelling to a site and while recreating on the site. As a scarce commodity, time clearly has an implicit (or shadow) price.

Chevas *et al.* (1989) provide recent estimates of the value of time. They distinguish between the opportunity cost measure of travel time and the 'commodity value' measure of travel and on-site time. Time has a positive commodity value if its consumption directly generates positive utility. On-site time clearly has a positive value, while travelling time may have a positive or negative value. Chevas *et al.* used a household production function approach to estimate this commodity value for recreational boating in East Texas, looking at travelling time alone. They found the commodity value of travel time to be small but positive, varying across sites and reaching a maximum of USD 0.41 an hour.

After reviewing empirical evidence, Cesario (1976) valued the opportunity cost for time to be one-third of the hourly wage rate. Using a simulation process, and choosing the value which maximised the $R^2$, McConnel and Strand (1981) and Common (1973) also estimated a value for time. Comparing results from the Cesario, McConnel/Strand and full-cost (hourly wage) alternatives for 23 recreation sites in the USA, Smith and Desvouges (1986) found that the full cost and Cesario alternatives were rejected (at the 10% level) in 7 cases. However, the McConnel/Strand method fared worse in terms of the variance of its estimates (Hanley & Spash 1993).

### *Statistical problems*

The dependent variable is both censored and truncated. 'Truncated' means that as only visitors to the site are recorded, there is no information on the determinants of the decision to visit the site. Also, visits are only recorded during the sampling period and may thus incorrectly describe the preferences of those visiting at other times of the year. 'Censored' means that less than one visit cannot possibly be observed. This implies that the dependent variable (visits) is censored at one, and that OLS estimates of demand parameters will be biased (Smith and Desvouges, 1986). The solution to truncated problems is to use a maximum likelihood (ML) estimator instead of OLS. Data shows that OLS gives larger consumer's surplus estimates than ML. The choice of the appropriate functional form can also be problematic (Hanley and Spash, 1993).

### *The value of fuelwood in Ghana*

The travel cost model therefore provides a measure of willingness to pay for fuelwood based on travel cost data. The two basic means by which travel costs are computed are the individual travel cost and zonal travel cost. The individual travel cost computes travel cost for individuals, while the zonal travel cost computes travel cost for groups of people based on their average distance from the point where the facility to be benefited from is located. The paper's welfare measure is equivalent to the consumers' surplus obtained through the consumption of fuelwood as a household energy source (Johansson, 1987).

Even though not heavily forested, the northern savanna zone of Ghana has been well known for its nationwide supply of biomass for energy. The Tamale metropolis is the largest settlement in Northern Ghana and acknowledged to be one of the fastest growing cities in West Africa, with a population of about 293 881 (Ghana Statistical Service (GSS 2000). The metropolis lies between the latitudes $9^0$ $18^1$N and $9^0$ $26^1$N and longitudes $1^0$ $15^1$E and $1^0$ $23^1$W. The choice of Tamale was deemed appropriate since the use of fuelwood there was well established and probably the largest in Ghana. Two main modes of acquiring fuelwood exist in Ghana – through collection and purchases. In most urban centers commercial and large household users purchase fuelwood from sellers at very moderate prices depending on the season and also tree species. However, most household users collect fuelwood freely from nearby wooded vegetation.

Face-to-face interviews were used to elicit responses from respondents who were household heads in 2010. The number of trips to fetch fuelwood from various sites was the sum of trips of all members of the household who went to fetch fuelwood. Communities were selected by simple random sampling, while households were selected through a second stage systematic sampling. The total number of communities which used fuelwood was 179, out of which 100 communities were selected. Given a total population of households using fuelwood in the Tamale municipality as 20 407 (GSS 2000) a sample size of 392 was computed. The respondents provided the distances they covered and the times used to collect fuelwood as well as some socio-economic data.

A zero price was assigned for fuelwood collected. Sellers of fuelwood would normally price the product based on where they went to collect the wood and the cost of transportation to the point of sale. The wood itself is normally freely obtained in most cases. The travel cost (TC) in this case represents the cost of collection, which is its implicit price. Travel distance costs were based on fares of locally used means of transport (called 'tro-tro'), commonly used by low income earners in Ghana, while time cost (opportunity cost of time) was one-third of the minimum wage as used by Cesario (1976). Thus the functional form of the travel cost model used was $TC = f\ (TN + TM)$ where *TC* is total cost of travel to collection site, *TN* is cost of transportation to site and *TM* is time cost to site.

### *Results of travel cost estimation*

Using the zonal travel cost estimation, households were grouped according to their distances from the places of fuelwood collection: Zone 1 being the nearest with mean distance of less than 2 km, Zone 2 with mean distance of 3 km, Zone 3 with a mean distance of 6 km, Zone 4 with mean distance of 9 km and Zone 5 being the furthest with mean distance of 12 km (a detailed account of the use of the TC model can be found in Garrod & Willis (1999).

Table A1 shows the computation of the TC per trip of fuelwood for each household member in Tamale. Based on the fact that it is mainly women and children who pick fuelwood, and given an average family size of 5.5 for the region, about 3 members of the average household normally go out to fetch fuelwood. This makes the TC per year 108 051.32 x 3 = GHS 324 153.96. About 80% of households predominantly rely on fuelwood for their energy needs in Ghana (GSS 2008). This brings the total number of households in Ghana using fuelwood to 4.4 million. Thus if for the households sampled the TC to fetch fuelwood per year is GHS 324 153.96 for 20 407 households, this translates to GHS 15.88 per household. Therefore, the total travel cost for the 4.4 million households would be GHS 69.87 million, which is an equivalent of USD 43.67 million per annum.

Since the travel cost model estimation shows the value placed on the commodity, the USD 43.67 million represents the value placed on fuelwood by its users in Ghana per annum. This is also described as the benefit derived from consuming fuelwood by households in Ghana per annum. Thus the consumers' surplus (welfare value) of fuelwood use in Ghana is USD 43.67 million per annum.

**Table A1: Computation of annual travel costs for fuelwood collection in the Tamale municipality in Ghana cedis (GHS) [USD1.00 = GHS1.60]**

*Source: Author's field work in 2010*

| Zone (a) | % of households (b) | Population of households (c ) | TC per visit (GHS) (d) | No. of visits per year (e ) | TC per year for population (GHS) (f = d x e ) |
|---|---|---|---|---|---|
| Zone 1 | 19.9 | 4 061 | 0.56 | 25 324 | 14 181.44 |
| Zone 2 | 53.3 | 10 877 | 0.58 | 65 884 | 38 212.72 |
| Zone 3 | 20.7 | 4 224 | 3.98 | 10 764 | 42 840.72 |
| Zone 4 | 2.0 | 408 | 6.77 | 572 | 3 872.44 |
| Zone 5 | 4.1 | 20 407 | | 103 376 | 108 051.32 |

# Visualising development impacts: Experiences from country case studies

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***Abstract***

The historical institutional divide between development goals and tackling man-made climate change is disappearing. On the one hand, development activities are increasingly being judged against their compatibility with climate change and, on the other hand, the dialogue around climate change is being reframed to recognise the national priorities of developing countries to improve their economies, societies and environment. An example of this can be seen in the emerging United Nations Framework Convention on Climate Change concepts of Low Emission Development Strategies (LEDS) and Nationally Appropriate Mitigation Actions. In this context there is a need to understand the impacts of countries' actions from both a development and mitigation perspective. To do this a development impact assessment (DIA) visual was developed within the LEDS Global Partnership. It links an action's development impacts with its mitigation potential and cost, in order to provide a more comprehensive basis for decision making and communication, as compared to mitigation analysis using marginal abatement cost curves alone. The output can be used within government or with development partners and other stakeholders to help demonstrate priorities, communicate impacts and compare different low-carbon actions. This paper discusses the application of the DIA visual through three country case studies in Ghana, Kenya and Montenegro. These pilot experiences demonstrate several strengths of the visualisation: its flexibility to complement other planning processes; its ability to communicate qualitative information about development impacts; and its potential to support sector-specific and economy-wide decision making. At the same time the experiences provided important lessons around: the country and policy context sensitivity of development impacts; the challenges in using qualitative assessments of impacts; participatory stakeholder DIA processes; and the practical limitations of using prioritisation tools in the policy making process.

*Keywords:* climate change, sustainable development, low emission development, assessment frameworks, mitigation

## 1. Introduction

Development activities are increasingly being judged against their compatibility with climate change, indicating a growing need to understand the impacts of actions from both development and mitigation perspectives. At the same time, the dialogue around climate change is being reframed to recognise the national priorities of developing countries to improve their economies, societies and environment. Although there is a relatively long history of assessing sustainable development impacts of low-carbon projects, for example in relation to the Clean Development Mechanism (CDM), few tools are available to decision-makers at the national or sector level for high-level planning and strategy.

Several tools have been used to help analyse and present development and climate impacts. Examples include cost-benefit analysis (CBA), with a focus on quantifying various impacts in economic terms, and marginal abatement cost (MAC) curves, which consider the costs of achieving climate (specifically mitigation) impacts. These tools can provide valuable insights, but they tend to exclude certain types of benefits that are more difficult to include in the frame of their analytical approach (for example, climate impacts in CBA, or social impacts in a MAC curve).

This paper reviews the development impact assessment (DIA) visual, a tool that aims to link an action's development impacts with its mitigation potential and cost. Developed within the Low Emission Development Strategies Global Partnership (LEDS GP), the tool is intended to provide a simple way to communicate development benefits and facilitate decision-making around low-carbon interventions. The output can be used within government or with development partners and other stakeholders to help demonstrate priorities, communicate impacts and compare different low-carbon actions. The paper first provides a brief discussion of the history of development impact assessments, and how these assessments have influenced decision making. Section 3 introduces the DIA visual, followed by a summary of three case studies of the DIA visual in Montenegro, Kenya and Ghana in Section 4. The Ghana case study, as unpublished work and the first live application on the visual in a workshop setting, is described in more detail than the other two cases. Section 5 describes lessons learnt from the three pilot applications and the conclusions provide ideas for improving the DIA visual, drawing on experience with the tool in Ghana, Kenya and Montenegro; as well as input from the LEDS GP meeting held in Manila in October, 2013.

## 2. The CDM and early LEDS experiences: Assessment of development impacts

Low-emission, or low-carbon, development strategies are expected to result in greenhouse gas (GHG) mitigation as well as help to meet broader national development goals, such as poverty alleviation, economic growth and energy security. DIAs can help governments determine if low-carbon actions contribute to meeting these development goals. In addition, they can be helpful in monitoring sustainable development impacts by identifying the areas that need further research, elaboration and development of detailed indicators. Development impacts are typically assessed using the three pillars of sustainable development: economic, social and environmental impacts.

The term 'sustainable development' has existed for decades, yet no coherent set of quantified goals, targets and indicators exists to measure its progress (UNEP 2012). Twenty-five years ago, the 1987 World Commission on Environment and Development proposed to develop new ways to assess this progress. This was echoed in subsequent international summits and agreements on sustainable development, including the first Rio Summit in 1992, the Johannesburg Plan of Implementation in 2002, the UN Commission on Sustainable Development, and the Millennium Development Goals. These efforts have influenced sustainable development assessments, including those taken under the CDM and early efforts to measure development impacts under LEDS and Nationally Appropriate Mitigation Actions (NAMAs).

This section provides a brief discussion of the history of development impact assessments. The review draws on the experience of the CDM and early lessons from low-carbon development strategies in Kenya and Guyana, focusing on how the impact assessments have influenced decision-making.

### *Development impacts in CDM*

A variety of tools and approaches have been used to assess development impacts in CDM projects, helping host governments, developed country governments and private sector investors select CDM activities that bring positive sustainable development impacts. The voluntary CDM sustainable development (SD) tool was approved by the CDM Executive Board in November 2012 to assist project participants in describing the sustainable development co-benefits of their CDM activities against established criteria. This tool aims to provide sound qualitative and quantitative criteria for describing sustainable development impacts, consistency across SD evaluations, and a means to report on aggregated performance of sustainable development co- benefits for various types of CDM activities in various host countries over time

(UNFCCC 2012a; 2012b). Other important tools in the CDM with staying power and broad reach include the Gold Standard and the Climate Community and Biodiversity Alliance for land-use projects.

Developing-country decisions to pursue or approve CDM activities have been influenced by outcomes of sustainability assessments. For example, early in the development of CDM activities, Uruguay stressed the importance of sustainable development benefits as a criterion for approval of CDM activities, and developed and used the sustainability assessment tool, Multi-Attributive Assessment of CDM Projects, to facilitate a quantitative assessment of potential projects regarding their contribution to sustainable development (Heuberger *et al.* 2008). Several studies have attempted to determine if the CDM contributed to sustainable development, and what types of projects created the most benefits (see for example Cosbey *et al.* 2005; Olsen & Fenhann 2008; Sun *et al.* 2010; TERI 2012). This body of work generally determined that the greatest level of co-benefits could be generated through renewable energy, energy efficiency, agriculture and forestry activities if they account for sustainable development early in the design phase.

Two examples of how sustainable development assessments have impacted country decisions are described below.

- *Example 1:* Actions by the government of China were influenced by initial studies of the sustainable development impacts of CDM projects. China decided to impose a tax on revenues from CDM projects, with proceeds going to a sustainable development fund. CDM activities considered to contribute less to sustainable development were taxed at a higher rate, with hydrofluorocarbon decomposition projects taxed at rate of 65% compared to 2% for renewable energy projects (KPMG 2009).
- *Example 2:* Early identification of CDM projects by Sweden included an assessment of sustainable development impacts (Arvidson 2002), and the Swedish Energy Agency currently focuses investment on small and medium sized renewable energy or energy efficiency projects that make a strong contribution to sustainable development. An example is the purchase of credits from a improved cooking stove project in Ghana. The Agency paid above market price for the credits, with the decision driven by a desire to invest in CDM activities that demonstrate real development benefits at the community level (Owino 2013).

### *Considering development impacts in LEDS*

Most LEDS state the importance of sustainable development in the identification of priority actions, yet few strategies have a robust assessment of development impacts to inform implementation decisions. Current impact assessment approaches used for LEDS and NAMAs are often based on 'subjective scoring with little knowledge about the data informing it' (Olsen 2012: 17). The strategies often make the assumption that low-carbon actions will always have helpful environmental, social or broader economic effects, or that that sustainable development needs and priorities will be addressed through adaptation plans and actions. Two examples are set out below.

- Example 1: Brazil's LEDS include commitments to, and stressing the importance of, sustainable development (de Gouvello 2010), but does not go beyond broad assumptions that low-carbon growth is good for economic development and will generate multiple benefits.
- Example 2: Ethiopia's Green Economy Strategy identifies priority actions using a screening process that includes examining appropriate GHG abatement technology as well as potential contributions to and alignment with the Growth and Transformation Plan's objectives. An OECD review cautioned that GHG abatement in agriculture, livestock and forestry especially, but also in power and transport, will not always have positive development impacts. For example, proposals to reduce emissions in the livestock sector by shifting beef producers to poultry may result in GHG abatement, but they are extremely challenging and do not necessarily have positive sustainable development impacts. Such actions could cause considerable social upheaval and remove ecologically optimal use of rangelands (Bass *et al.* 2013).

LEDS and DIA are relatively new ideas, yet lessons on how DIAs have influenced decision-making can be learned from early actors. The three case studies discussed in this paper provide insights from the first applications of one particular way of describing development impacts, the so-called DIA visual.

## 3. DIA visual

The DIA visual was developed by the National Renewable Energy Laboratory, the Energy Research Centre of the Netherlands, the International Institute for Sustainable Development and the Gesellschaft für Internationale Zusammenarbeit within the LEDS GP (Cowlin *et al.* 2012). The DIA visual links an action's development impacts with its mitigation potential and cost in order to provide a more comprehensive basis for decision making and communication – as compared to mitigation analysis using MAC curves alone. The process and results attempt to combine climate impacts – which are often relevant to an international

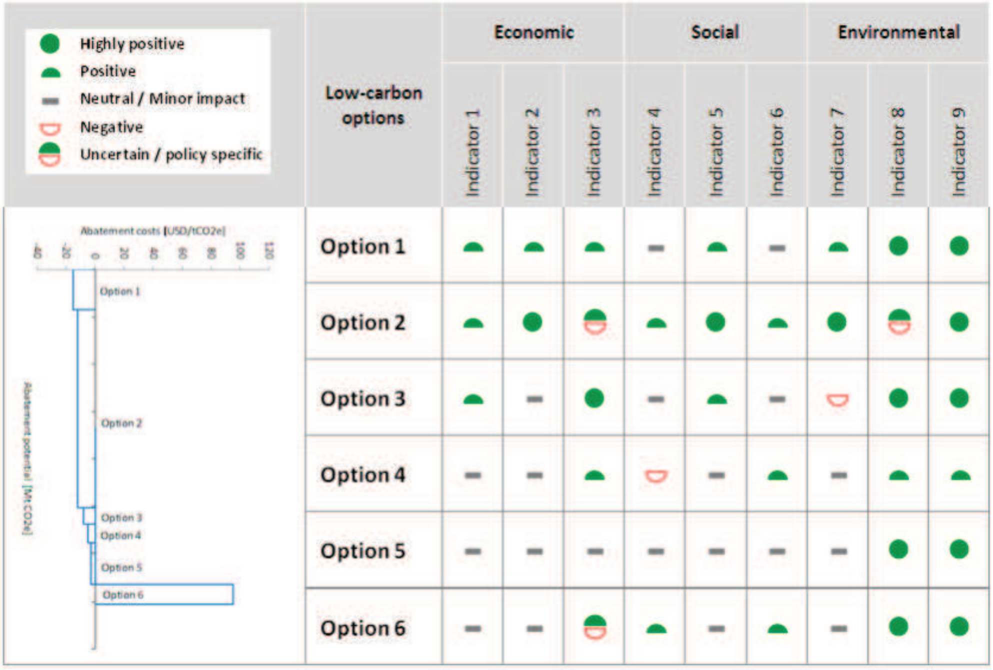


**Figure 1: Conceptualisation of the DIA visual**

audience of negotiators and donors – alongside development impacts – which are most relevant for domestic stakeholders.

The visual includes both the information found in MAC curves and an assessment against different development indicators based on an impact scale (Figure 1). On this scale impacts can be depicted as 'highly positive', 'positive', 'neutral or minor impact', 'negative' or 'uncertain / policy specific'. In its application, the visual is flexible; it can be used with or without MAC information and with various development indicators and scales, depending on interests, circumstances and data availability. A key benefit of the DIA visual is that it provides a framework for identifying and assessing impacts through a structured process; each low-carbon option's impact, with regard to each indicator, is assessed in turn, building up a fuller understanding of overall impacts.

There is no predefined guidance for how these impacts should be assessed. They can be assigned through quantitative analyses (for example, a calculation of the number of jobs created) or qualitative analyses (based on expert judgment and supporting evidence, for example) depending on data availability and method preferred by stakeholders. In that sense, the application of the DIA visual is flexible, yet it provides a simplified method to compare options using multiple criteria of most interest to stakeholders (Cox *et al.* 2013). Reflecting this flexibility, Cox *et al.* consider a case study that extends the DIA visual with indicators for 'Ease of implementation'; showing both development impacts and barriers on the same visual.

The DIA visual, therefore, has a relatively open-ended scope (in terms of what types of indicators or impacts are considered) and can be more or less rigorous depending on how these impacts are estimated. Figure 2 tries to show different tools (that could be used for assessing climate or development impacts) on two spectrums of scope and complexity, simply to give a sense of where the DIA visual could be considered to 'fit' versus other tools. Nearly all of the tools in Figure 2 can be applied in different levels of detail; for example, accounting for more or fewer impacts, so this picture should be considered as a conceptualisation only. The key point is that the DIA visual is methodology-neutral, in terms of how impacts are actually assessed, and flexible in terms of scope by changing the number and nature of indicators used.

The main strengths of the DIA visual include the following:

- It facilitates discussion and communicates findings to assist in prioritisation exercises. The DIA visual can facilitate comparison of technology and policy options by providing information on the initial assessment of development impacts and mitigation impacts.
- It raises awareness of the importance of assessing development impacts, and helps to build consensus among stakeholders that mitigation and development impacts are both important components of policy and programme decisions.
- It presents an overview of mitigation and development impacts in a concise manner. The results of the tool can generally be illustrated on one page,

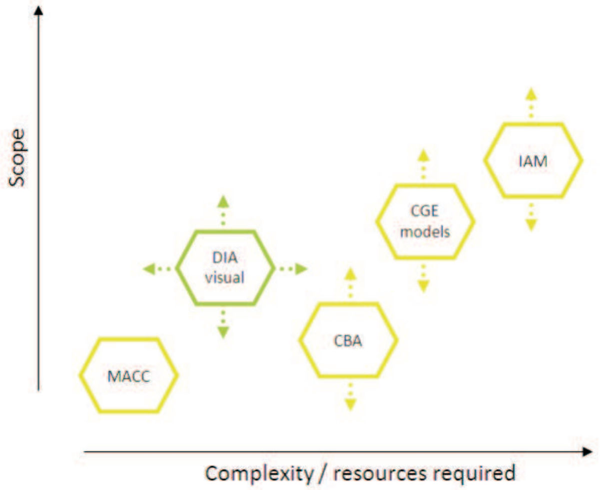


**Figure 2: Conceptualisation of the relative complexity of different tools versus their scope (in terms of considering impacts and interactions)**
*(MACC = marginal abatement cost curves; CEA = cost effectiveness analysis; CBA = cost benefit analysis; CGE = computable general equilibrium; IAM = integrated assessment model)*

which can be helpful in briefing senior level officials, conveying messages in stakeholder discussions, and succinctly presenting the rationale for action in a specific area in discussions with potential funders.

- It provides information on positive and negative impacts, rather than co-benefits. Not all impacts are positive, and it is important to provide a balanced view. This helps to improve the understanding of benefits and trade-offs, recognizing that work is still needed in this area.
- It identifies critical areas of potential development impact, which can be an initial input into the development of indicators, and the design of monitoring and reporting systems for the implementation of technology and policy options.

## 4. Case studies

This DIA visual has now been applied in Ghana, Kenya and Montenegro and this paper presents lessons from these three country applications, with a focus on the most recent study in Ghana. In Kenya and Montenegro the assessment of impacts was developed based on stakeholder feedback and local input, but the initial assessment was carried out by experts involved in those efforts. In Kenya, a team of international and local experts engaged to undertake a low-carbon scenario assessment used expert judgment and supporting evidence to complete the DIA visual. The overall assessment of impacts was then validated at sector stakeholder workshops and through written responses (Cox *et al.* 2013). In Montenegro, the visual was applied to summarise outputs from a technology needs assessment (TNA) process and was largely populated by expert consultants. While this approach did leverage outputs from the stakeholder consultations that took place during the TNA process, it was concluded that the outputs would benefit from further input and discussion with stakeholders to validate the findings (Cox *et al.* 2013). In Ghana, the DIA visual was applied as a case study to six options in the energy sector, with the explicit aim to apply the tool in a 'live' setting with stakeholder involvement. This was the first time that an assessment of development impacts was done collaboratively using the DIA visual with a group of country stakeholders.

The Kenya and Montenegro cases are briefly summarised here. Cox *et al.* (2013) provide a more detailed discussion of these two applications of the DIA visual. The Ghana case study is considered in more detail, as it has not been previously presented.

### *Kenya*

Kenya's low-carbon scenario assessment used a variation of the DIA visual. The assessment of both emissions reduction and development goals was important for Kenya, whose National Climate Change Action Plan determines that a mitigation action is only considered a priority if it generates positive sustainable development impacts in line with the government's long-term development plan and/or has climate resilience benefits (Government of Kenya 2013: 26). The low-carbon scenario assessment, which included the results of the DIA visual, directly influenced Kenya's decision to move forward on NAMA development in the geothermal sector. Geothermal was identified as one of six priority low-carbon options because of substantial abatement potential and strong sustainable development benefits. Geothermal had the second largest mitigation potential of all low-carbon options in the assessment and contributed directly to the goals of Vision 2030, which states that 'electricity is a prime mover of the modern sector of the economy', and aims to generate more energy at a lower cost and exploit geothermal power as a new source of energy (Government of Kenya 2007: 8).

### *Montenegro*

The government of Montenegro began a TNA in 2011 to assess technology needs for climate change mitigation and adaptation. Approximately 25 abatement technologies were identified by the Montenegrin TNA task force and these, in the form of technology specific fact sheets, were used as the input for the pilot of the DIA visual. Development impacts were primarily assessed by interpreting the results of the multi-criteria analysis (MCA) tool that forms a part of the TNA process, called TNAssess. Additional indicators were defined to assess ease-of-implementation of the various technology options and simple indicators for mitigation potential and costs were used in the absence of MAC calculations. Although the TNA documentation was used to populate the DIA visual, the visual itself was not integrated into the TNA process, which uses its own MCA approach to prioritisation, but was rather intended as a first pilot application of the visual.

### *Ghana*

Ghana has set ambitious targets to cover 10% of its electricity supply with renewable energy by 2020 as well as achieving 'availability of and universal access to energy services and for export'. At the current moment the Government of Ghana is developing concrete strategies and programmes in order to meet these targets. Part of this process has included engagement with the UN's Sustainable Energy for All (SE4ALL) initiative, which produced a Situational Analysis Report and a Country Action Plan in 2012 (Energy Commission 2012; Government of Ghana 2012).

The DIA visual was applied to improve the understanding of the potential, costs, development impacts and trade-offs of the priority options considered in the SE4ALL initiative, as well as other selected technology options proposed by stakeholders. Following discussions with local stakeholders, the DIA visual was applied as a case study to six technology options in the Ghanaian energy sector.

1. *Improved cook stoves:* With a focus on improved woodfuel stoves, as this is the dominant fuel source in rural areas where LPG is less likely to reach in the short term and where traditional cookstoves are dominant.
2. *LPG for cooking:* Replacing charcoal as this is the most common fuel in urban areas where LPG distribution would be most effective in the short term
3. *Productive uses of energy:* For example, solar drying, wind pump irrigation, etc.
4. *Biodiesel:* Assumed to be for domestic use, taking care to differentiate between productive and non-productive crops; that is, does the feedstock have an alternative market outside of biofuels?
5. *Landfill gas for electricity:* Based on managed municipal solid waste landfills.
6. *Charcoal production:* Focus is on production for domestic use, the largest single primary energy use in Ghana. Production for export is already regulated to require sustainable sources.

A four-stage process was followed to apply the DIA visual in Ghana. This process was designed to, first, ensure alignment of the process with national needs and, secondly, to obtain direct stakeholder input during the assessment of development impacts. These four stages are described in more detail here.

#### *Engagement and scope*

The first stage initiated engagement with stakeholders in order to both introduce the DIA visual and determine a relevant scope for the study. The case study started from the priority options in the SE4ALL Action Plan but with no agreed final scope, in terms of which energy sector options should be included in the analysis, nor an agreed set of indicators. The first action was to hold a series of meetings with a wide range of stakeholders across line ministries, relevant agencies, NGOs, development partners, the private sector and independent experts. These meetings aimed to introduce the DIA visual, determine the detailed scope of the work (such as which options to include in the analysis) and define how the case study could best support the decision making processes in Ghana. The meetings suggested three additional options in addition to the SE4ALL Action Plan – biodiesel, charcoal production and landfill gas – all of which were felt to have a large potential in Ghana but were not reflected in current energy policy. These three options had the common characteristics that they were proposed by at least two different stakeholder groups and had a reasonable potential for implementation based on a quick scan of the sector.

#### *Indicators*

Closely linked to the setting of scope, it was important to develop a set of indicators with stakeholders that was appropriate to the chosen technologies (and their end-users) and Ghanaian priorities. This is key to the use of the DIA visual as it is this set of indicators against which each technology option is assessed. The visual itself does not propose any particular set of indicators and, although previous applications of the visual could offer some insights, it is necessary to choose indicators that are relevant for the country context and scope.

Two main sources were used to develop inputs for the final set of indicators – first, discussions with stakeholders, and, secondly, a literature review of previous experiences with development indicators. A final review with stakeholders was undertaken before adopting a final set of indicators. Stakeholders suggested specific indicators and also gave input on a preferred approach to indicator development. Two main points were raised. First, indicators need to be relevant to the target audience for each option; if some of the technology options are targeted at the rural population it will be important to have indicators that can reflect this. Secondly, indicators should not be overly disaggregated; it is important that impacts can be estimated and understood in a workshop environment, which requires relatively straightforward categorisation. This input on specific indicators by stakeholders was broadened to a full list of indicators based on the results of a literature review of 8 existing set of sustainable development indicators dating back to the back to the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. The final list was chosen to reflect stakeholder desires for relevance and practicality (Table 1).

**Table 1: Adopted DIA visual case study indicators**

| *Category* | *Indicator* |
|---|---|
| Climate | Abatement potential ($ktCO_2$)<br>Abatement cost (USD/tCO)<br>Climate resilience |
| Economic | GDP / macroeconomic impact<br>Energy security<br>Rural economic impact / development<br>Household / consumer impact |
| Social | Employment<br>Energy access<br>Health<br>Education<br>Gender |
| Environmental | Aggregate (biodiversity, land, water, etc) |

*Impacts*

Once a set of indicators had been agreed, it was possible to start on background work that examined the impacts of the six technology options. Two different approaches were used: first, a quantitative analysis of mitigation impacts (i.e. abatement potential and cost) based on 2020 scenarios for each option; and secondly, preparation of supporting, generally qualitative, information on the impacts of each technology option for all non-mitigation indicators.

It is also important to note that the SE4ALL Action Plan was not developed as a mitigation strategy, but rather to provide development benefits. Its focus is predominantly on improving sustainable energy services, in line with the overall objectives of the SE4ALL initiative to i) increase access to energy, ii) improve energy efficiency, and iii) increase the penetration of renewable energy (UN Foundation 2013). The mitigation calculations made for the options were, therefore, 'after the fact' and were not the primary objective in the design of Ghana's SE4ALL actions. However, this links back to the value of the DIA visual, the ability to present both climate impacts alongside development impacts. In this case study, the starting point were options that were proposed due to their potential to contribute positively to development, with a mitigation perspective applied afterwards.

In order to estimate mitigation potentials and abatement costs, a baseline scenario and low-carbon scenario were developed for each technology option. From these the abatement potential in 2020 could be estimated. Marginal abatement costs were estimated from existing studies in similar contexts, or through calculation where estimates did not exist or were felt to be non-representative of the Ghanaian context.

The assessment of development impacts was undertaken later in the process by stakeholders in a workshop environment. For a number of reasons, however, it was considered important to provide workshop participants with background information to guide these discussions. First, not all participants would be familiar with all technology options, particularly those that are in sectors where they have less experience. Secondly, even those experts who specialise in a particular technology might not have experience in the full range of impacts that a technology could have. Thirdly, an evidence base could help facilitate discussion in instances where participants disagreed about impacts.

To build this evidence base, each of the technology options was characterised for each of the indicators (Table 1). Information was drawn from a wide range of sources, including studies that had already been considered development impacts in the Ghanaian or similar contexts, as well as anecdotal evidence from the previous bilateral stakeholder meetings.

This process gave long, referenced descriptions of each of the technology options by indicator, focused on the Ghanaian context. As a final check of this background information, a second series of meetings was held with local experts. These meetings involved a trial, or mock, assessment of the DIA visual for those technologies where they had expertise. This allowed for final updates of the background study where details may have been missed in the desktop research or prior interviews. The long technology descriptions were too detailed to be useful in a workshop environment, so concise one-page factsheets were created for each option.

*Assessment*

The main objective of the case study was to apply the DIA visual with stakeholders in order to assess development impacts. Nineteen stakeholders from a wide variety of backgrounds and interests attended the workshop, allowing for representation of a range of views and perspectives. The focus was, of course, on the energy sector, but many of the options being discussed had implications for other sectors such as forestry or central ministries such as planning.

Two discussions sessions were held at the workshop. The first was in smaller groups, with each group discussing two technology options. Each of these groups was provided with the one-page factsheets and asked to fill in the DIA visual for their two options, based on the rating scale. Following this each group reported back to the wider group on their discussions and resulting assessment, including areas where there was disagreement, or where there was difficulty in assessing an indicator. In general the assessment process found a high level of agreement amongst participants. Only for some indicators or technology options was there less agreement, typically due to limitations of the DIA visual itself.

In the second session the overall results for the six technology options were discussed side by side with the full group of stakeholders. Assessments that didn't make sense to others or were felt to be inaccurate were questioned and discussed, leading to some changes to the overall assessment matrix (Figure 3). In general the level of change was minor and both sides of an issue could be accommodated by clarifying the interpretation of a scenario.

It was notable that consensus could be reached, suggesting that the process had assisted in building a common understanding of the six technology options. Observation of the initially divergent positions of many of the participants in the first session suggests that the DIA visual process is highly likely to have contributed to building agreement. It was also interesting to note that the final assessment broadly supported the prioritisation of actions that was observed in the SE4ALL Action Plan. The workshop and results showed that a more formal DIA process could be used to complement government planning or policy processes and build consensus amongst stakeholders.

### 5. DIA visual: Lessons learnt

The application of the DIA visual in Ghana, Kenya and Montenegro has provided a number of insights regarding the visual specifically, as well as the assessment of development impacts more broadly (lessons from the Montenegrin and Kenyan case studies are partly drawn from Cox *et al.* (2013)). This section summarises the lessons learnt and observations resulting from the case studies grouped into four categories:

1. *Stakeholders* – relating to which stakeholders are included in the process, when this should be done and how they are communicated with.
2. *Indicators* – the choice of indicators and their characterisation.
3. *Assessing impacts* – in terms of the level of detail and quantification provided, as well as how to compare options.

Key: Highly positive; Positive; Neutral / Minor impact; Negative; Uncertain / policy specific

| | Climate | | | Economic | | | | Social | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Abatement potential (2020 ktCO$_2$) | Abatement cost (2020 USD/tCO$_2$) | Climate resilience | GDP / macroeconomic impact | Energy security | Rural economic impact / development | Household / consumer impact | Employment | Energy access | Health | Education | Gender | Environmental impact |
| **Improved cookstoves** Rural woodfuel use intensity reduced by 10% through improved cookstoves | 200 | -2 to 0 | Highly positive | Positive | Positive | Positive | Positive | Positive | Positive | Highly positive | Highly positive | Highly positive | Highly positive |
| **LPG for cooking** LPG access by 2020 is 50% as opposed to projected 24.5% | 360 | 3 to 85 | Highly positive | Positive | Highly positive | Positive | Positive | Positive | Highly positive | Highly positive | Highly positive | Highly positive | Highly positive |
| **Productive uses of energy (PUE)** Irrigation 14000ha with RE (pilot prog.) 2000 RE powered MFPs (pilot prog.) | 20 | n.a.* | Positive | Positive | Neutral / Minor impact | Highly positive | Positive | Neutral / Minor impact | Positive | Highly positive | Positive | Highly positive | Neutral / Minor impact |
| **Improved charcoal production** Plantations and improved conversion technologies penetrate 10% of supply | 100 | 1.5 to 20 | Positive | Neutral / Minor impact | Neutral / Minor impact | Positive | Neutral / Minor impact | Positive | Neutral / Minor impact | Positive | Neutral / Minor impact | Neutral / Minor impact | Positive |
| **Landfill gas generation** Accra and Kumasi landfills developed by 2020; approx. 30 MW of generation | 360 | 18 | Highly positive | Neutral / Minor impact | Neutral / Minor impact | Neutral / Minor impact | Neutral / Minor impact | Neutral / Minor impact | Neutral / Minor impact | Highly positive | Neutral / Minor impact | Neutral / Minor impact | Highly positive |
| **Biodiesel production** Domestic requirement for 5 percent blend by 2020 | 295 | 66 | Uncertain / policy specific | Neutral / Minor impact | Neutral / Minor impact | Positive | Positive | Positive | Neutral / Minor impact | Highly positive | Neutral / Minor impact | Positive | Positive |

**Figure 3: Completed Ghana case study visual resulting from the stakeholder workshop**

4. *Relevance* – how the DIA visual can be used effectively within the policymaking process.

### Stakeholders

*Stakeholder diversity*

A sensitivity to stakeholder mix was recognised at the workshop, with the question being raised as to what would happen if the same exercise was undertaken by a different group of stakeholders. It is, therefore, important to include a diverse range of stakeholders when applying the DIA visual, with experience across different relevant sectors and the full range of development indicators.

*Common aims*

It is important that the aims of the workshop and DIA visual are clearly explained in advance and that, insofar as is possible, individual stakeholders have been part of the process of developing a set of indicators and providing information on technology options. This makes it easier to have a discussion about impacts, rather than spending time on building awareness of the tool and agreeing on scope and indicators.

*Supporting information*

Most stakeholders will not be familiar with the full range of technology options or development indicators. It is important to provide supporting information, in this instance through one-page factsheets, that will allow participants to have a common minimum level of understanding of each technology option. This process of providing supporting evidence requires a careful balance between a more neutral provision of information versus guidance that could overly influence the assessment.

*Format*

The use of smaller break-out groups encouraged stakeholders to contribute to the discussions and allowed a focus on a smaller sub-set of options without overwhelming people with the full matrix. At the same time, the process of subsequently building consensus for the final matrix amongst the whole was important to allow participants to take results from their break-out session and see how they compared to other groups outcomes.

### Indicators

*Prior knowledge*

In the Ghana cases study there was a strong awareness amongst stakeholders of the types of development impacts of low-carbon actions. However, it was often the case that participants had not considered these impacts in significant detail or in a structured way. The structured assessment of impacts against a common rating scale is therefore a valuable process, as it forces stakeholders to think about each technology and indicator in turn.

*Type and number of indicators*

The indicators that are used need to be relevant to the target audience, that is, the group that stands to be impacted by the option. Equally, balancing pragmatism with detail was seen as important. Too many indicators makes the assessment difficult and lengthy, and crucially also makes interpretation of the results difficult. Too few indicators runs the risk of overly simplifying development impacts or providing insufficient differentiation between options to be useful.

*Complex indicators*

It was practically very difficult to assess aggregate indicators (such as GDP or climate resilience) which are effectively composites of (or at least influenced by) a number of other more specific indicators. There would be significant value in having a more holistic assessment of complex indicators, like GDP, that takes into account interactions and indirect effects. The pilots of the DIA visual in Kenya and Montenegro also highlighted the need to 'unbundle' complex indicators. For both pilots, causal chains to link technologies to impacts were not clearly defined. Development of causal chains for impacts and technologies considered could improve the robustness and reliability of the visual.

*Uncertainty*

Some indicators are associated with a significant degree of uncertainty. As an example, Montenegrin stakeholders found 'unstable price development' to be a key issue related to choice of cooking fuels, particularly natural gas. It is useful to provide a way of indicating uncertainty when applying the DIA visual. In the Ghana case study this was done by allowing stakeholders to rate impacts as 'uncertain/policy-dependent'.

### Assessing impacts

*Context sensitivity*

Impacts are not only influenced by technologies or deployment scenarios, but also by the form of implementation (i.e. policy). Any technology scenario being described should try to be as descriptive as possible about the approach to implementation. Similarly, impacts are often country- or region-specific. Taken together, these considerations mean that it is difficult to generalise about the development impacts of any one technology. The calculation of MACs is also linked to the approach to implementation, making firm estimates of abatement costs difficult in the absence of agreed policies.

The DIA visual is most relevant early in a strategy or planning process, when decisions on priorities are being made. Hence, it may not always be possible to be prescriptive about policies. However, any technology scenario should be as descriptive as possible about the approach to implementation.

*Judging scale*
It is difficult to account for scale when comparing impacts of different options. One option may have large impacts per unit effort or cost when compared to another, but the DIA visual is not normalised in this way. Hence, a technology that is implemented at pilot scale may look much less favourable when held up against a full-scale implementation of a second technology. Increasing the level of quantitative assessment of development impacts may be one way to help overcome this challenge, but this may not always be possible due to limited data or indicators that are difficult to quantify.

*Absolute or relative impacts*
It is clear that mitigation potentials and abatement costs are calculated relative to a business-as-usual (BAU) or reference case. However, this use of a baseline technology as a reference is arguably less relevant when assessing development benefits, particularly in a workshop environment. An absolute approach to assessing development impacts (i.e. ignoring the BAU technology that is displaced) tended to be naturally adopted by workshop participants and was more relevant to the way in which people thought about development impacts. Another solution to this challenge would be to include the BAU technology in the DIA visual as one of the options to be assessed. This would guarantee that impacts versus a reference technology are assessed.

*Quantitative inputs*
Although the DIA visual was applied through qualitative processes in Ghana, Kenya, Montenegro, it may be useful in the future to underpin the visual with more quantitative analysis to justify the level of impact assigned to technologies (e.g., highly positive versus positive). Providing this information to stakeholders before and during DIA workshops (including relevant analytical assumptions, etc.) could support more robust discussions and instill greater confidence when prioritising options and presenting information to high level decision-makers. Notwithstanding resource requirements for a quantitative analysis, observations from the three case studies in Ghana, Kenya and Montenegro suggest that there will often be data limitations that will limit the ability to perform such analysis. In the absence of quantified local impacts, assessments conducted elsewhere may provide a useful basis for stakeholders to use in evaluating impacts, provided due care is taken in confirming sufficiently similar country contexts that allow the data to be used.

*Timeframes*
The four-point rating scale ('highly positive,' 'positive,' 'neutral/uncertain' and 'negative') used to describe development impacts of different options provides a relatively simple scoring framework that is conducive to stakeholder-led qualitative processes. However, this scoring framework does not take into account different timeframes. The visual may be improved by including an assessment against different temporal scales (whether, for example, impacts are long- or short-term).

*Weighting*
Developing a process to weight priority impacts may improve the usefulness of the visual for decision-makers. Weighting may also help to provide a numeric mechanism for comparison across different options, noting that such a process could be similar to traditional multi-criteria analysis approaches.

***Relevance***
*Relevant implementation scenarios*
For the application of the DIA visual to provide value to the decision-making process it is vital that relevant implementation scenarios are chosen, which are either grounded in current government ambitions or based on a realistic potential for implementation. In practice, this can mean that the visual is used to complement planning and strategy processes already underway in a country. In Montenegro, outputs from a stakeholder-led TNA process fed into the visual to allow for a more streamlined way to visualise and compare impacts across technologies. Outputs from the DIA visual and TNA process were also complementary in the sense that the DIA work focused more on absolute scoring of technologies, while the TNA process focused on ranking technologies relative to one another. In the case of Kenya, the DIA visual was used to complement the National Climate Change Action Plan development process that was already underway, by providing another approach for stakeholders to assess and compare technology options.

*Recognition of limitations*
It is important not to oversell the DIA visual and to make it clear that it is a discussion and communication tool; an aid to decision-making rather than a formulaic tool for prioritisation. Policy-makers may not be receptive to the idea of using a ranking or prioriti-

sation tool to make decisions, but are more welcoming of an approach that summarises information and communicates the rationale behind multi-criteria decisions.

*Expansion beyond impacts*
It may be valuable to complement the development indicators in the DIA visual with information on barriers. Without these barriers, it was felt that there could be a tendency for the results of the visual to look overly positive. The prior case study in Montenegro included a barrier assessment in the DIA visual (Cox *et al.* 2013) and, although this added to its visual complexity, the Ghana case study suggests that this may be a useful addition. Closely linked to this is the potential to consider measures of cost other than marginal abatement cost, such as total investment costs or public funding requirements, which are often more relevant to policymakers.

*Cross-sector application*
Although the DIA visual can be used to compare technologies across sectors, in the cases of Ghana, Kenya and Montenegro the application of the visual was limited to comparisons of technologies within sectors. However, ministries of finance, development and planning often have to consider actions across the economy. Using the visual with a more sector-oriented approach, for example by compiling the sectoral outputs into a cross-sectoral overview, Cox *et al.* (2013) note that '[s]uch economy-wide analysis could also be used as a means to bring together diverse stakeholders and to break down traditionally siloed line ministries to build support for mutually beneficial LEDS options.'

*Influence*
Further study is needed on how the DIA visual can be most effectively used to inform prioritisation and high-level decisions on LEDS actions. There is also a need for further input from decision-makers on the usefulness of the DIA visual and areas for improvement. For example: When in a policy process should the visual be applied? What types of stakeholders are most relevant to include in impact assessments? What level of supporting analysis is most useful to complement the presentation of impacts in a visual format?

## 6. Conclusions

There are limited examples of how 'formal' DIA processes affect government decisions, but important lessons and insights are emerging from early work to assess development impacts in low-carbon plans, as well as lessons from the CDM. The lessons provided from the DIA visual case studies and the resulting observations set out below aim to improve the understanding of how best to assess both development and mitigation impacts in a way that effectively informs decision-making.

At the same time, previous experiences in the application of development impact assessments provide some useful insights into limitations of such approaches:

- As CDM impact assessments have determined, many important elements of sustainable development, such as technology transfer, employment generation and poverty alleviation, can be very difficult to quantify (Olsen 2012). The DIA visual allows a range of approaches to be used in assessing impacts.
- While countries attempt to strategically opt for actions that generate positive development impacts, there are few examples of integrated sets of indicators that allow for analysis of the trade-offs and inter-linkages across the economic, social and environmental pillars of sustainable development. It remains difficult to compare development impacts across, for example, forestry and the transport sectors.
- DIAs often assumes that low-carbon actions will create development benefits or ignores negative impacts. The OECD notes that environmental solutions can turn out to be 'poverty traps' rather than 'routes out of poverty' (Bass *et al.* 2013: 23). The DIA visual allows negative impacts to be shown during assessment, but needs appropriate indicators to capture these effects.

The case studies in Ghana, Kenya and Montenegro showed that the DIA visual benefits from the following: a diverse group of well informed stakeholders with appropriate facilitation and workshop format; a pragmatic set of development indicators that allows uncertainty in assessment to be reflected and provides a holistic assessment of complex indicators; detailed technology or scenario descriptions, with impacts assessed on an absolute scale with quantitative analysis of key indicators; and policy-relevant implementation scenarios that take into account barriers and trade-offs and can be compared across sectors. From this, some potential areas for improving the DIA visual are:

- Development impact assessment is often qualitative. Work needs to continue to identify quantitative (measurable) indicators.
- The consideration of interactions across a portfolio of actions should be an important element of an improved DIA that can inform decision-making about how trade-offs in the short term need to be managed and reconciled with anticipated long-

term low-carbon benefits.

- The DIA tool provides a useful comparison of mitigation and development benefits within a sector, but has limited application to compare development impacts across sectors. Work is needed to identify metrics to improve comparability across sectors.
- To properly inform decision-making, DIAs needs to include information on winners and losers of low-carbon actions. DIA should work to predict such outcomes of policy and investment shifts toward low-carbon options.

In addition to these ideas, the LEDS GP recently held a half-day training on DIA at the Asia LEDS Forum in Manila, Philippines (Asia LEDS Partnership 2013). The session brought together stakeholders from a number of institutions engaged with DIA activities to produce the following suggestions for improving the DIA visual:

- Development of a guidance document to provide information on use of the visual through stakeholder processes.
- Incorporation of default values for certain technologies and indicators with supporting documentation. This could provide a starting point for practitioners trying to understand how to apply the DIA visual, but needs to be balanced with the need to consider local contexts when making final assessments.
- Adapting the visual into an online tool where users can choose indicators and technologies of most interest.
- Application of the tool in more countries, particularly with more quantitative analysis underpinning the assessment of impacts.

Ultimately, the utility of the visual rests on its perceived credibility by decision-makers. This, in turn, depends on the transparency of the process used to develop the information reflected and the stakeholder group(s) involved. Although the visual has been primarily used in more qualitative processes in the three pilot studies, incorporation of quantitative information could help to further strengthen objectivity of results and build confidence in decision-makers when using the visual to assess low-carbon options.

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