UNEP DTU PARTNERSHIP

Adaptation metrics: Perspectives on measuring, aggregating and comparing adaptation results

UDP **Perspectives series** **2018** /1

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March 2018

UNEP DTU Partnership
UN-City Copenhagen, Denmark
http://www.unepdtu.org

ISBN: 978-87-93458-27-7

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Front cover photo Acknowledgements
Dmitry Pichugin/Shutterstock

This guidebook can be downloaded from http://www.unepdtu.org

Please use the following reference when quoting the guidebook:
Christiansen, L., Martinez, G. and Naswa, P. (eds.)
Adaptation metrics: perspectives on measuring, aggregating and comparing adaptation results. UNEP DTU Partnership, Copenhagen

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Foreword

John Christensen
UNEP DTU Partnership

Addressing adaptation and resilience issues is increasingly becoming an imperative in the global fight against climate change and large amounts of resources, both public and private, are being directed towards the purposes of enhancing adaptive capacity, strengthening resilience and reducing vulnerability.

But how are we actually doing? Are we succeeding in making our societies and economies less vulnerable and more resilient to the impacts of climate change? And are we getting the most 'adaptation' or resilience out of our investments? These questions have become increasing urgent in recent years, reflecting the increasing amount of funds being invested and the Paris Agreement's formulation of a global adaptation goal and its general provisions toward transparency in both mitigation and adaptation actions.

This new edition of the UDP perspectives series seeks to fuel continued global discussions on these important questions, by bringing together knowledge and unique perspectives from a range of global experts and practitioners. The articles contained in this volume highlight that the purpose of measuring adaptation, and consequently WHAT we are measuring, is highly context dependent. The question of what constitutes meaningful adaptation metrics, will thus result in very different answers, depending on whether you ask a vulnerable farmer in Africa, an adaptation fund manager or a UNFCCC negotiator. The wide range of perspectives provided in this volume on what meaningful adaptation metrics are, or could be, thus help to further contextualize the international discourse on adaptation metrics. They also serve as reminder that the frameworks and processes we develop for measuring, aggregating and comparing adaptation results have to meet the needs of all stakeholders – from local to global levels.

While we cannot promise that any of articles provide any gift wrapped solutions, it is our hope that the publication will bring valuable insights that can benefit everyone concerned with the issues of transparency and metrics for adaptation, from international experts and UNFCCC negotiators, over national ministries and technical experts, to stakeholders working with adaptation at community levels.

This new perspectives edition builds on and enhances the UNEP DTU Partnership's expanding portfolio of transparency related activities, including the Initiative for Climate Action Transparency (ICAT), support to countries under the Capacity Building Initiative for Transparency managed by the Global Environment Facility, and the annual Adaptation Gap Reports.

John Christensen

A note on terminology

The term *'metrics'* is used in the title of this publication to emphasise that the publication's main interest is in the quantitative rather than qualitative assessment of adaptation and with results rather than process. The question of interest is essentially the 'unit(s) of measurement' that could be used to measure, aggregate and compare adaptation results. However, going through the monitoring and evaluation (M&E) literature, and even the articles in this volume, it quickly becomes clear that many other terms are being used, either interchangeably with *'metrics'* and/or with slightly different meanings, the most common one being *'indicators'*.

A full discussion of the various definitions and minor nuances between them (not to mention which definition is more academically 'correct') would require a separate article in itself, which would go beyond what is intended here. In general, however, one simple way to make a distinction between *'indicators'* and *'metrics'* might be to use *'indicators'* for the particular element of adaptation success being assessed (e.g. the level of climate change vulnerability in a given population or the resilience of crop yields to climate change-induced drought) and *'metrics'* for the specific 'unit of measurement' with which to quantify it (e.g., with reference to the above, a specifically designated vulnerability index value or water use in m^3/tonnes of harvest). In this definition (which seems to correspond well with most, but not all, articles in this volume), any given *'indicator'* could have several *'metrics',* whereas any given *'metric'* could refer to several different *'indicators'*. In other words, the two would be conceptually distinct, but at the same time mutually dependent, which may explain the interchangeable use of the concepts.

Given the lack of any universal agreement on terminology, even among experts and practitioners, we have not striven to impose any one definition of *'metrics'* upon authors, but rather emphasized that articles should provide perspectives on the volume's core question of how to measure, aggregate and compare adaptation results, otherwise leaving what terms to use and with what definitions (or lack of them) to the authors. Beyond their individual perspectives, therefore, the articles also provide an interesting sample of how the term *'metrics'* is defined and used. While there do not seem to be very serious practical implications of the unclear and sometimes contradictory use of the terms used in these articles, it does highlight the importance of agreeing on common and unambiguous definitions of terms like *'metrics'* and *'indicators'* for adaptation purposes, for example, through UNFCCC or IPCC processes.

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EDITORIAL

Adaptation metrics: perspectives on measuring, aggregating and comparing adaptation results

Background

The UNEP DTU Partnership (UDP) 'Perspectives' Series is a series of publications aimed at sharing expert and practitioner opinions and experiences on emerging topics related to climate change. 'Perspectives' publications aim to kick-start and further discussions at the academic, political and practical levels. This new volume addresses a key question for adaptation policy and practice: **'How can we measure, aggregate and compare climate change adaptation needs and results across activities, countries and sectors?'** The volume collects together eleven articles from international experts and practitioners, each offering their own unique insights and perspectives on this main thematic question.

The issue of how to establish meaningful metrics for climate change adaptation is gaining impetus on both the political and academic agendas. There is increased recognition of the need to prioritize and directing limited adaptation funding to the most vulnerable countries and population groups in the most cost-effective way (Persson & Remling, 2014; Leiter & Pringle, 2018; Michaelowa & Stadelmann, 2018). Similarly, there is a growing focus on measuring, aggregating and comparing the results of ongoing adaptation investments spanning multiple regions, sectors and specific local contexts (GEF, 2010; Spearman & McGray, 2011). Finally, the Paris Agreement has, for the first time, defined a 'global goal on adaptation' of 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2' (UNFCCC, 2016). Progress towards this goal will need to be periodically assessed, starting with the global stocktake in 2023 (Article 14 of the Paris Agreement), but the exact metrics to be used have yet to be agreed (UNEP, 2017). The establishment of a global goal stresses the urgency of addressing the issue of how to measure and track adaptation at and across different levels over time. It may also help promote the creation of a global (i.e. more universal) framework for understanding adaptation and approaching its assessment.

To address such needs, approaches for identifying standard international 'adaptation metrics' must be discussed. Surprisingly few concrete ideas for deriving standard comparable and aggregable metric(s) for practical application are currently available, whether in academia, at the institutional level or in climate negotiations. This apparently stalled progress is probably indicative of both the scientific complexities involved and the lack of a political appetite for pinpointing specific countries or sectors as more vulnerable than others and thus as more in need of funding. While consensus on an 'answer' to the basic question asked in this volume is thus probably still a long way off, the articles it brings together do demonstrate some emerging patterns in respect of the key challenges that will be faced and outlines some general directions on what potential solutions could look like. These are summarized in the sections below under three main headings:

- The gap between theory and practice
- The importance of context
- Learning from experience

The gap between theory and practice

The global conversation around the measurement and tracking of adaptation is marked by a disconnect between the policy level and scholarly discussions, and practitioners in the field, who, in the absence of a global consensus on concepts and methodologies, have developed *de facto* approaches and methodologies while implementing national and project-specific monitoring and evaluation systems. A common theme across all the articles in this volume is therefore the struggle to find a balance between conceptual and methodological considerations and the pragmatism needed to implement MRE for adaptation in practice. In this way, several of the articles in section A on methodology discuss how best to align generic approaches with local needs and interests, while many of the more practice-oriented articles in section B describe efforts to translate theoretical concepts into local reality. This complex situation of disconnect is rooted in key methodological and practical issues as described below.

The nature of adaptation and implications for measurement

As made clear throughout this report, there is no universally accepted definition of what counts as adaptation in practice. General definitions like the one proposed by the IPCC[1] (2014) may be difficult to operationalize for a multitude of diverse activities, projects or policies. The complexity of the causal pathway between climate change and its impacts makes the application of such general definitions extremely challenging. Climate impacts unfold differently across locations, timeframes and scales, being influenced by a variety of social, economic and environmental factors. The same applies to the ability of natural and human systems to respond to such impacts, thus making what constitutes successful adaptation differ depending on the circumstances. This inherent difficulty in defining successful adaptation cascades into the definition of desired outcomes and the causal pathway to achieve them. Without defining precisely how an activity will build resilience to climate change, it is impossible to know whether any choice of indicators or metrics are actually measuring the results of the specific adaptation activity or those from any other effect modifier.

In addition, adaptation takes place against a moving baseline, so conventional 'ex-ante' and 'ex-post' assessment tools (i.e. tools with a fixed baseline) are often unfit for adaptation processes. Ideally, the baseline for measuring the impacts of adaptation interventions should be 'development as it would have happened in the absence of adaptation investments'. That is, it should include the effects of any regular development projects or investments made for purposes other than addressing climate change and including also all the uncertainty of climate impact modelling. In practice, however, such methodological challenges, combined with data and resource constraints, often mean that baseline development follows conventional approaches, which in turn means that results from impact assessments need to be interpreted with caution.

[1] IPCC (2014) defines adaptation as "the process of adjustment of human or natural systems to actual or expected climate and its effects, aiming to reduce or avoid the negative impacts of climate change or exploit beneficial opportunities".

Measuring adaptation versus measuring development
The conceptual development of the techniques, theory and practice of measuring adaptation has from an early stage been driven by the need for accountability in adaptation funding. When funding streams targeting adaptation were set up by the international climate community, it became necessary to demonstrate value for money. In particular, it became urgent to document to what extent these funds achieved their objectives of helping vulnerable countries and populations adapt to the impacts of climate change, and to provide clear guidance with regard to the metrics for both prospective and retrospective evaluation.

Meanwhile, the links between development and adaptation have become increasingly obvious. Climate change impacts have the clear potential to set back development achievements. Moreover, this interlinked nature of problems adds urgency to the need to achieve development gains in light of committed climate change. The vulnerability reductions that are among the aims of adaptation frequently support development and vice versa. Attribution, or the documentation of how an observed positive change on vulnerability can be attributed to a specific adaptation activity, is an additional challenge of adaptation MRE, an issue closely related to this embeddedness of adaptation processes within general development.

In practice, the development of formal and de facto methodologies for adaptation MRE has been heavily influenced by general development thinking and the donor community. This influence has been underpinned and reinforced by years of practice by development agencies of mainstreaming adaptation into their portfolio. The rooting of adaptation MRE in existing experience of general development is probably both unavoidable and desirable, but it is critical that appropriate adjustments are made in adaptation methodologies to take account of methodological issues such as shifting baselines, attribution and timing.

The complex landscape of current approaches
Without a clear, all-encompassing metric like that used in the context of mitigation (CO_2 equivalents), and in the absence of wide agreements on a general system, a multitude of adaptation and resilience MRE frameworks have been proposed. Several key institutional players have all produced various forms of overview and guidance documents on M&E for adaptation. In particular, various donors and developing agencies (e.g. GIZ, which is featured in this volume) have either created their own adaptation metrics frameworks or mainstreamed standardized indicators into their M&E practice. The experience of GIZ in using adaptation indicators within its Results-Based Management system points to the wide range of practices already established in adaptation funders. This uncoordinated state of affairs is justifiably described in the article by Michaelowa and Stadelmann as a 'hodgepodge'. It represents a potentially large-scale waste of resources and institutional attention, further reinforcing the urgency of wide agreements in this area.

The importance of context

A key theme brought out in the articles in this volume is that the use and value of metrics is highly context-specific. The scale of inquiry is one of the critical issues: metrics that are appropriate in measuring the results of adaptation at the local or project level may not be appropriate at the national or international (aggregate) level. Similarly, different metrics are often used in different sectors: agriculture-specific metrics, disaster-risk specific metrics, etc. Moreover, the specific local economic, environmental or social context could make it necessary to use different metrics even for activities at the same scale and in the same sector. This context-specificity of metrics illustrates that adaptation is itself a complex and highly embedded process that cannot easily be separated from the physical and social contexts in which it happens. The upside of 'localized' results frameworks, when used, is that relevance and accuracy are maximized in each case. In turn, this may improve ownership by the immediate stakeholders involved in the process (local residents, project staff etc.) and provide better learning. The downside is that the aggregability of results across scales, time, geographies and sectors (required at the national and global levels) is generally more difficult when metrics are tailored to local contexts. Finding a balance between the needs and relevance of metrics for all stakeholders (local to global) is thus a key theme of many of the articles in this volume.

Finding ways to match MRE needs at different scales: from local to global
The recently published adaptation gap report (UNEP, 2017) reviewed a number of adaptation assessment frameworks designed for aggregation[2] and concluded that most of these are in fact not well suited for aggregation nationally or globally. It also found that the indicators used in these frameworks

[2] Interpreted as the extent to which frameworks use indicators that are comparable, consistent and comprehensive, with the potential for the country-level indicators to be aggregated globally.

were mostly proxies for adaptation outcomes and that the need for standardization came at the expense of sensitivity to context and validity of the proxies. The report identifies key characteristics and principles for the development of a more effective global adaptation assessment framework including: 1) using standardized indicators; 2) combining activity- and results-based indicators; 3) clearly articulating assumptions underlying the choice of indicators; 4) collecting data repeatedly over a longer time span; 5) providing examples of scoring criteria and guidelines for standardized indicators; 6) using narratives such as theory of change, logic models etc. to justify and contextualize targets vs. baselines; 7) focusing on 'contribution' rather than 'attribution'; and 8) strong stakeholder engagement in the development and application of national adaptation targets.

In parallel with these ongoing efforts to define standardized assessment frameworks that can meet both local and global needs, the articles in this volume demonstrate how stakeholders at the national (Karani and Von Rüth & Schönthaler), project/local (Quesne et al. and Fisher & Anderson) and sectoral (Ebi) levels are already defining their own assessment frameworks and metrics and applying them in practice. At least to an extent, most of these efforts are trying to apply general assessment frameworks provided, for example, through IIED's 'Tracking Adaptation and Measuring Development' (TAMD) framework, or GEF's 'Adaptation Monitoring and Assessment Tool' (AMAT). The overarching lessons from these efforts, which seems to support the conclusions of the adaptation gap report, seem to be that the general assessment frameworks should be either open and flexible, which in turn implies a need for significant local fine tuning and sacrificing standardization and aggregability, or include only indicators that are so general that they need to be supplemented by other (non-aggregable) context-specific indicators. To some extent these outcomes seem very similar, as they basically leave it to local stakeholders to fill in the gaps. It is clear that significant work is still needed to come up with a framework that is both flexible enough to be locally relevant and specific and standardized enough to truly provide a common approach and sufficient guidance to local stakeholders on designing adaptation assessment frameworks that work at all levels and across all sectors.

Universal metrics?

A particular question arising out of the issue of scale outlined above is the implicit common thread found across the articles contained in this volume (and explicitly in the article by Michaelowa and Stadelmann) about the potential role of 'universal indicator(s)' in adaptation. In a global context of scarce public funds and competing priorities, the idea of investing in activities whose results cannot be fairly measured and compared is difficult to defend before constituencies. Therefore, it is not surprising that international donors and national budget managers are pushing for the design and use of standardized metrics for adaptation that could ideally be applied to all sorts of adaptation projects. Standard economic principles of cost-efficiency (i.e. getting the most adaptation per dollar) are practically impossible to imagine without a single standard metric that can be applied across all types of adaptation investment options. This kind of thinking is bolstered by the fact that the other dimension of the climate change problem (mitigation) is working with one relatively simple and universal metric of CO_2 equivalents, which can be applied across specific contexts to measure impacts in an easily comparable format.

A universal, intercomparable set of adaptation metrics would have advantages. It would set the basis for improved fairness and accountability in resource allocation, as well as increasing the probability of prioritizing high value-for-money and impactful adaptation activities. However, the pitfalls and disadvantages are also clear, and far-reaching. Low-capacity settings and actors with low data availability may be at a disadvantage in presenting their cases for adaptation needs. A set adaptation MRE universal framework may overlook important but difficult to measure social and cultural dimensions. In many ways the idea of universal metrics is thus the extreme version of the local vs. global problem outlined above. That is, almost by definition, universal metrics will be far removed from the local context in which adaptation takes place. Moreover, in the case of monetizable metrics (a frequently proposed element of universal metrics for adaptation), a universal framework may skew allocation towards projects where monetization is easier or to higher income settings. Unsurprisingly, then, several of the articles contained in this volume are highly critical of the potential for defining and applying universal metrics in practice. However, in the absence of some kind of universal 'unit of measurement' or 'unit of comparison', critical decisions about the prioritization of limited adaptation funding will remain qualitative and difficult to objectively verify.

Learning from experience

As discussed above, a consensus on the conceptual and practical approaches to MRE for adaptation is probably unlikely in the near future. In the meantime, adaptation projects continue to be funded and implemented, most of them including some kind of M&E component and thus creating an increasing body of practical experience and lessons. The compilation of lessons obtained from ongoing or implemented projects provides great learning opportunities that could potentially inform both political and academic discussions. Some examples of such practical experiences are included in the articles contained in section B. This begs the question of what we can learn from such practical experience.

Learning from stakeholders

Beyond the actors represented in the international policy arena, several types of stakeholders demand information for adaptation. The article by Wang et al. presents a survey of exactly this question, observing that various groups of stakeholders have different information demands. Intergovernmental organizations are more interested in the assessment of adaptation efforts, whereas governments and private businesses mainly demand effective translation of risk into impacts for specific sectors or business activities. The priorities of the latter groups regarding adaptation MRE should be credibly mainstreamed into international climate discussions. Moreover, their study suggests that private-sector stakeholders in particular have difficulty in distinguishing adaptation from other activities on the ground. This underscores the urgency of raising awareness and developing participatory processes in this area.

Beyond the consideration of stakeholders' needs, however, active stakeholder engagement is fundamental for effective adaptation tracking and MRE. The engagement of stakeholders in the co-creation of indicators has proved important in both sectoral projects and local adaptation tracking. Including stakeholder views and their assessments of results is crucial to the credibility of adaptation evaluation and is as such routinely included in the adaptation RBM of several donors.

Learning from national and subnational experiences

Nationally, government-mandated national M&E frameworks can provide valuable insights for progress. More than thirty countries have developed or are developing national adaptation M&E systems, largely based on data already collected by government agencies or academia. Several countries are also linking national and subnational adaptation M&E systems. These national efforts add value through the compilation of scattered data into a partial national illustration of adaptation progress. They also provide examples of how to work across governmental levels and sectors, strengthening the evidence base for supranational planning and decision-making.

Local-level experiences are also crucial, given the local dimension of adaptation implementation. The article by Fisher and Anderson included in this volume analyzes experiences in developing climate adaptation metrics for local government and community planning in several countries using the Tracking Adaptation Measuring Development (TAMD) framework. Among other lessons, they observed: 1) the importance of maintaining a clear picture of desired changes and outcomes and the causal pathway with which to achieve them; 2) the need to adapt indicators and metrics to local realities and to contextualize the results; and 3) the value of participatory discussions on metrics to help create ownership of adaptation activities, underscoring again the importance of stakeholder engagement.

As the authors note, all these experiences are already greatly strengthening our grip on several aspects of the question regarding how we can meaningfully measure, aggregate and compare adaptation results, distinguish adaptation within development action, work across levels and engage different actors effectively. However, these lessons can only inform, not replace, the great political effort needed to reach global-level agreements to track and monitor adaptation effectively.

Overview of articles contained in this volume

As outlined in the background section above, this volume collects together articles offering insights and perspectives from a number of experts and practitioners, all organized around the question: **'How can we measure, aggregate and compare climate change adaptation needs and results across activities, countries and sectors?'**. The articles contained in this volume span more conceptual and methodological discussions related to this question (section A) and share the experiences and lessons of practitioners, who, in the absence of a global consensus, apply *de facto* responses to (elements of) this question in their work at the national and/or project levels (section B).

All the articles are intended as stand-alone pieces. They can be read individually and/or in any order. There is, however, an underlying logic to how they have been ordered.

Section A kicks off with **Moehner** providing an overview of the broad evolution of the concept of 'adaptation metrics' under the UNFCCC and in the Paris Agreement. It notes the general evolution of its objectives from prioritizing countries' adaptation needs to ensuring the accountability and effectiveness of adaptation projects and more recently towards assessing global progress. **Leiter and Pringle** then examine the distinct characteristics of climate change adaptation versus mitigation and the implications for measuring progress in these two interrelated policy domains. Through this discussion, the chapter also outlines some of the main pitfalls of applying adaptation metrics. As such it serves as good introduction to many of the general themes in the volume. In their article, **Wang et al**. present a comprehensive study of adaptation tracking needs among 191 stakeholders across the public and private sectors, showing how the objectives of adaptation metrics can be very different depending on who you are asking. Finally, **Michaelowa and Stadelmann** discuss why, in their view, universal metrics is an unavoidable concept when comparing the effectiveness of adaptation projects and prioritizing funding for them. They assess two possible candidates for generic effectiveness metrics: economic benefits, and disability-adjusted life years.

Section B is sequenced based on a scale ranging from the local and/or project level to the national and sectoral or portfolio levels. **Fisher and Anderson** analyze experiences in developing adaptation metrics for local government and community planning in several countries using the Tracking Adaptation Measuring Development (TAMD) framework, concluding broadly that local metrics need to be contextualized to reflect local realities. They further suggest that the best way forward for comparing and aggregating across such local contexts are through scorecard measurements. **Quesne et al.** discuss M&E frameworks and metrics applied in three donor-funded adaptation projects in Madagascar, analyzing how successful they were in measuring adaptation impacts. Experiences from the development of two national-level adaptation M&E frameworks are then presented in the articles by **van Rüth and Schönthaler** (Germany) and **Karani** (Kenya). The two articles together illustrate the similarities of the conceptual challenges involved, as well as large differences in national contexts in terms of data availability, institutional capacity and budgetary capacity. A common lesson, however, seems to be the importance of basing national adaptation M&E systems on existing data and processes, both to reduce costs and avoid duplication of data-collection processes, and also to improve the integration of adaptation into general national planning and development. **Naswa et al.** look at experiences from the global Technology Needs Assessment project and the indicators proposed by countries for measuring the impact and outcomes of prioritized technologies. They then contrast these with the performance metrics expected by global adaptation investment funds such as the Green Climate Fund and propose ways to improve alignments between the two, thus increasing the chances of acquiring funding to implement countries' Technology Action Plans. From the viewpoint of such an international adaptation funder, **Leiter** presents the approaches applied by GIZ, Germany's development cooperation organization, and explains how it has mainstreamed adaptation into its existing M&E systems. Finally, the article by **Ebi** presents experiences from the health sector in developing outcome-specific indicators and advocates the development of indicators adequate for health adaptation. These would address both the factors that affect individual and social vulnerability to the hazards associated with a changing climate and the process of increasing resilience to the health risks of climate change.

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SECTION A

Conceptual and methodological perspectives

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The evolution of adaptation metrics under the UNFCCC and its Paris Agreement

Abstract

Adaptation metrics under the UNFCCC have evolved considerably over the last twenty years, starting with measuring the degree of vulnerability of countries to monitoring and evaluating adaptation at the project, sectoral and subsequently national levels to more recently reviewing the adequacy and effectiveness of adaptation and support, as well as the collective progress made in achieving the global goal on adaptation following the adoption of the Paris Agreement in 2015. Despite the progress made, no common metrics have yet been agreed for adaptation under the Convention, and the global goal on adaptation remains unspecified in respect of targets and indicators. Considering the context-specific nature of adaptation, the inherent methodological challenges and the evolving objectives for measuring adaptation, the desirability, feasibility and above all necessity of common metrics remains to be seen.

* The views expressed in this article are in the author's personal capacity and do not necessarily reflect the views of the United Nations or of the United Nations Climate Change Secretariat.

1. Introduction

This article illustrates the broad evolution of adaptation metrics under the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement.

The understanding of adaptation metrics under the UNFCCC has evolved over the last twenty years (see figure 1) from measuring the degree of vulnerability of countries ('metrics to identify and prioritize adaptation needs' – section 2), to monitoring and evaluating adaptation at the project, sectoral and subsequently national levels ('metrics to monitor and evaluate adaptation progress and actions' – section 3) to more recently reviewing the adequacy and effectiveness of adaptation and support, as well as the collective progress made in achieving the global goal on adaptation as established in the 2015 Paris Agreement ('metrics to evaluate effectiveness, adequacy and collective progress' – section 4).

2. Metrics to identify and prioritize adaptation needs

Besides mitigation, adaptation is the other major response for addressing climate change under the United Nations Framework Convention on Climate Change (UNFCCC). Adaptation entails anticipating any adverse effects of climate change and taking appropriate action to prevent or minimize any resulting damage, as well as taking advantage of opportunities that may arise. Since its inception in 1992, the UNFCCC has shaped and supported global action on adaptation. An overview of the relevant adaptation provisions included in the Convention can be found in Box 1.

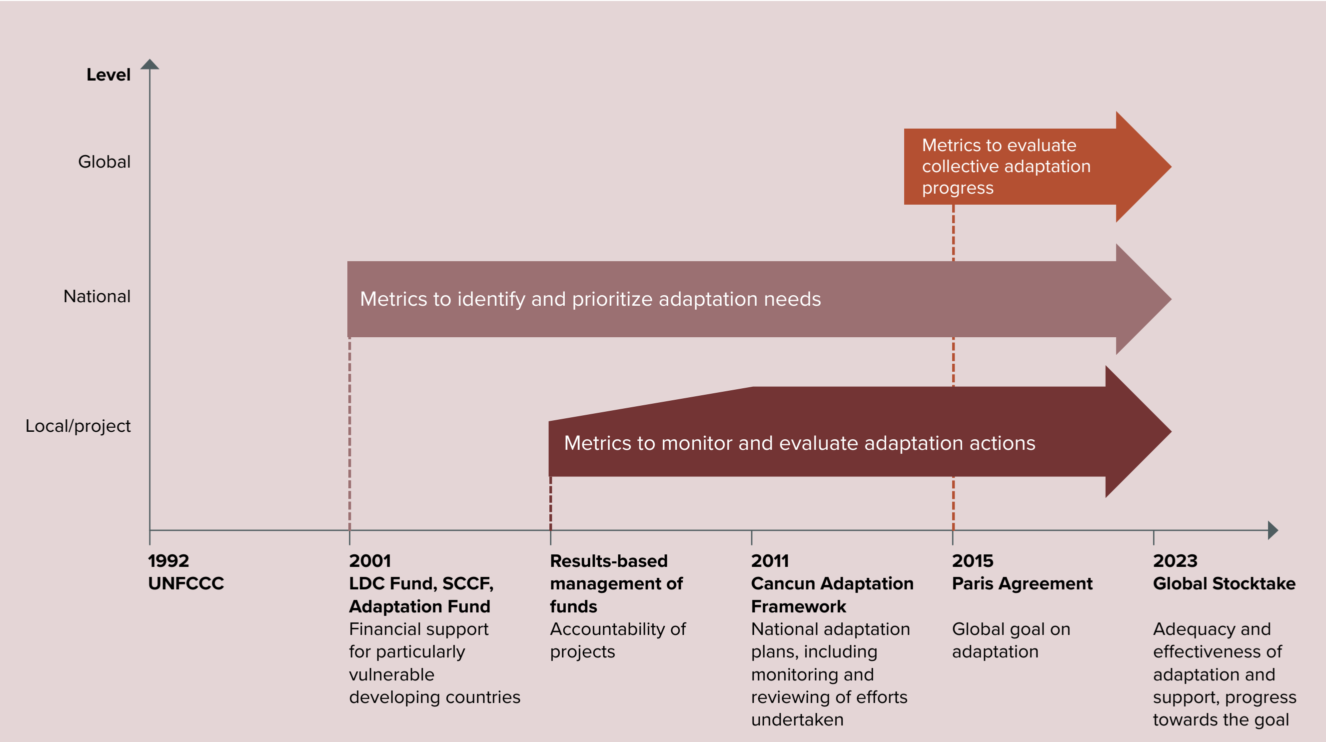
2.1 Establishing the need for adaptation

In the lead-up to the entry into force of the Convention in 1994, the focus was on mitigation, and Parties to the UNFCCC mainly considered the question, '**Do we need to adapt**?'. They undertook systematic climate observations and carried out impact assessments based on global models, which constructed a range of possible long-term scenarios. Although these scenarios were not sufficiently detailed at the regional or national levels, they were instrumental in identifying the key impacts of climate change. Parties reported the findings of their vulnerability and adaptation assessments in their initial national communications. Second-generation assessments complemented the more scenario-based first generation by looking at current climate variability and at ways in which people are becoming vulnerable and adapting. This approach also includes risk assessment along with the more refined climate change scenarios which allow consideration of what will happen in the future, given changes in both natural and socio-economic environments. More detailed historical accounts of the

Box 1. Adaptation provisions in the Convention (UNFCCC, 1992)

- The Convention recognizes 'that low-lying and other small island countries, countries with low-lying coastal, arid and semi-arid areas or areas liable to floods, drought and desertification, and developing countries with fragile mountainous ecosystems are particularly vulnerable to the adverse effects of climate change' (preambular paragraph 19).
- All Parties are to 'formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to … facilitate adequate adaptation to climate change' (Article 4.1(b)).
- All Parties shall 'Cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods' (Article 4.1(e)).
- All Parties shall 'Take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change' (Article 4.1(f)).
- 'The developed country Parties … shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects' (Article 4.4).
- 'The Parties shall give full consideration to what actions are necessary under the Convention, including actions related to funding, insurance and the transfer of technology, to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change …' (Article 4.8).
- 'The Parties shall take full account of the specific needs and special situations of the least developed countries in their actions with regard to funding and transfer of technology' (Article 4.9).

Figure 1. **Evolution of functional needs of adaptation metrics over time in relation to the UNFCCC process**



development of the adaptation concept and its application in political and legal contexts are provided by Verheyen (2002), Schipper (2006), Khan and Roberts (2013), and UNFCCC (2013a).

2.2 Prioritizing among the identified adaptation needs at the national and international levels

With the publication of the third assessment report of the Intergovernmental Panel on Climate Change (IPCC) in 2001, the Parties acknowledged that mitigation alone will not be sufficient, so they began planning and implementing adaptation measures in earnest. Recognizing that many developing countries, in particular the least developed countries (LDCs), were already facing a high degree of vulnerability to current climate variability, in 2001 the Conference of the Parties (COP) established a work programme to address the specific needs and special situations of LDCs (UNFCCC, 2002a). The work programme included the so-called National Adaptation Programmes of Action (NAPAs), which provide a process for LDCs to identify and communicate priority activities that respond to their urgent and immediate adaptation needs. These priority activities were to be supported through a specific LDC Fund.

In addition to the specific support for LDCs, the COP also agreed:

- To provide funding for pilot or demonstration projects in developing countries to show how adaptation planning and assessment can be translated practically into projects, which became the Strategic Priority on Adaptation (SPA) managed by the Global Environment Facility (GEF).
- To start to implement adaptation activities promptly where sufficient information is available to warrant such activities, inter alia in the areas of water resources management, land management, agriculture, health, infrastructure development, fragile ecosystems, including mountainous ecosystems, and integrated coastal zone management with funding from the Special Climate Change Fund (SCCF) under the Convention and the Adaptation Fund under the Kyoto Protocol.

Once the need for adaptation had clearly been established, the question evolved from 'Whether to adapt?' to '**How do we prioritize among identified needs**?' The quest for prioritization sparked the development of adaptation metrics, including criteria and indicators, to allow for a robust and comparable standard of measuring.

Regarding prioritizing at the national level, the NAPA guidelines (UNFCCC, 2002b) stipulated that the list of priority activities should be communicated 'with a concise justification based on a tight set of criteria'. LDCs were invited to follow a two-tiered approach, whereby in a first step four general criteria were to be used to select priority adaptation activities from a long list of potential activities: (a) level or degree of adverse effects of climate change; (b) poverty reduction to enhance adaptive capacity; (c) synergies with other multilateral and environmental agreements; and (d) cost-effectiveness. In a second step, LDCs were encouraged to select a small set of criteria that were most applicable to their national circumstances out of a longer list[1] to be used to rank the selected NAPA activities. The prioritizing was entirely country-driven, and once projects were submitted to the LDCF, no further ranking was envisaged at the international level. All LDCs were to have an equal share of resources from the LDCF. Since then, no other adaptation planning process under the Convention has required an explicit prioritization approach among possible adaptation activities.

While LDCs had their separate planning process and support available consistent with Article 4.9, other developing countries were facing a prioritization of their identified adaptation needs at the international level in line with 1) Article 4.4, which envisaged assistance in meeting the costs of adaptation for those developing country Parties that were particularly vulnerable to the adverse effects of climate change, and 2) Article 12.8 of the Kyoto Protocol, which stipulated that a share of the proceeds from certified project activities under the Clean Development Mechanism (which later materialized in the form of the Adaptation Fund) should be used to assist developing-country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.

The Convention in its premabular (UNFCCC, 1992) provides a long list of different geographical and biophysical traits that make a country particularly vulnerable. However, the list did not offer appropriate metrics for guiding decision-making on the limited adaptation finance available through the SPA, SCCF and the Adaptation Fund. So the question of 'How to prioritize?' became '**How to define and compare vulnerability**?'

According to Klein and Möhner (2011), defining 'particularly vulnerable' has both a scientific dimension and a political one. The scientific dimension concerns the design and use of methods for assessing, quantifying and comparing between vulnerability across regions and countries. The political dimension concerns the choices to be made in the application of these methods, and how results (i.e. vulnerability measurements and ranking) would affect decisions on the prioritization and disbursement of adaptation finance, including the timing and amount of funds.

Regarding the scientific dimension, the IPCC defines vulnerability as 'the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes' (IPCC, 2007). None of the research on vulnerability to date has resulted in a systematic and agreed way of assessing, measuring, expressing and comparing the vulnerability of countries to climate change (Hinkel, 2011; Remling & Persson 2015).

Likewise, the political dimensions have not been resolved either. Despite the construction of various vulnerability indices, including DARA's Climate-vulnerability-monitor,[2] the ND-GAIN Country Index,[3] the Climate Change Vulnerability Index by global risks advisory firm Maplecroft,[4] Germanwatch's Global Climate Risk Index[5] or the GCCA+ Index,[6] not a single one of them has been endorsed by the COP. In addition, the Parties could not agree to define 'particularly vulnerable' beyond the initial listing of 1992. While the 2007 Bali Action Plan referred to 'taking into account the urgent and immediate needs of developing countries that are particularly vulnerable to the adverse effects of climate change, especially the LDCs and small island developing States, and further taking into account the needs of countries in Africa affected by drought, desertification and floods' (UNFCCC, 2008), again the 2015 Paris Agreement only refers to developing country Parties that are particularly vulnerable in the context of adaptation support (UNFCCC, 2016a).

1 (a) Loss of life and livelihood; (b) Human health; (c) Food security and agriculture; (d) Water availability, quality and accessibility; (e) Essential infrastructure; (f) Cultural heritage; (g) Biological diversity; (h) Land-use management and forestry; (i) Other environmental amenities; (j) Coastal zones, and associated loss of land.

2 http://daraint.org/climate-vulnerability-monitor/climate-vulnerability-monitor-2010/.
3 http://index.gain.org.
4 https://maplecroft.com/about/news/ccvi.html
5 https://germanwatch.org/en/12978.
6 http://knowsdgs.jrc.ec.europa.eu/gcca/gcca-index

The question of being particularly vulnerable has not been that prominent in the context of the SCCF or the SPA. All developing countries were eligible, and funding for projects was distributed on a first come, first served basis that took the need for regional and sectoral balance into account. As for the Adaptation Fund, it follows the Convention's preambular to determine overall eligibility. While its Strategic Priorities, Policies and Guidelines list seven criteria to guide decision-making on the allocation of resources among eligible Parties, including the 'level of vulnerability' (Adaptation Fund Board, 2016), the Adaptation Fund Board has not yet agreed how to determine the level of vulnerability. So far, funding has been provided on a first come, first served basis, provided that project proposals comply with the guidelines. None of the rejected proposals has been rejected for not demonstrating particular vulnerability.

Against the backdrop of the IPCC's fourth assessment report, which confirmed that more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change, in 2007 the Parties agreed to the Bali Action Plan (UNFCCC, 2008). This plan launched a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action. Following three years of negotiations, in 2010 the COP adopted the Cancun Agreements (UNFCCC, 2011), which affirmed that adaptation must be addressed with the same level of priority as mitigation and that scaled-up, new and additional funding should be provided to developing countries, taking into account the urgent and immediate needs of developing countries that are particularly vulnerable to the adverse effects of climate change. The COP further agreed that a significant share of such funding, which could amount to USD 50 billion per year by 2020, should flow through the newly established Green Climate Fund (GCF).

The 2011 governing instrument of the GCF reflects the Bali Action Plan notion and stipulates that, in allocating resources for adaptation, the Board of the Fund is to take into account the urgent and immediate needs of developing countries that are particularly vulnerable to the adverse effects of climate change, including LDCs, SIDS and African states, using minimum allocation floors for these countries as appropriate (UNFCCC, 2012). No further metric was required, as being particularly vulnerable was translated as fitting into either of the three country categories of LDCs, SIDS or African.

As demand for adaptation support, in particular finance, is expected to exceed available supply,[7] the question of who is most vulnerable persists. Most recently at the 2015 Climate Change Conference in Paris, representatives of Egypt, speaking on behalf of the African Group, and of Sudan, speaking as chair of the African Group of Negotiators, recalled the vulnerability of the African continent as confirmed by United Nations resolutions and specialized bodies and requested that the Presidency undertake consultations on the issue of the vulnerability of Africa in 2016 (UNFCCC, 2016b). As of the 2016 Climate Change Conference in Marrakesh, no resolution was in sight, as many groups of Parties had elaborated on their specific vulnerability to the adverse effects of climate change (UNFCCC, 2017). Consultations will continue, albeit focusing on the specific needs and special circumstances of Africa rather than its vulnerability.

3. Metrics to monitor and evaluate adaptation progress and actions

In light of the complexity and long-term nature of climate change and its impacts and the need for adaptation to be designed as a continuous and flexible process and subject to periodic review, the monitoring and evaluation (M&E) of adaptation actions and progress gained traction, and the Parties started to consider '**How to undertake the M&E of adaptation?**'.

While the purpose of monitoring is to keep continuous track of progress made in implementing a specific adaptation action in relation to its objectives and inputs, including finance, evaluation is a process for systematically and objectively determining the effectiveness of an adaptation action. Assessing the effectiveness of an adaptation action involves several questions, including (UNFCCC, 2013b):

- Have the objectives and targets been achieved?
- Can this achievement be attributed to the adaptation action taken?
- Does the action effectively reduce vulnerability and enhance adaptive capacity?

[7] UNEP's 2016 Adaptation Finance Gap Report concluded that total finance for adaptation would have to be six to thirteen times higher than current levels of international adaptation finance to avoid an adaptation gap in 2030. For 2050, the report concluded that adaptation costs are projected to be in the range of USD 280 – 500 billion, which translates to an adaptation finance gap of 12-to-20 times of current flows of international public adaptation finance received (UNEP 2016).

Choosing an appropriate M&E set-up not only affects how the actual results of an adaptation intervention will be measured (ex-post), it also influences the design of the adaptation intervention (ex-ante) by clarifying the results frameworks through which interventions will be assessed.

3.1 Monitoring progress at project level, and evaluating effectiveness at portfolio level

The development of metrics in support of the M&E of adaptation was initially driven by the climate funds with the aim of ensuring accountability of resources spent and showing value for money in line with results-based management. The funds make use of indicators, as these allow a comparison of the situation after the adaptation action was implemented with the initial conditions prior to implementation. Two types of indicators are used: process indicators, which measure progress in the process of developing and implementing an adaptation action; and outcome/impact indicators, which measure the effectiveness of the adaptation action (UNFCCC, 2010; Pringle, 2011).

For example, the GEF launched its first GEF tracking tool for climate change adaptation projects the Adaptation Monitoring and Assessment Tool (AMAT), in 2011. AMAT has since been revised in 2014 and seeks to measure progress toward achieving the outputs and outcomes established at the portfolio level under the LDCF/SCCF results framework. AMAT introduces fourteen indicators and associated units of measurement along with comprehensive guidelines and methodologies for each indicator to ensure consistent use of each indicator across projects and to allow for the aggregation and communication of progress at the portfolio level.[8]

The results frameworks developed for the GEF, the Adaptation Fund[9] and the Pilot Program for Climate Resilience (PPCR)[10] under the Climate Investment Funds feature similar and partly identical indicators and corresponding metrics (see Table 1), which can be attributed to the similar objectives and expected results they are trying to achieve. Indicators range from simple qualitative ones (number of beneficiaries or plans) to more sophisticated qualitative scores to capture, for example, the degree to which institutional arrangements are in place and effective enough to result in the integration of adaptation into relevant policies, plans and processes.

The GCF has yet to finalize its results-based management framework and agree on a final list of indicators. However, drafts suggest that they follow the path of the GEF, the Adaptation Fund and the PPCR.

As many adaptation projects and programmes are still under implementation or have only recently concluded, the focus has mostly been on monitoring progress, i.e. establishing whether objectives and targets have been met, rather than on making a comprehensive assessment of effectiveness. And even if the effectiveness of projects and programmes could be established, it does not necessarily allow for an assessment of whether a country as a whole has increased its resilience and whether such an increase in resilience can be attributed to the adaptation action at hand.

3.2 Monitoring progress and evaluating the effectiveness of adaptation at the national level

Given that planning and implementing adaptation at the national level is a complex process involving many actors and stakeholders taking adaptation actions at different moments in time and with different rates depending on the level of vulnerability and past adaptation efforts, the M&E of adaptation at national level is challenging.

As early as 2002, the guidelines for the preparation of national communications for developing countries were encouraging developing countries to provide information on and, to the extent possible, an evaluation of strategies and measures for adapting to climate change in key areas, including those of the highest priority (UNFCCC, 2003). However, so far no evaluation of strategies and measures has been reported. The M&E of adaptation nationally gained momentum in 2010 when the Cancun Agreements requested all Parties to provide information on 'activities undertaken, including, inter alia, progress made, experiences, lessons learned, and challenges and gaps in the delivery of support, with a view to ensuring transparency and accountability and encouraging best practices (UNFCCC, 2011). However, the metrics for providing such information were not specified. Motivations behind calling for increased M&E nationally were diverse: some Parties sought to increase the exchange of lessons learned and good practices, others sought enhanced accountability for increased international support, while yet

8 www.thegef.org/documents/gef-climate-change-adaptation-tracking-tool
9 www.adaptation-fund.org/wp-content/uploads/2015/01/Results%20Framework%20and%20Baseline%20Guidance%20final%20compressed.pdf
10 www.climateinvestmentfunds.org/sites/default/files/knowledge-documents/ppcr_monitoring_and_reporting_toolkit_march_2016_revised.pdf

Table 1. Examples of indicators measuring the achievement of expected results of different funds for adaptation[a]

Expected results	GEF's LDCF/SCCF	Adaptation Fund	PPCR
Reduction of vulnerability	Number of direct **beneficiaries**	Number of **beneficiaries**	Number of **people supported** to cope with effects of climate change *(Quantitative reporting at the investment plan level)*
	Type and extent of **assets** strengthened and/or better managed to withstand the effects of climate change *(ha of land, km of road, km of coast)*	**Physical infrastructure** improved to withstand climate change and variability-induced stress *(Scale 5-1 ranging from fully improved to not improved)*	
	Population benefiting from the adoption of diversified, **climate-resilient livelihood** options *(number of people, % of females and of targeted population)*	Percentage of households and communities having more **secure** (increased) access to **livelihood** assets *(Scale 5-1 to express level of improvement of access)*	Change in percentage of households (in areas at risk) whose **livelihoods have improved** *(optional)*
Strengthened institutional and technical capacities	**Public awareness** activities carried out and population reached *(Yes/No, number of people, % of females)*	Percentage of targeted **population aware of predicted adverse impacts of climate change, and of appropriate responses** *(Scale 5-1 ranging from fully aware to not aware to express awareness)*	Quality of and extent to which **climate-responsive instruments and investment models** are developed and tested *(project or program-level qualitative assessment using scorecards)*
	Capacities of regional, national and sub-national institutions to identify, prioritize, implement, monitor and evaluate adaptation strategies and measures *(Number of institutions and score*[b]*)*	**Capacity of staff** to respond to, and mitigate the impacts of, climate-related events from targeted institutions increased *(Number of staff, capacity determined via survey or questionnaire)*	Evidence of **strengthened government capacity and coordination mechanism** to mainstream climate resilience *(national-level focused qualitative assessment of a) strengthened government capacity to mainstream climate resilience; and b) strengthened coordination mechanism to mainstream climate resilience with scorecard)*
Integration of adaptation into relevant sectoral and development policies, plans and processes	Institutional arrangements to lead, coordinate and **support the integration of adaptation** into relevant policies, plans and associated processes *(score)*	Climate change **priorities integrated into national development strategy** *(Scale 5-1 ranging from all (fully-integrated) to none)*	**Degree of integration of climate change at national level, including sector planning** *(national-level focused qualitative assessment of relevant strategies, policies, plans and documents with scorecards)*
	Regional, national and sector-wide **policies, plans and processes** developed and strengthened to identify, prioritize and integrate adaptation strategies and measures *(number of policies/ plans/ processes and score)*	Number, type, and sector of **policies** introduced or adjusted to address climate change risks	**Changes in budget allocations** at national and possibly sub- national level of government to take into account effects of climate variability and change *(optional)*

[a] Where not self-evident, metrics are included in parentheses and italics.

[b] By way of example, this score is calculated by assessing and scoring five criteria for the extent to which the associated criterion has been met: not at all (= 0), partially (= 1) or to a large extent/completely (= 2). The five criteria are expressed as questions:

1. Are there any institutional arrangements in place to coordinate the integration of climate change adaptation into relevant policies, plans and associated processes?
2. Are these arrangements based on one or more clear and strong mandates and supported by adequate budget allocations?
3. Do these arrangements include authority over fiscal policy?
4. Do these arrangements include broad stakeholder participation across relevant, climate-sensitive sectors?
5. Are these arrangements effective, i.e. is climate change adaptation coordinated across key national and sectoral decision-making processes?

others sought to point out the lack of support vis-à-vis the increasing challenges of adaptation.

The Agreements also established a process to formulate and implement national adaptation plans (NAPs) to support LDCs in identifying medium- and long-term adaptation needs and developing and implementing strategies and programmes to address them. Other developing countries were invited to avail themselves of the process as well. The objectives of the NAP process are:

- To reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience.
- To facilitate the integration of climate change adaptation in a coherent manner into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.

The NAP guidelines feature a 'reporting, monitoring and review' element under which Parties should undertake a regular review at intervals determined by themselves:

- To address inefficiencies, incorporating the results of new assessments and emerging science and reflect on lessons learned from adaptation efforts.
- To monitor and review the efforts undertaken, and provide information in their national communications on the progress made and the effectiveness of the NAP process.

The LDC Expert Group, an expert body established under the Convention to provide technical support to LDCs, has developed an M&E tool to assist LDCs and other developing countries engaging in the NAP process (UNFCCC, 2015). Its 'Progress, Effectiveness and Gaps M&E tool' proposes generic metrics divided into five main types to monitor and assess the process of formulating and implementing NAPs, including:

1. **Process** (measures a course of action taken to achieve a goal), e.g. a leader with sufficient authority to direct the process or a functioning participatory process in place.
2. **Input** (measures the available resources to be used by the process to achieve a goal), e.g. sufficient commitment of resources or sufficient intellectual and technological foundation.
3. **Output** (measures the products and services delivered), e.g. the activities of the process produce peer-reviewed or publicly reviewed and broadly accessible results or syntheses, and assessment products are created.
4. **Outcome** (measures results that stem from use of the outputs and that influence stakeholders outside the programme), e.g. assessment results and pilot activities have been transferred to operational use or institutions and human capacity have been created that can better address a range of related problems and issues in addressing adaptation.
5. **Impact** (measures the long-term societal, economic or environmental consequences of an outcome), e.g. the results of the NAP process have informed policy and improved decision-making in the country, or public understanding of climate adaptation issues has increased.

Noting that responding to the proposed metrics will mainly be in the form of 'yes' or 'no' or a numerical score (similar to the indicators used by the different funds for adaptation), the LDC Expert Group emphasized that the formal evaluation should include a commentary explaining the meaning of the score, and that this explanation and commentary is as important as the 'yes' or 'no' answer.

As of January 2018, nine developing countries have submitted their NAP documents to the UNFCCC secretariat.[11] While some provide detailed lists of proposed goals, outputs, outcomes and indicators to measure progress over time – for example Brazil and Kenya – others provide a more general indication of their plans to undertake M&E – for example, Sri Lanka and Sudan.

Many developing country Parties (137) also chose to report on their adaptation plans, including how they intend to measure needs and progress, through adaptation components of the nationally determined contributions (NDCs) or climate action plans, which outline countries' contributions towards achieving the objectives of the Convention.

The 2016 UNFCCC synthesis report of intended NDCs found that most of the components had a defined long-term goal or vision, which was either aspirational, qualitative, quantitative or a combination of all three (UNFCCC, 2016c). In their adaptation components, the Parties referred to actions in

[11] Available at http://www4.unfccc.int/nap/Pages/national-adaptation-plans.aspx.

Table 2. Examples of quantitative targets and goals included in the adaptation component of the communicated intended nationally determined contributions (UNFCCC, 2016c p. 68).

Sector/area	National example
Water	• Ensure full access to drinking water by 2025 • Increase water storage capacity from 596 m^3 to 3,997 m^3 in 2015–2030 • Increase desalination capacity by 50% from 2015 by 2025
Agriculture	• Convert 1 million ha of grain fields into fruit plantations to protect against erosion • Increase the amount of irrigated land to 3.14 million ha • Reduce post-harvest crop losses to 1% through treatment and storage
Ecosystems and biodiversity	• Protect 20% of marine environments by 2020 • Regenerate 40% of degraded forests and rangelands • Establish 150,000 ha of protected marine areas
Forestry	• Increase forest coverage to 20% by 2025 • Maintain 27% forest coverage • Achieve 0% deforestation rate by 2030
Disaster risk reduction	• Ensure that all buildings are prepared for extreme events by 2030 • Reduce the number of the most vulnerable municipalities by at least 50% • Relocate 30,000 households
Energy	• Ensure that hydropower generation remains at the same level regardless of climate change impacts • Increase the proportion of renewable energy to 79–81% by 2030
Other	• Ensure that 100% of the national territory is covered by climate change adaptation plans by 2030 • Reduce moderate poverty to 13.4% by 2030 and eradicate extreme poverty by 2025

virtually every sector and area of the economy, with water, agriculture and health being the top three priorities.

Several Parties also described how they will monitor and evaluate their intended adaptation actions and the support provided and received. While some Parties referred to an integrated system for monitoring, reporting and verifying their mitigation and adaptation components, others referred to developing adaptation-specific monitoring and evaluating systems and institutional arrangements. A few Parties outlined their intention to integrate the review of adaptation into existing monitoring and evaluation systems and processes for national development, for example, into annual sector-based progress reports or results-based management systems, or into reporting supervised by a designated national authority to ensure that adaptation achievements are captured and reported in regular development reports.

In terms of metrics, some Parties highlighted that they have established or will establish adaptation and vulnerability indicators and baselines to monitor and measure progress. Parties reported both quantitative indicators (e.g. number of people benefiting from adaptation activities, number of hectares with drought-resistant crops under cultivation, and forest coverage increases to 45 per cent) and qualitative indicators (e.g. degree of integration of adaptation into sectoral policies and plans and level of awareness) (see Table 2).

Given the diversity of M&E systems for adaptation nationally and the wide range of indicators in use to measure adaptation progress as seen in the NAPs and INDCs submitted the far, in 2013 the Adaptation Committee – the Convention's overall advisory body on adaptation – organized a workshop to elaborate on the definition of success in adaptation, aligning different project- and national-level assessments and on ways to learn from M&E. In its workshop report (UNFCCC, 2014), the Committee concluded that success is context-specific and dynamic, i.e. it means different things at different levels and to different stakeholders. It further concluded that there will not be any single measure of success. Participants at the workshop cautioned against trying to identify and agree on a common set of indicators.

Participants at the workshop agreed that, at the outset of any adaptation action, vulnerabilities and impacts need to be identified, actions prioritized and underlying principles agreed upon, including targets and indicators to measure whether those targets have been met. Such targets should not only encompass those that can be measured quantitatively, but also qualitative factors, such as drivers of vulnerability, e.g. inequality, lack of agency and insufficient skills to overcome challenges.

Regarding the question of developing a framework that links individual assessments to national-level assessments in order to capture progress toward strengthened adaptive capacity nationally, participants agreed that adding up indicators from the local level to arrive at an aggregate number is neither possible nor necessarily desirable. Rather than creating a framework that links the two levels, experts suggested that national-level assessments should measure aspects of adaptive capacity other than subnational and project-based assessments. National-level assessments could, for example, seek to measure the degree of coordination and integration of adaptation into national priorities. Participants ultimately stressed that the current M&E of adaptation focuses on monitoring actions. However, there is also a need to evaluate impact to assess the contribution of actions to enhancing adaptive capacity.

4. Metrics to evaluate effectiveness, adequacy and collective progress

The need for an additional focus on evaluating the impact of adaptation actions and thus on adaptation metrics gained traction in the lead up to the adoption and ratification of the 2015 Paris Agreement and subsequently (Ford et al. 2015). An overview of the key adaptation provisions included in the Agreement can be found in Box 2. This requires the effectiveness of adaptation to be reviewed as part of a regular global stocktake of progress, as well as its adequacy, i.e. considering whether adaptation action is sufficient in the context of the long-term temperature goal of holding the global average temperature increase to well below 2°C. Making such assessments of adequacy is challenging, not least because of the long-term horizons and uncertainty regarding global emission pathways or mitigation trajectories and subsequent temperature increases.

The Agreement intends that the global stocktake should also review the overall progress made in achieving the global goal on adaptation, which could benefit from adaptation metrics that allow the aggregation of national adaptation efforts to assess progress made globally.

Box 2. Key adaptation provisions in the Paris Agreement (UNFCCC, 2016a)

- Recognizes 'the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, as provided for in the Convention' (preambular paragraph 5).
- Takes full account of the 'specific needs and special situations of the least developed countries with regard to funding and transfer of technology' (preambular paragraph 6).
- Establishes 'the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2' (Article 7.1).
- Recognizes 'the importance of support for and international cooperation on adaptation efforts and the importance of taking into account the needs of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change' (Article 7.6).
- 'Each Party shall, as appropriate, engage in adaptation planning processes and the implementation of actions, including the development or enhancement of relevant plans, policies and/or contributions, which may include … monitoring and evaluating and learning from adaptation plans, policies, programmes and actions' (Article 7.9(d)).
- Periodically take stock of the implementation of the Paris Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals (referred to as the 'global stocktake') (Article 14.1).
- 'The global stocktake shall, inter alia: […] (c) Review the adequacy and effectiveness of adaptation and support provided for adaptation; and (d) Review the overall progress made in achieving the global goal on adaptation' (Article 7.14).

The methodologies and modalities for reviewing the adequacy and effectiveness of adaptation and the progress made in achieving the global goal on adaptation are still being considered by the Parties, and conclusions are not expected to be made before 2018. However, many Parties provided their views on how they see such reviews taking place.

A major bone of contention is the question, '**Should the review of the adequacy and effectiveness of adaptation take place at the national/sub-national or global levels**?'. For some, such reviews could and should only take place at the national or sub-national levels given the serious methodological difficulties associated with aggregating across countries to produce a global review (e.g. different understandings of what counts as appropriate or sufficient adaptation, given that different societies vary in risk adversity; efforts to mainstream adaptation challenge evaluations). Parties also point to the fact that adaptation success is measured through proxy indicators, such as the percentage of smallholders with access to drought-tolerant cultivars or the percentage of a country covered by early warning systems. Even if 100% of smallholders have access to appropriate cultivars, there is no guarantee that these smallholders will cope well in the face of a shock (United States of America, 2016).

For others, effectiveness and adequacy should be assessed globally, whereby the Parties could assess whether the collective adaptation action taken by them is adequate in relation to the temperature goal as set out in Article 2 of the Paris Agreement. While the review would take place at the collective level, recommendations should be directed at the individual, i.e. country level (Mali, 2016).

Regardless of the level at which the adequacy of adaptation would be assessed, many point to the difficulty of developing a universal metric for determining adequacy and effectiveness, as well as to the fact that there is no 'one size fits all' metric that can be applied to all countries (Democratic Republic of Congo, 2016; Maldives, 2016; Slovakia, 2016; Argentina, Brazil and Uruguay 2017). In addition, the Parties raise concerns that the creation of complex adaptation metrics to assess adequacy and effectiveness could result in restricting access to climate finance, as adaptation projects could be prioritized according to their effectiveness per unit of money invested (Maldives, 2016; Guatemala, 2017).

4.1 The way ahead

To allow the adequacy and effectiveness of adaptation and progress towards the goal of adaptation to be reviewed, the Parties propose multiple ways forward, including 1) learning from related assessment processes, and 2) agreeing on metrics to be developed over time that allow progress with adaptation to be measured more effectively.

Regarding related assessment processes and associated metrics, the Parties suggest using metrics identified under the NAP process in the context of the Sustainable Development Goals, the aid effectiveness agenda or the Global Partnership for Effective Development Cooperation (Slovakia, 2016).

In addition, the Parties point to the need to combine different metrics to allow different aspects of adaptation to be assessed across different scales (Maldives, 2016; Mali, 2016), including:

– From simple quantitative ones:
  - Number of people supported in a certain sector or region
  - Financial resources spent on adaptation in a sector or region

– To more complex quantitative ones:
  - Percentage of populations, sectors or proportion of GDP at risk
  - Economic assets saved from destruction by climate change impacts (Saved Wealth)
  - Human lives and health protected (Saved Health)

– To, finally, a qualitative description of the type and form of adaptation.

Irrespective of the metrics or indicators chosen, many suggest reviewing the adequacy and effectiveness of adaptation over time using a baseline or reference level of risks and vulnerability and a target or goal (Maldives, 2016; Guatemala, 2017). Periodic assessment could then offer a meaningful way of tracking the success of adaptation for specific sectors or regions over time.

Finally, many Parties point out that, unlike for the SDGs, for which targets and indicators have been or are being agreed, the global goal for adaptation has yet to be made operational. The 2018 review of the NAP process, which includes an assessment of progress made towards achieving its goals, will offer lessons for the first global stocktake to take place in 2023. As countries develop more sophisticated M&E systems at national level, including agreeing and applying different adaptation metrics, a review at the global level will become more fruitful.

5. Conclusion

Despite progress made, no common metrics have yet been agreed for adaptation under the Convention. Considering the context-specific nature of adaptation, the inherent methodological challenges and the evolving objectives for measuring adaptation (prioritizing among countries' adaptation needs, ensuring the accountability and effectiveness of adaptation projects to assessing global progress on adaptation), the desirability, feasibility and above all necessity of common metrics are matters still to be resolved.

While simple, qualitative indicators, drawing on the Sendai and SDG indicators, could be used globally to provide a rough snapshot of some adaptation outcomes, support needs and the remaining adaptation challenge vis-à-vis mitigation outcomes, only country-tailored national adaptation metrics that rely on quantitative and qualitative data will allow accurate reporting on progress and be able to guide future decision-making on adaptation.

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Pitfalls and potential of measuring climate change adaptation through adaptation metrics

Abstract

The need to understand progress in climate change adaptation is increasingly being recognized at the global, national and subnational levels, including in the context of the Paris Agreement. Indicators or metrics are commonly viewed as being critical to this process. The article first examines distinct characteristics of climate change adaptation and mitigation and the implications for measuring progress in these two interrelated policy domains. The multiple purposes of adaptation metrics are then presented and analysed, including identifying adaptation needs, allocating resources, tracking implementation, assessing results and aggregation across scales. Reflecting upon recent practice, the article outlines some of the pitfalls of applying adaptation metrics and identifies the potential for a better understanding of adaptation. By acknowledging and learning from the pitfalls of adaptation metrics, practitioners, advisors and policy-makers can avoid mismatches between what metrics are expected to do and what they can actually deliver in practice. Reviewing the pitfalls and potential of adaptation metrics will help inform the international debate and may contribute to improved applications of adaptation metrics in policy and practice.

* The views expressed in this article are those of the authors and do not necessarily reflect the views of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH or its commissioning Parties, in particular the Federal Ministry for Economic Cooperation and Development (BMZ) and the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

1. Introduction

The assessment of progress in adapting to climate change and the application of adaptation metrics have sparked significant interest in the international climate and development communities. An increasing number of events such as the 2nd International Conference on Evaluating Climate Change and Development and the Pre-COP22 Adaptation Metrics Conference, as well as several publications, have been devoted to this topic, including studies providing overviews of adaptation M&E approaches in multiple countries (Hammill et al., 2014a; OECD 2015; Pringle et al., 2015, Leiter, 2017a). UNEP's Adaptation Gap Report 2017 focused on how progress towards the global goal on adaptation can be assessed (UNEP, 2017). Indeed, the Paris Agreement (UNFCCC, 2015) acknowledges the role of 'Monitoring and Evaluation and Learning from adaptation plans, policies, programmes and actions' (Article 7, paragraph 9d), and its transparency framework requests countries to provide information on climate impacts and adaptation, as well as on progress towards achieving nationally determined contributions (Article 13) (Möhner, Leiter & Kato, 2017).

Reflecting upon recent practice, this article outlines some of the pitfalls involved in applying adaptation metrics and identifies the potential for enhancing assessments of adaptation.[1] It aims to inform discussion on the use and limitations of metrics and to indicate where progress can be made to improve understanding of adaptation. By acknowledging and learning from the pitfalls of adaptation metrics, practitioners, advisors and policy-makers can avoid mismatches between what metrics are expected to do and what they can actually deliver in practice. Awareness of the strength and weaknesses of metrics helps in putting them to use where they best suit the intended purpose. Moreover, we argue that greater effort is needed to understand how metrics can interact with qualitative learning by improving the links between monitoring, evaluation and learning, rather than searching for an elusive universal indicator of adaptation.

Although indicators are subject to a variety of definitions, they tend to be broadly consistent in describing 'a quantitative or qualitative variable that provides reliable means to measure a particular phenomenon or attribute' (USAID, 2009). A 'metric' is usually described as an aggregate measure calculated on the basis of multiple components or indicators. For instance, the resulting score of a quantitative vulnerability assessment based on numerous indicators could be considered a metric. However, the distinction between metrics and indicators does not seem to prevail in practical discussions such as those that took place at the Adaptation Metrics Conference, partly because a metric can also be an indicator. For example, a composite vulnerability index could be used as indicator of the need for action. Given the way metrics and indicators are so closely linked in practice and in climate policy discussions, we therefore use both terms interchangeably in this article.

The article starts with an analysis of how the monitoring and evaluation (M&E) of adaptation differs from the measurement of greenhouse gas mitigation, and it explores both the appropriateness and the practical reality of generating a single, all-encompassing adaptation metric. It then outlines the main purposes of using adaptation metrics and describes common pitfalls that can be associated with their application. The article then considers four areas with potential for improving assessments of progress with adaptation. The article is informed not only by academic literature, but also by the increasing number of adaptation M&E publications from implementing agencies, NGOs and international organizations (an overview can be found in Bours, McGinn & Pringle, 2014a). The authors also draw upon their own experiences, as both have been closely involved in the science-policy interface on adaptation M&E both nationally and locally since 2011 (e.g., Leiter, 2011, 2015, 2016, 2017a, 2017b, 2018; Pringle, 2011, 2014; Pringle et al., 2015;).

2. The nature of adaptation and its implications for adaptation metrics

There have been repeated calls for a standardized way of quantifying adaptation in the form of adaptation metrics, which it is hoped can lead to more ambitious action, improved comparability and prioritization of investments, better assessments of global progress and increased mobilization of funds. For instance, a 'Metrics of Adaptation Conference' took place in advance of COP22 in Morocco with the aim of 'developing a set of transferrable indicators to measure and track the success of adaptation projects' (COP22 Scientific Committee, 2016). Similarly, Conservation International hosted a workshop aimed at identifying common metrics to quantify the benefits of ecosystem-based adaptation (Donatti et al., 2016). Such attempts typically draw a comparison

[1] Key messages from this article, together with recommendations for the Global Stocktake under the Paris Agreement, are available as a Policy Brief (Leiter and Olivier, 2017a).

with climate change mitigation where measurement of the success of interventions is centred on the common indicator of avoided emissions (expressed in CO_2 equivalents[2]), albeit often complemented by context-specific information such as the reference year or business-as-usual scenario. The 'universal' mitigation metric of reduced CO_2 equivalents has the following properties:

1. **Universal applicability.** It is equally applicable
- In all contexts (geophysical and socioeconomic)
- At all geographical levels
- For all types of interventions[3]

2. **Uniform effect.** Each ton of avoided emissions has the same effect[4]
- Irrespective of location
- Irrespective of how many tons are reduced by any one intervention (i.e. there are no economies of scale[5])

These two properties are derived from the physics of greenhouse gases that, upon release, mix evenly in the atmosphere within around one year (Archer & Rahmstorf, 2010).[6] The effects of climate change thus depend on *global* greenhouse gas (GHG) concentrations and their composition over time, meaning that every emitted or avoided ton of CO_2 equivalent emissions can be treated equally, irrespective of its geographical origin. These principles of **universal applicability** (property 1) and **uniform effect** (property 2) enable mitigation outcomes to be aggregated and compared across the globe.[7] Could a metric with similar properties exist for adaptation? To answer this question, we need to examine the **nature and characteristics** of adaptation.

Adaptation is the process of adjustment of human or natural systems to the actual or expected climate and its effects, the aim being either to reduce or avoid the negative impacts of climate change or to exploit beneficial opportunities (IPCC, 2014b). Climate impacts unfold differently from place to place and time to time, and it is the mixture of global, regional and site-specific social, economic and environmental factors that influence both the impacts and the ability of natural and human systems to respond to them. The design of adaptation and what constitutes success therefore differ depending on the circumstances. Moreover, value judgements are necessarily involved when determining successful adaptation, for example, if adaptation by one population group may negatively affect the abilities of another to adapt (Adger, Arnell & Tompkins, 2005). In addition, an adaptation that works well at a certain point in time may not be sufficient to deal with an even higher level of future climate impacts. What constitutes successful adaptation therefore changes over space and time and is dependent on the perspective taken. Psychological factors such as values, beliefs and perceptions of risk also play a role (Grothmann & Patt, 2005). This marks a major difference from mitigation, where one ton of avoided emissions is treated as an equal measure of success, no matter how and where it was achieved. For adaptation, the context-dependency and the lack of an objective way of defining success severely limit the possibility of a universally applicable metric that meaningfully expresses adaptation outcomes (as opposed to simple outputs like the number of trainings conducted).

Another difference between measuring mitigation and measuring adaptation is that mitigation has a measurable target of holding warming to 'well below 2°C above pre-industrial levels' (UNFCCC, 2015, Article 2). Progress towards this goal can be assessed by estimating the remaining carbon budget for the purposes of keeping within 2°C at different levels of confidence and comparing it to actual or projected carbon emissions (Friedlingstein et al., 2014). Adaptation, in contrast, does not have a target that is similarly measurable in an absolute way. Instead, adaptation can be viewed as an on-going process of adjustments to climatic, social and economic changes. As such, measuring progress with adaptation will always relate to the system(s) of concern and will require proxy measurements designed to determine the extent and nature of these adjustments. Concepts that are commonly used for this purpose are climate vulnerability, risk and resilience. Yet, these concepts are in turn context-specific and dynamic and there are

[2] The conversion of GHG emissions into CO_2 equivalents is complicated by the different atmospheric lifetimes of each gas. The impact of a short-lived but potent GHG like methane is undervalued in conversions that are based on hundred-year time horizons (IPCC, 2014a, Chapter 1.2.5).

[3] Exceptions are those that focus entirely on capacity-building or awareness-raising, which do not directly translate into emission reductions.

[4] This assumes a proportional response by the climate system to the level of greenhouse gases in the atmosphere. This assumption is typically made despite the likely existence of thresholds (tipping points) at which specific elements of the earth system are thought to change their behaviour abruptly (e.g. Lenton et al., 2008).

[5] The concept of 'economies of scale' comes from economics, in which it describes the reduction in costs per unit as production volumes increase. Applied to mitigation, it would mean that the effect of avoided emissions would depend on how many tons are reduced at the same time by the same intervention or in the same region.

[6] The concentration of GHGs in the atmosphere may be higher in close proximity to large emission sources like industrial areas or lower in close proximity to large sinks such as forests (ibid.).

[7] For example, the UNFCCC Synthesis Report of the aggregated effect of submitted INDCs and UNEP's Emissions Gap Reports estimate global emissions and the gap towards achieving agreed policy targets. In contrast, UNEP's Adaptation Gap Reports outline types of gaps, but have so far only attempted to quantify the adaptation finance gap.

multiple ways to construct and measure them which may lead to different results (Leiter, Olivier, Kranefeld, Helms & Brossmann, 2017). The IPCC (2014c. p. 854) even states that 'the concept of resilience … is particularly resistant to attempts to establish commonly accepted sets of indicators.' Units of vulnerability or resilience therefore cannot be easily aggregated like tons of GHG emissions.

Conceptually, another challenge is to define what counts as adaptation. While the IPCC's definition of adaptation is widely accepted, in practice it can be difficult to distinguish between adaptation and development (Sherman et al., 2016). A review of development aid to Oceania found that, depending on the criteria used, the amount of finance counting as adaptation varied between 3% and 37% of the available budget (Donner, Kandlikar & Webber, 2016). Similar results were found in a review of development projects classified as adaptation according to the OECD Rio marker system (Junghans & Harmeling, 2012). Even if development gains are taken as an ultimate outcome measure of adaptation, normalization against changing climatic conditions would still be required to determine whether adaptation had somehow contributed to development gains or had prevented losses that would have otherwise occurred. Measuring the outcomes of an adaptation intervention requires a comparison with what would have occurred without that intervention, while taking into account potential autonomous adaptation. The choice of such a counterfactual will influence the results of an assessment. This methodological problem also arises when evaluating mitigation interventions where business-as-usual (BAU) emissions need to be estimated and inflating BAU emissions makes even small carbon reductions appear like major achievements. For adaptation, another layer of complexity is added through the dynamic unfolding of climate events. For example, disaster risk reduction efforts may be judged sufficient so long as an extreme event of higher than expected magnitude does not occur. Finally, since adaptation takes place against the backdrop of evolving climate and non-climatic changes ('moving baseline'), a simple pre-post comparison may not be appropriate. In the case of these and other conceptual and methodological challenges, assessing progress with adaptation is different from assessing mitigation (e.g. Bours, McGinn & Pringle, 2014b; Dinshaw, Fisher, McGray, Rai & Schaar, 2014; Ford & Berrang-Ford, 2016). Table 1 contrasts the characteristics of measuring adaptation and mitigation.

Table 1 suggests that adaptation metrics are more complex to construct than metrics for mitigation. Critically, the lack of a single universal measure for adaptation means that efforts to reduce this complexity to a single or limited set of indicators risks over-simplifying, which in turn could lead to future maladaptation. Therefore, one pitfall of developing adaptation metrics is:

> **Pitfall:** there is no single, uniform and universally applicable metric to measure progress with adaptation in the same way as mitigation can be measured through greenhouse gas emission reductions.

This does not mean that adaptation cannot be assessed using metrics. It simply means that **the search for a single or simplified set of global, all-purpose metrics will be fruitless due to the nature of adaptation and the associated conditions of measurement** (Table 1). Similarly, there is no single metric for 'improvement in sustainable development.'[8] Rather, progress in achieving the Sustainable Development Goals will be assessed through 230 indicators to account for the breath of the topics they cover (United Nations, 2016). Hence, instead of focusing on a single metric, it is useful to examine how adaptation metrics might be used for different purposes and what their strengths and weaknesses are. We do this in the next section.

3. Clarifying the purpose of adaptation metrics

In the absence of a single, uniform adaptation metric, a multitude of alternative metrics can be formulated for a variety of purposes. The IPCC's Fifth Assessment Report distinguishes between three different uses of adaptation metrics (IPCC, 2014c, p.854ff.):

1. Identifying adaptation needs
2. Tracking implementation of adaptation actions
3. Assessing the achieved results of adaptation

The second and third usages together can be taken as assessment of adaptation progress in respect of what is being done (i.e. *process*-oriented: is implementation taking place?) and what is being achieved (i.e. *outcome*-oriented: what are the effects resulting from the actions?). Metrics can also be used to allocate resources and to aggregate progress with adaptation from the local to national or global

[8] Traditionally, GDP growth has been used as indicator for economic development, but it does not reflect sustainable development.

Table 1. **Characteristics of adaptation and mitigation measurement.**

Characteristic	Mitigation	Adaptation
Ultimate objective	'Stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (UNFCCC, 1992, Article 2)	Sustainable development achieved amidst climatic change; avoided negative impacts of climate change; reduced climate vulnerability and risk, and increased climate resilience
Global target	Quantitative: keeping 'the global average temperature to well below 2 °C above pre-industrial levels' (Paris Agreement)	Qualitative: 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability' (Paris Agreement)
Subject of measurement	Mainly physical or chemical conditions: GHG emissions, CO_2 concentrations in the atmosphere, climate parameters, including temperature[a]	Combinations of socio-economic and bio-physical conditions: changes in human or natural systems; the relationship between such changes with current and future projected climate impacts
Type of measurement	Direct: emission reductions, anthropogenic GHG emissions expressed in CO_2 equivalents, GHG concentration and composition in the atmosphere, essential climate variables including temperature.	Indirect, because direct measurement of avoided climate change impacts is plagued with conceptual and methodological challenges (Bours et al., 2014b; Dinshaw et al., 2014). Therefore, adaptation is often assessed through concepts such as risk, vulnerability and resilience, or through proxies that are expected to lead to adaptation, such as adaptive capacity.
Place dependence of definition of measurement unit?	No, there is universal applicability because the subject of measurement can be measured on objective scales like degrees Celsius, metric tons or parts per million.	Yes, vulnerability, risk and resilience are context-specific. There is no universal way to construct and measure them. As value judgements are involved, there is no single objective ranking of vulnerability (Klein, 2009).
Causality between intervention and outcome	Direct attribution of emissions reductions is possible for some interventions (e.g. installation of renewable energy), more difficult for higher-level policy interventions.	Attribution difficult to establish due to a host of other influencing factors and longer time horizons (Bours et al., 2014b; Dinshaw et al., 2014). Instead, it is common to measure contribution.
Additionality	Less conceptual, but practical challenges in demonstrating additional emissions reductions (Schneider, 2009).	Conceptual and practical challenges in separating adaptation from development: different framings of adaptation are used (Sherman et al., 2016)
Baseline	Absolute anthropogenic emissions in a particular year (e.g. 1990) or estimated future emissions (e.g. business as usual scenarios); GHG concentration and composition in a particular year.	No agreed baseline. Since climate impacts are increasing and fluctuate over time, the level of adaptation in the past may not be a meaningful reference point.

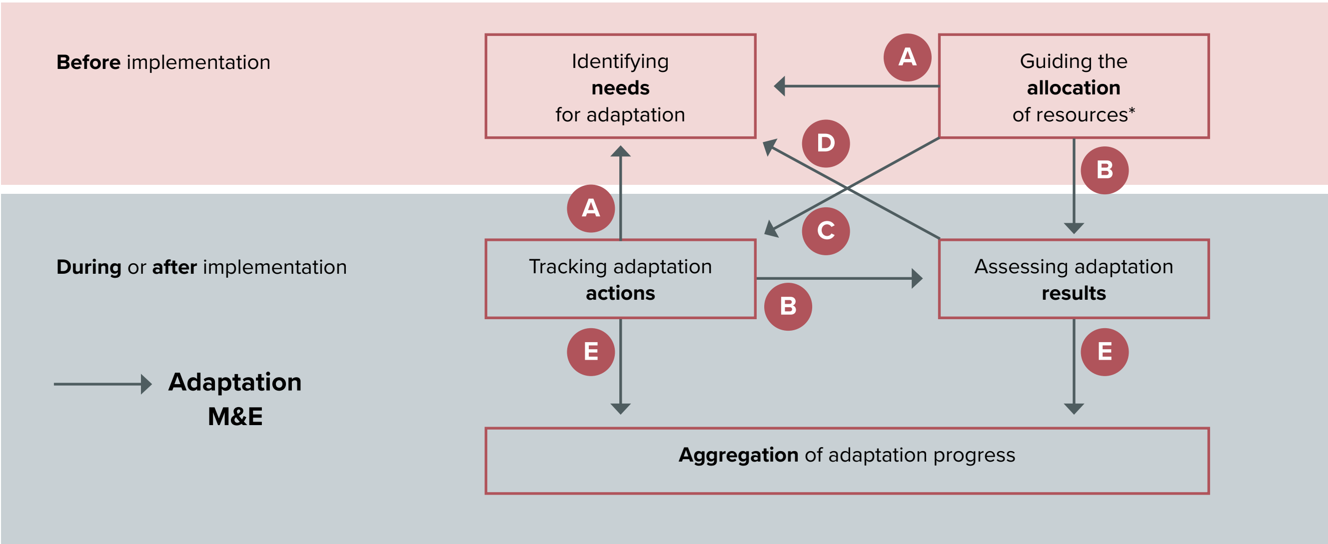
[a] Beneath this ultimate success level there may be a hierarchy of indicators pointing to different areas of progress, e.g. energy intensity per unit of GDP (Peters et al., 2017).

level, as anticipated in the Global Stocktake of collective progress towards the objectives of the Paris Agreement (UNFCCC, 2015, Article 14; see also UNEP, 2017).[9] Furthermore, adaptation needs, levels of implementation and achieved results can be compared through metrics across cases and countries. Figure 1 illustrates these uses and their interrelations.

The upper half of the diagram shows uses of adaptation metrics before implementation has begun, whereas the lower half is concerned with assessments during or after implementation of adaptation interventions. It is only the latter that is commonly referred to as monitoring and evaluation (M&E) of adaptation (see, for example, the special issue on adaptation M&E in the journal *New Directions for Evaluation, 147,* Fall 2015). These uses will be described in the following sections, each of which also addresses the issue of comparability. Common *pitfalls* in respect of practice will be summarized in the form of key take-away messages, as is

[9] Aggregating adaptation across scales can employ more than just metrics, as the practical examples from countries such as Mexico or South Africa demonstrate (Leiter, 2015; see also section 3.4, below).

Figure 1. Common uses of adaptation metrics and their interrelations



A Do allocation and actions **respond to needs?**
B Are allocation and actions **results-oriented?**
C Does **implementation** take place, i.e. does the allocation translate into actions?
D Are actions (represented by their results) **effective** in addressing the needs?
E What **collective progress** is being made through actions and their results?

Source: the authors

* Resources include human resources (know-how, time) and financial resources.

also the case for *potential* in part four. All pitfalls and areas of potential are then highlighted in the conclusion.

3.1 Identifying adaptation needs

Adaptation needs are typically identified through vulnerability assessments relating to current and projected climate impacts for a particular region, population or system and the capacity to respond to them (PROVIA, 2013). Vulnerability assessments can be conducted in a variety of ways. They differ along dimensions such as purpose, framing of adaptation, determinants of vulnerability, stakeholder involvement, data intensity and communication of outputs (Schröter, Polsky & Patt, 2005).[10] These dimensions show that indicators form just one part of vulnerability assessments and that they should only be formulated once the purpose of the assessment and the conceptualization of vulnerability have been determined (Fritzsche et al., 2014).

Adaptation spans multiple sectors and geographical regions, and the exact composition and interrelationship among the determinants of vulnerability can vary greatly. Therefore, each vulnerability assessment will likely have a unique set of indicators. For example, the UK's and Germany's national climate risk and vulnerability assessments, although conducted for similar purposes, differ in the methods and indicators used.[11] Several global indices consisting of collections of indicators have been constructed to compare vulnerability across countries (e.g., the Climate Vulnerability Monitor by DARA International (2012)). However, as noted by the IPCC (2014c, p.855), these indices often produce quite different country rankings,[12] which is not surprising given that each index uses a different set of indicators (Leiter et al., 2017). Even where the same indicators are used, variations in weighting can lead to different results, as Brooks, Adger and Kelly (2005) have shown for their own index. They conclude that 'assessments of vulnerability or adaptive capacity based on individual country rankings are generally not appropriate, due to the variation in rank across indices' (ibid.).

[10] A useful step-by-step guide to vulnerability assessments is provided by Fritzsche et al. (2014), and guidelines for climate impact and vulnerability assessment by UBA (2017). A framework for comparing different vulnerability assessments is available from Hammill et al. (2013).

[11] The European Environment Agency is currently working on a report comparing national climate risk and vulnerability assessments across Europe. It is scheduled to be published in 2018.

[12] For example, a comparison between a synthesis of climate vulnerability hotspots from multiple studies and the rankings of one particular global vulnerability index has shown 'notable differences' (Muccione, Allen, Huggel & Birkmann, 2017).

> **Pitfall:** as there is no single, objective set of indicators to determine adaptation needs universally across the globe, seeking such metrics risks overlooking key contextual insights.

Brooks et al. (2005) recommend grouping those countries that end up in similar positions, as this provides a more robust assessment than individual country rankings. Due to the political implications of vulnerability rankings and the fact that the results depend on the underlying methodology, the Parties to the UNFCCC have so far not agreed on a specific way of calculating which countries are 'particularly vulnerable' (see section 3.2).

3.2 Allocating resources

One particular use of adaptation metrics that is repeatedly advocated, for instance at the Pre-COP22 Adaptation Metrics Conference in Morocco, is to allocate financial resources such as those spent by international climate funds. The challenge of allocating resources based on levels of vulnerability goes back to the 1992 UN Framework Convention on Climate Change (UNFCCC), which states that developed Parties 'shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation' (UNFCCC, 1992, Article 4, paragraph 4). However, it has become clear that the seemingly logical idea of agreeing on a common way to assess and compare vulnerability cannot be realized that easily. The nature of adaptation and the conceptual ambiguity of vulnerability defy the construction of a single index that cannot be contested on the basis of its composition or calculation. Indeed, Klein (2009) and Klein and Möhner (2011) emphasise that normative decisions will inevitably be involved, such as which determinants of vulnerability to include and how to weight them, and they conclude that identifying ways to prioritize funding based on vulnerability indices will always be a political as much as a technical challenge. Muccione et al. (2017), who examined the role of global vulnerability distributions in adaptation funding, conclude that 'a lack of agreement on the definition of vulnerability components, their usage, and choices of representative indicators fail to convene a robust guidance for policy makers when confronted with the delicate issue of deciding on the distribution of financing.' The IPCC concurs: 'both theory and practice have shown **indices alone are not sufficient to guide decisions** on which adaptation actions to take, on how to modify sustainable development activities, **or on resource allocation**' (IPCC 2014c, p. 857).

The risks and limitations of relying on an index-led approach to allocating funding are also illustrated in Füssel's (2010) review of vulnerability indices: 'The development of aggregated national-level vulnerability indices requires substantial normative choices in the selection and aggregation of diverse information …, which largely determine the resulting vulnerability ranking.' Furthermore, he found that 'All existing indices of vulnerability to climate change show substantial conceptual, methodological and empirical weaknesses including lack of focus, lack of a sound conceptual framework, methodological flaws, large sensitivity to alternative methods for data aggregation, limited data availability, and hiding of legitimate normative controversies.' Thus, while political agreement on any particular method to rank countries' vulnerabilities is not impossible, **it is apparent that the establishment of an objective and non-normative way to allocate adaptation resources remains unlikely and not necessarily helpful.** Therefore, another pitfall observed on the basis of practice is:

> **Pitfall:** it is extremely unlikely that the notion of 'particularly vulnerable' countries can be determined in an objective, non-normative way, as this inevitably involves value judgements that can be contested.

Instead of trying to design 'the one and only' index or rallying political support behind any particular index, Muccione et al. (2017) recommend that funding decisions be based on a consensus arrived at through multiple studies, and they suggest that the IPCC conduct such an assessment. In their view this would allow better targeting of funding than is currently the case on the basis of country income groups. They also advocate replacing the widely used concept of vulnerability as consisting of exposure, sensitivity and adaptive capacity with the risk-based approach that was introduced in the IPCC's Fifth Assessment Report.

3.3 Assessing adaptation progress

Assessing progress with adaptation is fundamental to understanding whether adaptation is actually taking place, i.e. whether we are better prepared to respond to climate change and are reducing its adverse impacts. In line with the IPCC's (2014c) use of metrics for adaptation, adaptation progress can be assessed in terms of tracking implementation (what is being done?) and assessing actual results (what are the effects of our actions)? This corresponds to the common distinction between *outputs* and *outcomes* as elements of a results chain,[13] or between *process*-based and *outcome*-based indicators (Harley, Horrocks, Hodgson & Van Minnen, 2008). This distinction is important because actions like planning or capacity-building, while essential, do not guarantee that adaptation will take place. It is therefore important to assess actual adaptation results (i.e. outcomes), for example, whether farmers in drought-prone areas have adapted their farming techniques and as a result are achieving higher yields under conditions of drought than would have been possible using previous techniques. Due to the multi-sectoral and context-dependent nature of adaptation and the time scales involved, measuring the actual outcomes of adaptation has proved challenging. Initially, it was therefore suggested that process rather than outcome indicators should be the focus (e.g. Harley et al., 2008). However, with at least half a decade's experience in implementing adaptation at scale across the globe, and given the significant domestic and international resources being spent, it is no longer enough to focus adaptation M&E on the process of implementation alone. By the same token, it is insufficient only to measure how much is being spent on adaptation, because spending says little about actual results. This conclusion was also reached by an expert workshop on adaptation M&E in 2012 (Adaptation Partnership, 2012). A further pitfall on the basis of practice is therefore:

> **Pitfall:** tracking only what is being done or how much is being spent may lead to misleading conclusions about the actual degree of adaptation.

A good illustration of this pitfall, as well as of a way to address it, is provided by the first progress report of the Adaptation Sub-Committee (ASC) of the UK Committee on Climate Change, an independent body that reports to parliament on progress achieved in implementing the UK's National Adaptation Programme.[14] For every adaptation priority sector, the report examined three questions:

- Is there a plan?
- Are actions taking place?
- Is progress being made in managing vulnerability?

The first two questions are process-oriented, while the third is outcome-oriented. As shown in the summary of the first progress report to the UK parliament in Figure 2 (reproduced from the Committee on Climate Change (2015)), the results to the first two questions are generally positive, with green dominating the respective columns. However, results to the third question illustrate areas where progress in reducing vulnerability is lacking or partial and also shows that there is often insufficient information to draw conclusions regarding progress. Looking only at the process-oriented questions fails to show either these information gaps or the differential progress made in managing vulnerability. This example is a powerful illustration of the pitfall of inferring progress with adaptation from information on financial inputs and planning processes alone. The approach employed by the ASC, that is, to define and monitor measurable climate risk factors, also serves as an example of how to assess adaptation outcomes in the absence of specific policy targets.

M&E of adaptation can be carried out for a variety of different purposes (e.g. assisting project management or informing Members of Parliament), each of which seek different types of information and level of detail, and subsequently require different methods. For example, understanding *why* an adaptation intervention was successful requires an in-depth analysis, i.e. more than just indicators, whereas providing accountability may require just a few quantitative figures. The Adaptation M&E Navigator (Leiter, 2017b) outlines nine specific purposes of adaptation M&E and indicates suitable M&E approaches for each of them. Considering the range of specific purposes as described in Table 2, it becomes apparent that **there is no one size fits all approach to adaptation M&E** in terms of either methods or metrics. Another pitfall observed on the basis of practice is therefore:

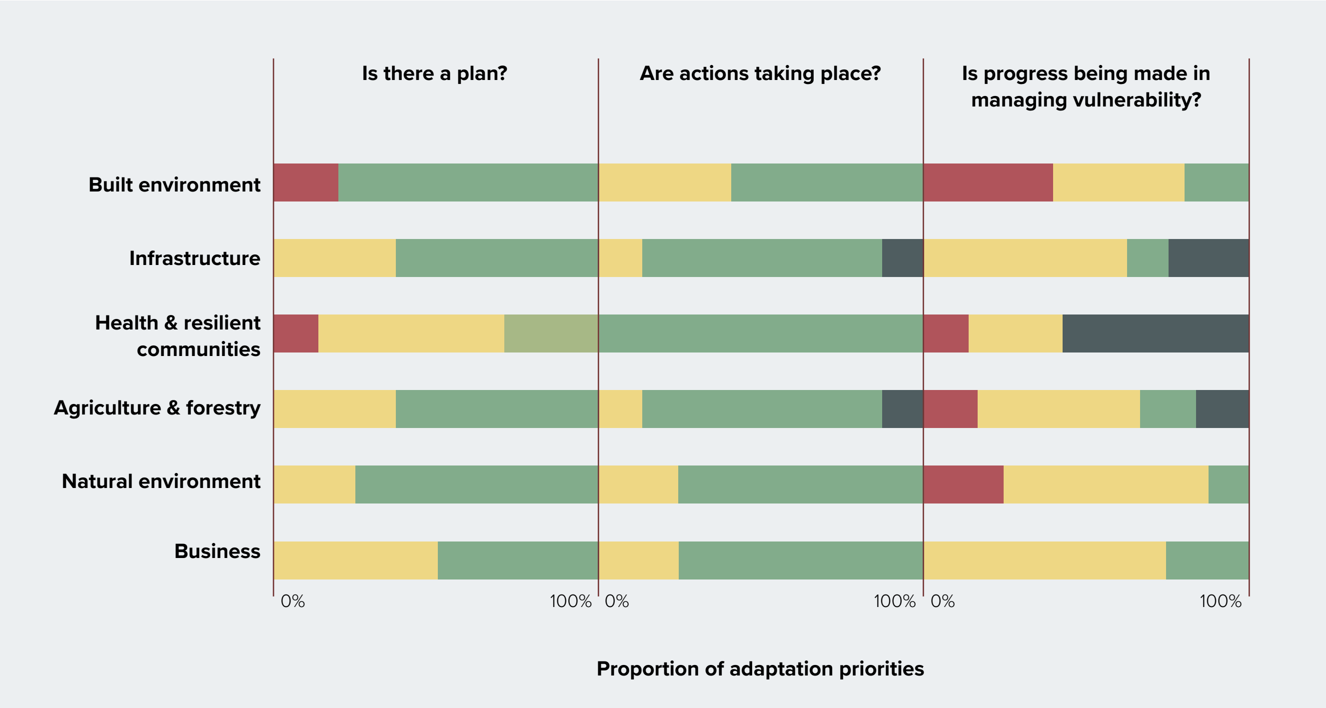
> **Pitfall:** there is no metric or set of metrics that can simultaneously fulfil the different purposes of adaptation M&E (e.g. adaptive management, accountability, learning) to a sufficient degree.

In recognition of this pitfall, available guidebooks on adaptation M&E typically focus on a specific level of application like the project level (e.g., Olivier, Leiter & Linke, 2013; Climate-Eval, 2015), the community level (e.g. Ayers, Anderson, Pradhan & Rossing, 2012) or the national level (e.g. Price-Kelly, Leiter, Olivier & Hammill, 2015). This enables them to provided targeted recommendations about suitable methods of undertaking adaptation M&E. The

[13] Results chains are a common way to express the results of development projects (refer to the glossary on results-based management by OECD, 2008). Yet, theories of change are an alternative method that is well suited to adaptation interventions and offers advantages over a linear results chain approach (Bours et al. 2014c).

[14] An overview of the UK's adaptation M&E framework is provided by GIZ (2017).

Figure 2. Summary of the ASC's assessment of progress by the UK National Adaptation Programme



Source: reproduced from the Committee on Climate Change (2015, p. 9).

Notes: The colours depict the proportion of risk factors ('adaptation priorities') within each theme of the National Adaptation Programme, categorized as one of:

- plans and policies, delivery of actions, or progress in addressing vulnerabilities, are lacking.
- the adaptation priority has been partially addressed, with some evidence of progress in some areas.
- plans are in place, actions are being delivered, progress is being made
- insufficient evidence to form a judgement.

Table 2. Different purposes for undertaking adaptation M&E (based on Leiter (2017b)).

Focus	Purpose of undertaking adaptation M&E
Adaptation *process* (i.e. implementation but not results)	Monitoring the integration of adaptation into planning (mainstreaming)
	Monitoring the implementation of adaptation programmes, projects or actions
	Monitoring the implementation of a National Adaptation Plan(ing) process
	Tracking adaptation activities at the national or sub-national level
Adaptation *outcomes* (*or process* *and* *outcomes*)	Assessing the results of adaptation programmes, projects or actions
	Assessing the results of a portfolio of adaptation projects
	Assessing whether vulnerability has been reduced as a result of adaptation programmes, projects or actions
	Assessing progress towards adaptation at the national level
	Assessing progress towards the global goal on adaptation

Adaptation M&E Navigator likewise refers users to suitable M&E methods for each specific purpose (Leiter, 2017b).

3.4 Aggregation and comparison of adaptation results

Quantitative comparisons between different adaptation interventions require a common metric to express adaptation results. As explained in section two, due to the nature of adaptation it is hard to define a single indicator of success. One way to enable comparison would be to express adaptation benefits in monetary values, but the valuation of avoided climate impacts comes with well-known problems, including the choice of discount rates, currency value fluctuations and equity issues.[15] A report by Vivid Economics (2011) found 'Some [climate] impacts can be measured adequately in money. For others, especially health, poverty and biodiversity, non-money metrics are needed as well or instead.' Nevertheless, increasing attempts are being made to quantify adaptation benefits in ways that are comparable (e.g. Stadelmann, Michaelowa, Butzengeiger-Geyer and Köhler (2014); Michaelowa and Stadelmann (2018), and applications in Köhler and Michaelowa (2013), as well as in REEEP (2016) and Leiter (2018)). Upscaling the use of such approaches could enhance the ability to compare adaptation results.

The question remains regarding the purpose of comparing already realized adaptation results, particularly if they have been achieved in very different contexts. Even if a common unit is used to express adaptation benefits, achieving a certain number of benefits in one context may not be comparable to achieving the same number in another context (e.g. in fragile states). Comparisons may therefore be most appropriate in the same or similar contexts, as done by REEEP (2016). Learning (a commonly cited objective of M&E) requires insights into how and why change occurred which cannot be captured through indicators alone (see section 4.3). Comparability is typically more relevant *before* implementation in order to select from among a number of alternative adaptation options.[16] This appraisal stage, sometimes referred to as 'evaluation of options', is not part of Monitoring and Evaluation (compare Figure 1). Some proposals for 'universal' adaptation indicators, for example, those of Stadelmann et al. (2014), are aimed primarily at the selection stage of adaptation projects rather than the ongoing or ex-post assessment of results, although in some cases indicators can be used for both purposes (Köhler & Michaelowa, 2013). In practice, funding decisions do not always conform to idealized situations of choosing from among a large number of alterative options at the same point in time. Even if comparison on a common unit was possible and meaningful across contexts, differences in timing, funding needs and political considerations may not enable a selection based on comparable criteria (Leiter, 2018).

Aggregation is concerned with summarizing the results of interventions that span multiple sectors or geographical levels, as is typically the case for climate funds such as the Green Climate Fund, the Adaptation Fund or the Least Developed Countries Fund. This often leads to indicators on the lowest possible denominator, like 'number of beneficiaries', that are applicable to a wide variety of interventions, but say little about the actual degree or success of adaptation. Indeed, there are limits to what standardized, quantitative aggregations of adaptation can achieve. Chen and Uitto (2014), who analysed the challenges of aggregating local actions to global results in case of the Small Grants Programme of the Global Environment Facility, point out that mechanical aggregation fails to capture important results. The pitfall to be avoided therefore is:

> **Pitfall:** if confined to adding up simple, quantitative numbers, aggregation cannot account for important insights about progress being made.

Instead of equating aggregation with simply adding up numbers, we argue for a broader understanding of aggregation as the collation or bringing together of information across spatial scales and geographical boundaries, whether quantitatively or qualitatively. Leiter (2015) shows how this can be operationalized through M&E frameworks that define focus topics while providing flexibility for subnational entities in how exactly to measure them. South Africa is currently exploring this approach for its national adaptation M&E system (Department of Environmental Affairs 2016, 2017). Overall, aggregation is an important task for M&E of adaptation, for example, in the context of the Global Stocktake stipulated by the Paris Agreement (UNEP, 2017; Leiter & Olivier, 2017a). While aggregation through simple quantitative figures may satisfy the aims of accountability, it should be recognized that this does not explain the richness of adaptation outcomes and their co-benefits. Adaptation

[15] For instance, a loss worth of USD 500 may ruin the livelihood of a poor person in a least developed country, whilst having only an insignificant impact on an average household in industrialized countries. Simply adding up the losses would therefore not account for the harshness of the impact.

[16] Methods for economic and non-economic appraisals of adaptation options are described in Noleppa, Leiter and Bünner (2013).

metrics used for quantitative aggregation may therefore be accompanied by further information on, for example, the reduction of vulnerability and risk and the link to sustainable development.

3.5 Limits of metrics

Quantifying adaptation progress is especially attractive to policy-makers, who often seek 'concrete evidence' on which to justify their decisions. Indeed, there is often pressure from funders and investors to report numbers or even to condense results into a single number. This is one of the drivers behind the call for standardized adaptation metrics, as was evident during the Adaptation Metrics Conference. As much as those pressures may exist, they neglect the limits of metrics or indicators. Indicators are generally described as a means of simplifying information (e.g. Harley et al., 2008), but adaptation takes place in a complex environment involving uncertainties regarding the type, timing and intensity of local climate impacts. Such circumstances do not easily lend themselves to simple 'indications', and assumed cause-and-effect relationships often go untested. In general, indicators 'indicate', they do not explain *why* or *how* changes have occurred. This important characteristic of metrics and indicators seems to be forgotten in many M&E discussions. This has particular impacts on the often-proclaimed M&E objective of learning, which does not take place automatically (compare section 4.3). Accordingly, during an adaptation M&E expert workshop organized by the UNFCCC Adaptation Committee (2014, p.6) 'participants stressed that indicators are not the only tools for M&E and are not always appropriate.' Furthermore, indicators are typically only part of an overarching M&E approach or framework based, for example, on a results chain or a theory of change. Without such framing, indicators lack clear links to actions and objectives and may become meaningless. M&E guidebooks therefore emphasise that the development of adaptation M&E systems at the project or national level should not start with indicators, but with a clarification of the purpose, scope and target audience of the M&E system (e.g. Leiter, 2016; Price-Kelly et al., 2015; Brooks & Fisher, 2014; Olivier et al., 2013). A final, yet important pitfall observed on the basis of practice is therefore:

> **Pitfall:** metrics or indicators cannot explain *why* changes take place, which has limitations for learning. Reducing a complex issue like adaptation into a single number inevitably means missing important information, and this could misguide decision-making.

4. Potential to enhance M&E of adaptation

Given the pitfalls that could be observed on the basis of practice to date, what are the potential ways of improving assessments of progress with adaptation through use of metrics and beyond?

4.1 National adaptation M&E systems

Almost half of the Parties to the UNFCCC that addressed the question of adaptation in their (Intended) Nationally Determined Contributions (INDCs) make reference to M&E. An analysis by the OECD found that about 70% of INDCs with adaptation components include qualitative indicators, and about 20% also have quantitative indicators (Kato & Ellis, 2016). Given the characteristics of some of these indicators, i.e. unspecific aims or unclear time references, they may not yet provide a sufficient basis for monitoring achievements as called for by the Paris Agreement's Transparency Framework (Article 13). This gap could be filled by means of the national adaptation monitoring and evaluation systems that have been or are being developed by more than forty countries, including Brazil, Cambodia, Columbia, France, Germany, Kenya, Morocco, Mozambique, the Philippines, South Africa and the United Kingdom (Hammill et al., 2014a; Pringle et al., 2015; Leiter, 2017a).[17] Several countries, such as Brazil and Thailand, are developing their M&E systems as part of the National Adaptation Plan (NAP) process, whose Technical Guidelines propose M&E as one of four key elements (UNFCCC (2012) and associated guidelines for M&E by Price-Kelly et al. (2015)).

Indicators form part of most national adaptation M&E systems (Hammill et al., 2014a). A notable exception is Norway, which has chosen a qualitative and learning oriented assessment process (ibid.). To reduce the burden of additional monitoring, many countries have compiled an inventory of already existing data sources and indicators and screened them for relevance to adaptation. Accordingly, most of the national adaptation M&E systems developed so far are based to a large extent on data already collected by government agencies or academia. Their added value is to bring these otherwise scattered data together to provide a better picture of progress with adaptation. A detailed list of the indicators used by the first generation of national adaptation M&E systems has been compiled by Hammill,

[17] Country factsheets of national adaptation M&E systems are available at http://www.AdaptationCommunity.net under 'Monitoring & Evaluation' and 'National M&E'. The national monitoring systems of Germany and Kenya are also described in separate articles in this publication.

Dekens, Leiter, Olivier and Klockemann (2014b). In addition, the European Environment Agency is in the process of developing a database of national-level indicators used by European nations.

To account comprehensively for progress with adaptation, national adaptation M&E systems also need to consider subnational adaptation actions and results. As discussed in section 3.4, aggregation is more than just a matter of mechanically adding up quantitative indicators. Leiter (2015) has proposed three avenues whereby countries can link national and subnational adaptation M&E systems and shows how pioneering countries are already practising them. Initially the main focus of national adaptation M&E systems has been tracking implementation (output-level) rather than assessing actual effectiveness (outcome-level). As these systems evolve, an important potential is to strengthen the outcome orientation of adaptation M&E. South Africa, for example, has defined Desired Adaptation Outcomes that will act as a framework to report annual progress on both process and outcome-level (Department of Environmental Affairs 2016, 2017). The example of the UK presented in section 3.3 (Figure 2) likewise demonstrates the importance and feasibility of combining process and outcome-based adaptation assessments. The potential to improve our understanding of adaptation is therefore:

> **Potential:** national adaptation M&E systems provide opportunities to understand progress on adaptation and to inform national and international planning and decision-making.

In doing so, M&E systems need to reflect the realities of the capacity and data sources available and to communicate their findings in a way that supports those charged with decision-making. Since the Paris Agreement is asking countries to provide information on their progress with adaptation under the transparency framework (Article 13) and Adaptation Communications (Article 7), country-specific adaptation M&E systems also have the potential to generate the necessary information and thus assist countries in implementing the provisions of the Paris Agreement (Leiter & Olivier, 2016; Leiter, 2017a).

4.2 Improving connectivity across policy themes

A further potential of M&E, and especially adaptation metrics, is in connecting policy themes. By its nature, adaptation is cross-sectoral and is reliant upon action in a range of policy areas in order to move towards a well-adapting society. International reporting requirements in other policy domains, including sustainable development (through the 230 global SDG indicators) and Disaster Risk Reduction (the Sendai Framework for Disaster Risk Reduction), present opportunities to share both data sources and metrics. Such approaches can help to reduce the burden of monitoring, but they also ensure that these policy domains are connected more effectively. In this section we consider two questions with implications for adaptation metrics:

1. How can we ensure the coherence of metrics and indicators between policy themes?
2. What can be learnt from other policy themes about developing and using metrics that might be applied to adaptation?

Recent global policy initiatives such as the Paris Agreement, the Sendai Framework for Disaster Risk Reduction (SFDRR) and the Sustainable Development Goals (SDGs) have demonstrated improved appreciation of the connections and interdependencies between the goals and objectives of these policy themes. The SDGs will not be sustainable in the face of climate change without action, hence climate resilience is included in several goals, and SDG 13 is explicitly related to Climate Action. To be effective, the implementation of the Paris Agreement, the SDGs and the SFDRR will need to reinforce each other. The SFDRR illustrates these connections neatly in stating that 'Disasters, many of which are exacerbated by climate change and which are increasing in frequency and intensity, significantly impede progress towards sustainable development' (UNISDR, 2015). These initiatives will each seek to track progress, including through the development of metrics and indicators to be reported nationally. This creates both potential and the risk of pitfalls. **If implemented mechanically, without connectivity, such measures will fulfil reporting requirements but do little to enhance decision-making.** However, if the connections between these policy themes are explored more comprehensively, there is the potential to develop **synergistic metrics** that can inform decision-making nationally and below. In fact, three of the eight proposed indicators for SDG goal 13 on Climate Action are identical to those of the SFDRR (Leiter & Olivier, 2017b). This potential is therefore as follows:

Potential: better alignment of the monitoring of related policy themes could potentially create synergies for understanding progress towards the objectives of the Paris Agreement, the SFDRR and the SDGs.

While the characteristics of climate adaptation outlined earlier in this article present specific challenges and opportunities for those responsible for measuring adaptation, these traits are not unique. For example, the lack of a single universal metric, attribution challenges and the need to integrate qualitative perspectives are true of other policy areas as well. These common characteristics present an opportunity for knowledge exchange between policy domains regarding M&E methodologies, including the development of metrics and indicators (Pringle, Karali, Mäkinen & Prutsch, 2017; Dinshaw et al., 2014). The examples contained in these references, including those from the biodiversity sector, provide useful insights into the process and governance of indicator development nationally, but they also show the overlap between biodiversity and adaptation metrics. Fisher, Dinshaw, McGrey, Rai and Schaar (2015) provide evidence that the adaptation community need not reinvent the wheel when it comes to M&E methods and metrics, and they suggest drawing on methods from the areas of health, natural resource management, agriculture and fragile states.

4.3 Monitoring and evaluation as a learning tool

There is a growing appreciation of the importance and potential of monitoring and evaluation as a means of learning (Pringle et al., 2015), which is now reflected in the design and objectives of some M&E systems. Learning is to some degree implied in all monitoring and evaluation, it being a reasonable assumption that we assess and gather evidence on progress and performance in order to learn and act upon that learning. However, the increased interest in learning represents a tacit acknowledgement that it does not happen automatically and that how we approach monitoring and evaluation can act to help or hinder learning processes. It also impacts on our ability to apply what is learnt in ways that can improve future policy and practice. But before looking into these issues, it is worth reflecting on what 'learning' means and why it is especially significant for climate change adaptation.

Learning is defined extensively and variously. O'Dell and Hubert (2011) refer to it as new knowledge that is used to shape behaviour, as manifested in decision-taking or actions. This framing places a strong emphasis on the application of knowledge generated and is thus pertinent to the commonly held objective of M&E for adaptation, namely to make evidence-based improvements to systems and processes in the context of the urgent challenge of climate change. It is the latter point that has partly driven the increased focus on learning with M&E for adaptation, as we need to make significant and in some cases radical and rapid adjustments to 'business as usual' societal decisions. Urgency and cost do not allow us the luxury of a trial and error approach. Climate change adaptation is also still an emerging field, and the effectiveness of adaptation policies and actions is often poorly understood (OECD, 2015; Pringle et al., 2015), further highlighting the critical role of learning.

However, there are a number of barriers to learning which it is important to acknowledge if we are to realize the learning potential of M&E. First, M&E approaches may be shaped by the information required by funders, rather than what is required by key adaptation decision-makers such as national authorities (OECD, 2015) or communities. This is often the result of tensions between accountability and learning objectives (Spearman & McGray, 2011) that can discourage learning by placing the emphasis on reporting and tracking agreed actions, rather than on reflexive processes that consider what has worked, why, for whom and in what contexts. Learning can also be hampered by only considering lessons that appear immediately relevant within the spatial, temporal and thematic boundaries of a given funding stream. Other related factors that constrain learning include the pressure to spend, a lack of incentives to learn, staff turnover and losses of institutional memory (OECD, 2001). It can also be difficult to ensure that lessons learned reach decision-makers in a timely and accessible form. A report on national-level M&E systems in Europe (Pringle et al., 2015) highlighted that, while considerable efforts have been made to develop effective systems, only a few countries have given significant thought as to how to communicate the findings and lessons in effective ways.

In spite, and perhaps because, of these barriers, more and more M&E systems are explicitly referring to learning through terms such as Monitoring, Evaluation and Learning (MEL), as well as the use of methods which more actively support learning. This is most evident within the development community (Pringle et al., 2017), where programmes such as the DFID-funded 'Building Resilience and Adaptation to Climate Extremes and Disasters' (BRACED) programme are actively designing learning into M&E approaches from the outset. The decision to create a specific Knowledge Management function within BRACED to act as a centre for developing and disseminating knowledge about resilience is an interesting innovation that could be interpreted as a deliberate effort to create a distance between accountability and learning agendas. The international development community has a longstanding focus on participatory approaches to engaging a broad set of stakeholders. Such approaches can be useful for M&E of adaptation, as they create opportunities for learning that reflect on and inform multiple perspectives. However, the benefits of such learning are too often focused on the needs of those initiating the M&E process, rather than ensuring that those participating can use lessons. Overall this potential is therefore as follows:

> **Potential:** deliberately designing M&E to facilitate learning may lead to important insights into progress with adaptation and is a much needed and complementary addition to the use of indicators for accountability purposes.

The momentum underpinning efforts to embed learning within M&E for adaptation is increasingly evident globally. For example, the Climate Investment Funds (CIF) have established the Evaluation and Learning Special Initiative, reflecting an 'urgent need to increase the evaluative work within the CIF, capture real-time learning, and facilitate sharing of lessons learned and good practice to improve effective delivery and achievement of results' (CIF, 2016). The emergent emphasis on learning will have implications for adaptation metrics, as **what we need to measure to ensure accountability may be quite different to what we need to learn**. This will also require improved alignment between quantifiable metrics and qualitative narratives, both important tools that should be complementary. However, although the separation of accountability-focused metrics from learning activities may provide a useful breathing space for learning, ultimately the two strands need to be connected to avoid creating two parallel, potentially contradictory perspectives on 'successful' adaptation. There is much to be gained from a focus on learning, but much to be learned too about how this should be achieved.

4.4 Metrics for understanding transformation

Transformation is an emergent concept in adaptation policy and planning that is likely to influence adaptation M&E. Increasingly the language of transformation is being used to shape adaptation objectives, including many of the largest climate finance initiatives, such as the Climate Investment Funds (CIF) and the Green Climate Fund. The term 'transformation' is interpreted widely and has no single clear working definition, immediately presenting a challenge for those seeking to measure it (Lonsdale, Pringle & Turner, 2015). Despite this, the concept has gained currency by being understood as actions that facilitate systemic and sustainable change with the potential for large-scale impact (World Bank IEG, 2016) in ways that are distinct from incremental adjustments to existing systems. Feola's (2014) review of the literature on transformation in global environmental change suggests that the lack of a definition may inhibit the usefulness and application of the concept of transformation, but paradoxically he warns against searching for a single definition. Instead he proposes a pragmatic approach based on conceptual plurality that assumes that the term can be characterized and articulated in ways that still allow dialogue, empirical testing and theoretical development.

The desire for transformational adaptation activities is driven by the urgency of climate change: increasingly we cannot assume that adjustments to 'business as usual' or existing systems will present the best approach. Yet to date the use of transformational language and objectives in adaptation programming has outrun developments in how to measure and evaluate it. That said, the last two or three years have seen increasing investment and interest in M&E of transformational change and an emerging literature on the topic. The challenge of how to measure transformation is great, but so may be the benefits. If adaptation outcomes can be linked to a deeper, more fundamental understanding of the systems within which they sit and are designed in contexts not wholly constrained by the limits of existing systems, the potential scale and pace of adaptation may be much greater, thus reducing loss and damage from climate change. Monitoring and evaluation can play a critical role in providing evidence for transformation, the conditions within which it thrives and who benefits (or not) from such changes. This also presents an opportunity to connect evaluation methods with learning processes, as is being explored as part of the CIF Evaluation and Learning Initiative (CIF, 2016).

> **Potential:** by giving greater consideration to transformational adaptation, M&E including metrics can contribute to better understanding of systemic changes that support or hinder the reduction of climate risks.

It will be critical to design these processes so as to take the question of 'transformation for whom?' into account and to incorporate perspectives on what transformation is from multiple levels in order to avoid a purely top-down approach. It is also important to remember that not all adaptation can or should be considered transformational: there is also merit in incremental approaches. Guidelines for embedding and assessing transformations at different levels are emerging, such as 'The Resilience Adaptation and Transformation Assessment Framework' (RAPTA) (O'Connell et al., 2016), which aim to help achieve this in a practical way.

5. Conclusion

This article has outlined the pitfalls and potentials of measuring adaptation through adaptation metrics. It argues that there are multiple and diverse purposes for the application of adaptation metrics which renders the search for a single set of indicators pointless. As the IPCC notes, 'The search for metrics for adaptation will remain contentious with many alternative uses competing for attention.' (IPCC 2014c, p.853). Due to the nature of adaptation, which is context-specific and cross-sectoral, **it is not possible to design a single, uniform global adaptation metric.** Nevertheless, there is a need to account for and demonstrate progress with adaptation in the context of sustainable development and to go beyond the currently common practice of just monitoring the implementation rather than the results of adaptation actions. Metrics can play a role in this regard, but they are not a silver bullet and often appear to be overloaded with expectations they cannot fulfil in practice. For example, Hinkel (2011) found that vulnerability indicators are only suitable to one out of six uses to which they have been ascribed, including allocation of funding. Due to the mismatch between what they are expected to solve and what they can actually deliver, Hinkel (2011) observes that 'indicators seem to be a typical example of failed science–policy communication'. It is therefore important to reflect on the role of indicators in assessing adaptation. We have identified some of the most common pitfalls of applying adaptation metrics in practice in order to aid their meaningful use. Table 3 summarizes the key 'take-away' messages from the article.

Table 3. Pitfalls and potential of using adaptation metrics.

Pitfalls
No single adaptation metric. There is no single, uniform and universally applicable metric to measure adaptation progress in the way that mitigation can be measured through greenhouse gas emission reductions.
No single way to identify adaptation needs. As there is no single, objective set of indicators to determine adaptation needs universally across the globe, seeking such metrics risks overlooking key contextual insights.
Limited applicability of vulnerability indices in allocating funding. It is extremely unlikely that the notion of 'particularly vulnerable' countries can be determined in an objective, non-normative way, as this inevitably involves value judgements that can be contested.
Need to focus M&E on outcomes of adaptation. Tracking only what is being done or how much is being spent may produce misleading conclusions about the actual degree of adaptation progress.
No one size fits all approach to adaptation M&E. There is no metric or set of metrics that could simultaneously fulfil the different purposes of adaptation M&E (e.g. adaptive management, accountability, learning) to a sufficient degree.
Aggregation beyond counting numbers. If confined to just adding up simple, quantitative numbers, aggregation cannot account for important insights into the progress being made.
Limits of metrics. Metrics or indicators cannot explain *why* changes take place, which has limitations for learning. Reducing a complex issue like adaptation to a single number inevitably means missing important information, and this could misguide decision-making.
Potential
National adaptation M&E systems provide opportunities to understand progress with adaptation and inform national and international planning and decision-making.
A better alignment of the monitoring of related policy themes could potentially create synergies for understanding progress towards the objectives of the Paris Agreement, the Sendai Framework for Disaster Risk Reduction (SFDRR) and the Sustainable Development Goals (SDGs).
Deliberately **designing M&E to facilitate learning** may lead to important insights on adaptation progress. This is a much needed complement to the common practice of relying on simple indicators for accountability purposes.
By giving greater consideration to **transformational adaptation,** M&E including metrics can contribute to a better understanding of the systemic changes that support or hinder the reduction of climate risks.

Assessing progress with adaptation is critical to understanding two basic questions: 'are we doing the right things and are we doing them right?' (Pringle, 2011). Adaptation metrics can provide valuable insights into the results of our adaptation efforts in a given context. But indicators are only an 'indication'; the adage that 'not everything that counts can be counted' is true for adaptation as well. Moreover, **indicators are only one part of an effective M&E system.** A focus on indicators or metrics should not overshadow essential aspects such as whether the information provided through the indicators will be useful and sufficient actually to address the stated M&E purpose. The multitude of specific M&E purposes requires the selection of suitable M&E approaches, as highlighted by the Adaptation M&E Navigator (Leiter, 2017b). Mixed methods that combine qualitative and quantitative information are also needed (Lamhauge, Lanzi & Agrawal, 2013; Pringle et al., 2015; Fisher et al., 2015) in order to understand not only what happened, but how, to what benefit and for whom. In particular, adaptation metrics need to be connected to broader learning objectives. The question is not 'can we measure this?' but 'how does measuring this enhance our understanding and improve future practice?'

This article has also suggested areas with a potential for enhancing the use of adaptation metrics. National adaptation M&E systems and their indicators provide an opportunity to improve understanding of progress with adaptation and may become an important source for international efforts to take stock of global adaptation progress alongside other sources of information (Leiter, 2017a; Leiter & Olivier, 2016). There is also the potential to improve the alignment of national and international monitoring frameworks and indicators with global conventions to increase synergies and policy coherence with regard to sustainable development, disaster risk reduction and climate change (Leiter & Olivier, 2017b). Much could also be gained from strengthening the learning potential of M&E and acknowledging that learning does not take place automatically. Finally, taking into account the systemic changes needed to reduce climate risk would benefit our understanding of transformational adaptation. Overall, we hope that our review of the pitfalls and potential of adaptation metrics will help to inform the international debate and contribute to producing useful applications of adaptation metrics in both policy and practice.

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Assessing Stakeholder Needs for Adaptation Tracking

Abstract

Faced with the increasing and irreversible impacts of climate change, a growing number of public and private stakeholders across vulnerable sectors are engaging in adaptation efforts. However, our knowledge is limited regarding the types of information being demanded in order to track adaptation progress nationally. To address this gap, we conducted a needs assessment of 191 public and private stakeholder organizations. Stakeholder needs are classified into fourteen themes, encompassing measurements in implementation, outcome and learning, data availability and methods, and crosscutting aspects. With approximately half of organizations surveyed expressing a need for adaptation tracking, we conclude that there is significant demand for: 1) translating climate risk data into impacts and damage costs; 2) monitoring institutional and policy coordination and coherence; and 3) evaluating adaptation outputs and outcomes to inform decision-making.

1. Introduction

In response to the growing risks of climate change, public and private stakeholders globally are engaging with climate change adaptation policy and planning (hereafter 'adaptation'). As a growing number of these policies and programs are reaching the implementation stage, Monitoring, Reporting, and Evaluation (MRE) approaches are needed for policy-makers and practitioners to assess where progress is being made, to identify persistent needs and gaps, and to make sense of what contributes to successful adaptation (Adger, Arnell, & Tompkins, 2005; Ford et al., 2015; Magnan & Ribera, 2016; Preston, Westaway, Dessai, & Smith, 2009). This article looks at the needs and gaps in adaptation tracking, a subcomponent of MRE that assesses where and how adaptation is being implemented and by whom (Berrang-Ford, Ford & Paterson, 2011; Ford & Berrang-Ford, 2016).

The absence of robust methodologies for tracking progress with adaptation is widely recognized by the Adaptation Committee of the United Nations Framework Convention on Climate Change (UNFCCC), as well as stakeholders at every level of government, civil society, the private sector and the research community. For instance, according to preliminary research on existing adaptation MRE tools by the UNFCCC, only two of the 88 methodologies examined attempt to evaluate national-level policies, programmes and projects against risk and vulnerability assessments in a comprehensive and rigorous manner (UNFCCC, 2016b). Better tools and frameworks are needed to understand the state of adaptation at the global level. Adaptation tracking aims to address this gap by systematically identifying, characterizing and monitoring adaptation progress across countries and over time (Ford et al. 2015; Ford, Berrang-Ford, Lesnikowski, Barrera & Heymann, 2013). While a number of tracking frameworks have been proposed to this end (Ford & Berrang-Ford, 2016; Füssel, 2008; Gagnon-Lebrun & Agrawala, 2007; Lesnikowski, Ford, Biesbroek, Berrang-Ford, & Heymann, 2016), numerous factors challenge our ability to track adaptation progress, including difficulties in constructing an adaptation baseline, the absence of a systematic and longitudinal reporting mechanism, reporting bias, insufficient and poor quality of data, and providing the right type of information to stakeholders participating in adaptation (Ford & Berrang-Ford, 2016; Ford et al., 2013). There are plenty of ideas about how to apply adaptation MRE at various scales (Arnott, Moser, & Goodrich, 2016; Bours, Mcginn, & Pringle 2013; Klostermann et al., 2015); a crucial question is whether these frameworks are built on a thorough understanding of the needs of stakeholders and interested users.

This study therefore conducts an assessment of needs and gaps linked to the demand for adaptation tracking information from stakeholders engaged in adaptation governance and practice. A needs assessment assists researchers, decision-makers and practitioners in identifying gaps and prioritizing challenges by systematically examining an issue and establishing a basis for formative evaluation (Altschuld, 2015). To our knowledge, no stakeholder-informed global needs assessment that identifies information demands for national adaptation tracking has yet been conducted. Previous assessments of needs for adaptation have been undertaken within isolated spheres focusing, for example, on knowledge gaps (UNDP, 2008; World Resources Institute, 2010) or general adaptation policy needs (Burton, Diringer, & Smith, 2006). In practice, many existing adaptation needs assessments are designed to deal with specific topics, such as coastal management (Finzi Hart et al., 2012), or for a specific sector such as agriculture (Liberia Ministry of Agriculture & Rothe, 2013). Other, similar analyses focus broadly on assessing physical vulnerability or the underlying need for adaptation capacity (Noble et al., 2014). Overall, none of the existing needs assessments identifies specific information needs and gaps with the goal of informing how a tracking framework for national adaptation progress might be conceptualized.

To address this gap, this study offers a comprehensive overview of adaptation tracking needs and gaps drawing on data from 191 stakeholders across the public and private sectors globally. This assessment comes at an important moment in climate change policy development, with the Paris Agreement and the UNFCCC Adaptation Committee calling for the creation and expansion of adaptation progress metrics (UNFCCC, 2015, 2016b). Given the significant developments being made in the area of adaptation governance research, we hope to catalyze the next critical step in connecting theories and practices to allow more refined, tailored and relevant adaptation tracking efforts.

2. Methods

2.1 Needs Assessment

Needs assessment is used in the social sciences to identify gaps between current states and desired outcomes (Witkin & Altschuld, 1995). It is a systematic way to approach a problem by thoroughly investigating different points of view, understanding its cause and prioritizing optimal resource allocation (Altschuld, 2015). Witkin and Altschuld (1995) identified over twenty mixed methods for conducting needs assessments, including literature reviews, surveys and interviews. Given the large quantity and geographical spread of the stakeholders involved in this case, we conducted both desk-based document analysis and semi-structured interviews to examine stakeholder needs for national-level adaptation tracking.

2.2 Stakeholder Selection

Combining desk analysis and interviews, this study assesses the adaptation tracking needs of 191 organizations, including 45 intergovernmental organizations (IO), 10 governments (G), 49 boundary organizations (B), 47 private businesses (P) and 41 research institutions (R). A full list of organizations included in the study can be obtained from the authors. In the following, organizations mentioned by name are spelled out at first occurrence and otherwise referred to by acronym to improve readability.

For the document analysis, intergovernmental organizations (44), boundary organizations (49), research institutions (40) and private-sector stakeholders (43) were initially selected from the UNFCCC Nairobi Work Programme (NWP) partnership database (UNFCCC, 2016a). As governments are also involved in tracking, but are not featured on the UNFCCC list, we selected a sample of the National Communications from nine national governments based on their Gross Domestic Product (GDP) and active participation in the UNFCCC process. The interviewee selection featured nine stakeholders already on the NWP list and four representatives from key organizations recruited through previous contacts, with a total of thirteen interviews being conducted. The breakdown of the stakeholder selection process is described in the subsequent sections.

The NWP organizations were included because their affiliation with the UNFCCC ensures a degree of alignment with one or more work areas in adaptation as defined by the NWP. Given the broad interpretation of what constitutes adaptation, this selection ensures a relatively standardized sample pool in which systematic assessments can be carried out. It also ensures the inclusion of dominant players within the adaptation community, given the high levels of dialogue within United Nations organizations.

2.2.1 Intergovernmental Organizations, Boundary Organizations and Research Institutions

Stakeholders belonging to intergovernmental organizations, boundary organizations and research institutes were categorized according to their NWP classification, supplemented by self-descriptions found under the ‘about’ section on their websites (Reed, 2008). Research institutions are often associated with academia or have research functions as their primary mandate. Since the NWP list does not feature individual governments, only international organizations with more than one participating government were categorized as such organizations. Non-profit organizations, boundary organizations and civil societies were all grouped together under boundary organizations. A total of 269 intergovernmental, boundary and research organization stakeholders were identified from the NWP list, and then filtered based on the subsequent exclusion criteria. Stakeholders without an active website, or whose websites do not feature climate change as a main area of activity were excluded. Organizations with a specific focus on a sub-regional rather than national level were also excluded, as were forums, informal networks and temporary collaborations. Following this process, 44 intergovernmental organizations, 49 boundary organizations and 40 research institutions were retrained for desk assessments of adaptation needs and gaps.

2.2.2 Private Sector

The private-sector list from NWP was further narrowed down to stakeholders with existing submissions to the UNFCCC Private Sector Initiative (PSI).[1] This list includes corporate case-study submissions from a wide range of regions and sectors. Since business websites often do not feature or report specific adaptation activities, we adopted a targeted approach by assessing the needs identified through these submissions. A total of 43 business submissions were retained for document analysis.

This list was then compared against the UN Global Compact,[2] an initiative to engage companies and corporations on sustainability and climate change issues worldwide. The Global Compact offers detailed company information, including the size of the business (number of employees), affiliated sectors and whether or not they are actively engaged in the environmental sphere. By crosschecking this information with the PSI list, the selection was narrowed

[1] http://unfccc.int/adaptation/workstreams/nairobi_work_programme/items/6547.php
[2] https://www.unglobalcompact.org/what-is-gc/participants

Table 1. Country Selection

Geographical Area	Selected Country	Status	Most Recent National Communication
East Asia and Pacific	China	Non-Annex I	2
South Asia	India	Non-Annex I	2
The Middle East and North Africa	Saudi Arabia	Non-Annex I	2
Sub-Saharan Africa	Nigeria	Non-Annex I	2
North America	USA	Annex I	6
South America	Brazil	Non-Annex I	3
Central America and the Caribbean	Mexico	Non-Annex I	5
Europe and Central Asia	Russia	Annex I	6
Western Europe	Germany	Annex I	6

down further by eliminating small and medium enterprises, that is, companies with fewer than 1,500 employees. Businesses listed as 'state-owned were also excluded.

2.2.3 National Governments

As already noted, since governments are also engaged in adaptation and adaptation tracking, but are not featured on the NWP list, nine national governments' national communications were selected for desk review (Table 1). The nation with the highest GDP in each of the nine geographical areas was selected as a proxy for economic performance and political influence, based on the World Bank indicator for Gross Domestic Product (in USD) for 2015 (WBG, 2015). This is a key criterion for our selection, as the availability of finance is crucial to funding adaptation (Berrang-Ford et al., 2014), and economic power may also signal the underlying capacity of a country to allow active engagement in climate change. Furthermore, these governments are demonstrating their active participation as signatories of the Paris Agreement and have submitted National Communications in the period since 2010. The inclusion of both Annex I and non-Annex I countries ensures that both developed and developing countries are represented.

2.2.4 Interviewee Selection

We conducted semi-structured interviews with thirteen organizations to gain deeper insights into adaptation tracking needs and gaps not present in desk-based document analysis. Each stakeholder category (R, B, IO, P, G) is represented among our interviews (Table 2).

Special attention was given to private-sector stakeholders, as the private sector has largely been understudied within adaptation research (Pauw, 2015), and PSI submissions offer limited information on adaptation MRE. We received seven responses from private businesses: Standard & Poor (S&P), International Business Machines Corporation (IBM), General Electric (GE), PriceWaterhouseCooper (PwC),[3] Baker & McKenzie (B&M), Swiss Reinsurance (SwissRe) and McKinsey & Company (MCK), all of which are participants in either the NWP or the UN Global Compact. Among the NWP partners, GE, SwissRe and MCK also provided submissions to the PSI.

Intergovernmental organizations include the European Environment Agency (EEA) and the World Bank Group (WBG). The World Federation of Engineering Organizations (WFEO) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) were selected from among the boundary organizations for interviews. They are all NWP partners.

Finally, to acquire a greater understanding of adaptation tracking needs and gaps in governments and research institutions, we interviewed two organizations not on the

[3] PWC is a NWP partner but does not have independent PSI submission.

Table 2. **Interviewee Selection**

Organization	Type
World Federation of Engineering Organizations	B
Standard & Poor	P
IBM	P
European Environment Agency	IO
General Electric	P
World Bank Group	IO
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	B
PriceWaterhouseCooper	P
Environment Agency Austria	G
Baker & McKenzie	P
Swiss Reinsurance	P
McKinsey & Co.	P
Simon Fraser University's Adaptation to Climate Change Team	R

NWP list: Environment Agency Austria and the Simon Fraser University's Adaptation to Climate Change Team.

2.3 Assessment Procedure

2.3.1 Document Sampling Process

The desk-based research reviewed 191 organizations and 203 items of documents and websites. Document-sampling identified 99 documents with articulated adaptation tracking and MRE needs and gaps.

Documents were selected using the embedded search engines on the organization's websites using the following search string: 'adapt*', 'climate change', 'M&E', 'monitor*', 'evaluat*', 'assess*', 'gap*', '*resilience*'. Among the top results, the most relevant one or two publications were selected for further analysis, with selection focused on examining major documents or those published by units specializing in climate change, including summary documents, policy papers and substantive reports on the theme of adaptation. The most recent publications were preferred when two or more documents were found on relevant topics. To avoid out-dated information, we only included documents published since 2006 following the establishment of the Nairobi Work Programme by the Subsidiary Body for Scientific and Technological Advice, which formalized and galvanized collective assistance to countries in addressing impacts, vulnerability and adaptation to climate change (UNFCCC, 2006).

The key question asked during document analysis is, 'What are the indicated needs and gaps related to adaptation tracking and MRE?' A challenge for desk-based reviewing is distinguishing between comments on general gaps in adaptation and the articulation of adaptation tracking needs and gaps. As adaptation tracking is a subcomponent of MRE, organizations often conflate the needs and gaps in adaptation tracking with those in adaptation practices, which may overlap but are not always the same. To take adaptation financing as an example, 'higher funding and finance for adaptation' is considered an adaptation need, whereas stakeholders may indicate a need to track 'if finance is effectively used to address adaptation concerns'. Therefore, recorded tracking needs and gaps are usually associated with phrases such as 'track*', 'monitor*', 'evaluat*', 'next step', 'gaps', 'assess*', 'needs', these often being found in the recommendation section of a publication. In addition, we found it difficult to distinguish needs from gaps and to identify information that the organization considers important but does not mention in documents. For example, an organization that is well equipped to work with quantitative data may omit or overlook this item when discussing adaptation tracking needs, even though it might consider quantitative methods an important aspect of adaptation tracking.

2.3.2 Interview Process

While document sampling offers a broad view of adaptation tracking needs, it was limited in providing depth, clarification and an explanation for how organizations identify and engage with information provided by adaptation tracking. For this reason, thirteen stakeholders were included in semi-structured interviews via telephone or Skype based on the interviewee selection criteria discussed above. These were later transcribed into thirteen different documents for coding purposes.

The thirteen open-ended questions were designed to understand, among other things, the stakeholders' main interests in adaptation, their capacity and preferences for MRE metrics, existing needs and gaps in information and practice, their perception of the government's role in adaptation, and their views on the major challenges in the field of adaptation. For private-sector actors, we found that the terms 'climate resilience' and 'resiliency' are more widely understood than 'adaptation' in the business context and are preferred to it. Aside from the physical impacts of climate change, we found that, in the private sector, resiliency is also associated with guarding against social and economic risks as a result of climate change-induced activities. Thus, the terms were used interchangeably during interviews. The term 'adaptation' is often used for when speaking with actors in the public sector.

2.4 Coding Documents and Interviews

We found that 93 of the 191 organizations, including the thirteen we interviewed, have identified needs and gaps in adaptation tracking or monitoring and evaluation. The coding process includes 99 documents from desk review and thirteen transcripts from interviews, a total of 112 individual entries.

The coding process treated interviews and documents in the same way. Each theme is only coded once within a text, regardless of the number of times the same theme appears. This method assigns the same weight to interviews and documents, which allows us to estimate how often a theme is associated with a particular type of stakeholder.

After recording adaptation needs, we identified fourteen themes falling into three main categories: 1) implementation, outcome assessments and learning, 2) data availability and methods, and 3) crosscutting aspects (Table 3).

2.5 Analytical Approach

Adaptation is a complex issue, and it is challenging to present adaptation tracking needs and gaps as clear-cut, reductive conclusions. We analysed how often a theme is associated with a particular type of organization and drew up qualitative descriptions and elaborations from documents and interviews. Each of the fourteen themes is further explored to identify specific adaptation tracking needs and indicators. As a result, we found that many of the themes identified above are interconnected. To convey interconnections and non-linearity within the adaptation system, we elected to cluster similar themes together and present them concurrently. For example, section 3.1, 'Monitoring and Evaluating Adaptation Impacts', discusses the themes *Assess results, Inform choices* and *Policy*, and draws relevant results from the themes *Qualify* and *Quantify*.

As discussed in section 2.4, since both documents and interviews are treated the same way by the coding process, the results presented in section 3 are a combination of analysis from interviews and documents, unless otherwise stated.

Section 3 will present extensive discussions of the three main findings in adaptation tracking needs and gaps. In tandem, we attempt to indicate the types of stakeholder associated with particular needs and give specific examples of the indicators and metrics where appropriate.

3. Results

Of the 191 organizations, we found 93, including the thirteen we interviewed, have identified needs and gaps for adaptation tracking. This represents 49% of all the organizations we reviewed.

We identified three dominant needs and gaps in adaptation tracking:

1. Evaluating and attributing adaptation impact
2. Monitoring coordination and coherence in policy and institutions
3. Translating climate risk data into tangible impacts on assets and human lives.

Furthermore, our analysis shows that the themes *Assess result, Inform choices, Policy, Qualify* and *Quantify* are strongly associated with evaluating and attributing adaptation impacts. Similarly, the themes *Mainstreaming, Policy* and *Coordination* are associated with monitoring coordination and coherence in policy and institutions. The themes *Cost appraisal, Qualify, Quantify* and *Physical data* are discussed under the section on climate risk data, together with related themes in *Baseline data* and *Longitudinal assessments*.

By linking needs to types of stakeholder, we found intergovernmental and boundary organizations are more interested in assessing adaptation efforts, whereas the key demand from governments and private businesses was the effective translation of risk into impacts for specific sectors or business activities.

Furthermore, through document sampling we observed that public-sector actors in intergovernmental, boundary and research organizations were especially active compared to private-sector stakeholders in adaptation MRE and

Table 3. Themes identified within adaptation tracking needs

Categories	Coded Themes	Description
Implementation, outcome assessments, and learning	Assess results	Indicate a need to evaluate adaptation success or failure as a result of an action, program or policy.
	Inform choices	Indicate a need to evaluate whether adaptation MRE and learning are being used to guide future decisions.
	Mainstreaming	Indicate a need to evaluate the integration of adaptation activities into government policy and planning.
	Policy	Indicate tracking needs where policy plays a central role.
	Coordination	Indicate the need to evaluate the ability of different actors to organize and cooperate effectively on adaptation activities. This can take place among horizontal government ministries, or vertically between public and private sectors.
Data availability and methods	Baseline data	Indicate a need to establish a point of reference against which progress can be compared.
	Cost appraisal	Indicate a need to evaluate adaptation result per unit of financial or economic input. Often means quantifying both costs and benefits.
	Longitudinal assessments	Indicate a need for consistent and continuous display of climatic information and adaptation progress across a substantive time frame.
	Qualify	Indicate a preference for displaying information and indicators in non-numerical or mathematical narratives.
	Quantify	Indicate a preference for displaying information and indicators mathematically or numerically.
	Scalability	Indicate a need to have a single indicator that is transferable for multiple levels of governance, whether local, sub-regional or national.
	Physical data	Indicate needs for both quantitative and qualitative information related to specific climate risk and vulnerability indicators. For example, numbers of houses build near flood-prone zones.
Crosscutting aspects	Capacity-building	Indicate a need to evaluate whether there has been any improvement in the tools, technology, knowledge and the stakeholder's abilities to undertake adaptation.
	Interdisciplinary	Indicate a need to evaluate whether adaptation is linked with other fields of study, such as development, poverty, gender and mitigation.

tracking discussions. Aside from the governments' National Communications, where all nine documents reviewed articulated some type of adaptation tracking need, the highest number of organizations with adaptation tracking needs were intergovernmental organizations (27/44, 61%), boundary organizations (22/49, 44%) and research organizations (14/40, 35%). This can be compared to the private sector, where, of the 43 desk-reviewed organizations, only 10 (23%) indicated needs and gaps in adaptation tracking and MRE. After presenting the results in more detail, we examine this further in the discussion.

3.1 Monitoring and Evaluating Adaptation Impacts

Our assessment identified a high demand for assessing, recording and monitoring adaptation impacts on vulnerability and resilience, predominantly among public-sector stakeholders in intergovernmental organizations, boundary organizations, governments and research institutions. Stakeholders demonstrated a need to evaluate the effectiveness and efficiency of adaptive actions, including their short-term outputs and long-term outcomes, and the ability to attribute these effects to policies, programs or practices in order to determine 'which adaptations work well, which do not, and why' (CSIRO, 2008). There was a desire for MRE assessments in quantitative, qualitative or mixed formats. Subsequently, taking the lessons learned from assessing current adaptation MRE, stakeholders highlighted the need to monitor whether learning has been incorporated into decisions to improve or revise future adaptation activities.

Stakeholders identified effectiveness and efficiency as the two main tenets when assessing adaptation actions. With regard to effectiveness, document reviews of GIZ, United

Nations Environment Programme (UNEP) and Overseas Development Institute publications recognized the need to monitor and evaluate whether adaptation has been successful in reducing vulnerability and risk, and whether the targeted outputs from implementing adaptation activities have been achieved. Organizations including the World Wildlife Fund International (WWF), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Center for International Climate and Environmental Research (CICERO), World Resources Institute (WRI) and Environment Agency Austria expressed the need to assess whether ineffective adaptations are recognized and revised, such as maladaptive practices that exacerbate poverty or gender inequality. Stakeholders also expressed the need to assess the effectiveness of more specific adaptation tools and methods, such as payments for ecosystem services, sustainable forest management strategies and ecosystem-based adaptation strategies.

We observed significant interest in monitoring and evaluating the effectiveness of adaptation policies through document analysis and interviews, as policies are strongly associated with governance, especially national government actions (see Dupuis and Biesbroek, 2013; European Environment Agency, 2013). This is identified as a key priority by organizations such as the Convention on Biological Diversity (CBD), Center for International Forestry Research (CIFOR), CSIRO, EEA, GIZ, Resources for the Future (RFF), United Nations High Commissioner for Refugees, WRI and WWF. This demand is also echoed by both Annex I and non-Annex I country governments, which displayed interests in assessing outputs and outcomes as part of adaptation tracking. Specifically, desk-based analysis of the German and American National Communications, as well as the interview with Environment Agency Austria, all identified the need to understand and aggregate the outcomes of a broad range of adaptation actions for a specific period of time in order to create a general summary of the nation's adaptation progress spanning multiple sectors. An indicator of this aggregation may be 'how many people have been reached [by adaptation actions]' within a particular time period (GIZ interviewee, 2016). National communications from Mexico and India also stated the need to evaluate adaptation actions, such as 'monitoring adaptation practices and their implications for resilience of different species to projected warming and climate change' (Government of India, 2012, p.250). Similarly, Brazil expressed the need to develop 'a system for monitoring, evaluating, and disseminating information on public policies on adaptation' (Government of Brazil, 2016, p.34).

Document reviews of the Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA), the International Fund for Agricultural Development (IFAD), Caribbean Natural Resources Institute, International Council on Mining and Metals and UNEP also indicated the need to evaluate efficiency as a function of resource input and resilience achieved. Interviews with the WBG and WFEO revealed more specific demands in evaluating resilience gained per unit of investment. While these organizations indicated concerns around financing, the source of the investment being evaluated was unclear. Public-sector organizations like PROVIA, IFAD and UNEP referred to adaptation and climate finance mechanisms in the public sector, whereas private-sector interviews with PwC, B&M and S&P highlighted the importance of quantifying benefits from business investments to build a compelling case for companies to participate in adaptation.

When representing adaptation output and outcome data and metrics, public-sector interviews with the EEA, the WBG and WFEO demonstrated support for a mixture of quantitative and qualitative indicators. Stakeholders argued that quantitative indicators are better at conveying the current situation, while qualitative indicators can inform practitioners of the conditions that led to a given state. For example, the quantitative indicator 'hectares of land with enhanced irrigation' means very little without a qualitative description of the climatic and agricultural context in which the irrigation program is taking place. Interpreting quantitative and qualitative information in tandem will improve our understanding of the status and changes in resilience (World Bank interviewee, 2016). Similarly, documents from PROVIA and Economic Commission for Latin America and the Caribbean (ECLAC) identified the need to recognize both methods when measuring the quality of adaptation processes and outcomes.

Moreover, public-sector stakeholders identified a need to monitor and evaluate whether learning is being effectively used to inform decision-making. Compared to the passive monitoring of outputs or outcomes, incorporating learning can lead to tangible changes in decision-making regarding adaptation. More specifically, stakeholders, including UNEP, United Nations Convention to Combat Desertification, WRI, CBD, EEA, CSIRO and the Intergovernmental

Panel on Climate Change, stressed the need to improve government policy through learning. WRI indicated that 'high awareness and receptivity to information by decision makers' is essential to inform decisions effectively, so actions can be designed to anticipate adjustments in response to new information (World Resources Institute, 2010). Campbell et al. (2016) at International Center for Tropical Agriculture proposed that a scaling up of practices or policy reforms would be an example of learning guiding decision-making.

We observed that only two companies in the private sector specifically expressed the need to assess adaptation actions. From the data collected, it is unclear why so few private-sector companies are interested in assessing their adaptation actions or the government's adaptation actions for learning purposes either within their companies or for the services they provide. It is possible that some of the private-sector companies we reviewed do not undertake adaptation actions themselves; for example, if the services provided are knowledge- or information-based, there will be no MRE of such adaptation services. Another possibility may be that the data sampled from the Private Sector Initiative is very much focused on describing companies' current adaptation activities.

3.2 Monitoring and Evaluating Policy and Institutional Coordination and Coherence

Public-sector stakeholders demonstrated an interest in monitoring and evaluating the processes of coordination when implementing adaptation policies and actions. Specifically, intergovernmental organizations, boundary organizations and government stakeholders expressed the need to monitor and evaluate coordination among sectors, ministries and departments, as well as the complementarity of policies and whether real actions have been implemented.

Desk-based research identified needs in monitoring coordination among key sectors such as land use, agriculture and energy, with over eleven organizations stressing the importance of integrating adaptation into sectoral planning. RFF provides an example of complementary policies: strengthening 'existing efforts to improve education, health services, and employment opportunities' can improve the situation for vulnerable populations that have less capacity and fewer resources for responding to climate change (Morris et al., 2010). On the flip side, according to the Organisation for Economic Cooperation and Development (OECD) (2015), a misaligned regulatory regime 'deter[s] investment in resilience [and have] planning policies that encourage development in vulnerable areas' (p. 5). Consequently, policy coherence also requires inter-ministerial coordination. GIZ noted in the interview that good coordination has a clear division of responsibility for each ministry and a standard reporting system that allows governments to form a comprehensive statement cutting across all sectors. This need is also articulated in Germany's Sixth National Communication (BMUB, 2013, p.156)

Furthermore, interviews with GIZ and Environment Agency Austria identified the need to monitor and evaluate whether government actors and sector ministries are truly putting adaptation into action, rather than symbolically acknowledging the need for adaptation or stalling at the planning stage. According to the OECD (2015), one strategy to follow here would be to assess whether adaptation has been mainstreamed into national and sectoral policy, likewise interpreted by the WWF as 'applying a system approach to consider how climate change impacts different aspects of an institution's activities' (Cook et al., 2011, p.15). However, stakeholders use the term 'mainstreaming' to refer to different objectives, including integrating adaptation into existing policies (see EEA, OECD), institutions (see WWF, GIZ) or practice (see CIFOR, African Development Bank). Therefore, it is not always clear what the suggested indicators would be for mainstreaming or – taking this a step further – how to attribute and separate the results of adaptation from the other activities once it becomes mainstreamed.

3.3 Better Understanding of Data and Indicators

There is substantial demand for impact data and indicators to monitor and evaluate how each country, sector and organization will be affected by climate risk, both quantitatively and qualitatively. As part of adaptation tracking, private-sector businesses were especially interested in using cost-benefit analysis to understand climate impacts and the benefits of adaptation actions. On the other hand, we found negligible interest for information on baseline setting, scalability and longitudinal tracking.

Representing climate impact in terms of the cost of climate damage was a key interest for a mixture of public and private stakeholders, including PwC, ECLAC, Pew Center on Global Climate Change, IBM and Environment Agency Austria, as was observed in both desk-based research and interviews. Specifically, this may be represented as a loss in human lives or economic assets. There was a consensus among stakeholders that having information on the costs of damage would allow organizations to interpret risk more easily and encourage participation in adaptation, particularly within the private sector.

Physical data related to climate risk was a key demand of private-sector stakeholders. However, some interviews revealed that a wealth of risk and resilience data and knowledge already exists within the private sector. For example, interviews with SwissRe revealed that the physical data requirements for conducting climate risk evaluations have largely been met for their adaptation services. Many companies maintain or work with their own risk intelligence, such as SwissRe's Sigma publications and IBM's acquisition of the Weather Company. This differentiated availability of data reflects an uneven access of physical data and a difference in the quality and quantity of risk intelligence among companies. This also points to varying levels of in-house capacity and skills to interpret and translate physical and socioeconomic risks into impacts relevant to specific business operations. Importantly, in order to establish relevance to private business operations, concepts such as *resilience* must be translated – and translatable – into practical insights that can be operationalized within a particular company, for example, incorporating climate risk into the overall risk management strategies of the supply chain (Interviewee General Electric, 2016). This barrier to translating conceptual and generalized concepts of risk and resilience into on-the-ground decision-making was flagged by companies such as Egis, HSBC, PwC, S&P and Rio Tinto.

Private companies displayed an inclination toward quantitative indicators for climate impacts to communicate risk and resilience. Interviews with PwC, MCK and IBM demonstrated the need for the quantitative reporting of losses, whereas B&M and S&P called for the results of resilience per unit of investment to be quantified to make the business case for adaptation, based on a cost-benefit analytical approach. In contrast, SwissRe expressed a preference for quantitative physical risk combined with qualitative information on policy development in order to understand overall risk better. This could involve not only risks posed by physical impacts, but also risks due to regulatory changes in response to anticipated climate change. Other private-sector companies also expressed this preference for both quantitative and qualitative indicators, though it is not always clear what the organization considers to be qualitative information. This dual preference was also identified in Germany's National Communication and by Environment Agency Austria in the public sector. Most other public-sector stakeholders did not articulate clear preferences, but nevertheless no stakeholders displayed a sole preference for qualitative indicators to assess climate impact.

4. Discussion and Scope for Future Work

To understand and encourage adaptation to reduce the negative impacts of climate change and take advantage of new opportunities, it is crucial to understand, analyse and track progress with adaptation. Through a desk-based review of key documents, combined with semi-structured interviews, we have conducted a needs assessment to identify the needs, gaps and preferences in the types of information favoured by stakeholders engaged in adaptation, with the goal of informing the development of adaptation tracking frameworks that are applicable to interested users. By compiling and systematically assessing 191 stakeholders, we have identified broad trends in adaptation tracking needs, including the need to translate climate risk into impacts on assets and human lives, to monitor and evaluate institutional coordination and policy coherence, and to assess the output and outcomes of existing adaptation policies and programs.

We observed that public-sector actors in intergovernmental organizations, boundary organizations, governments and research institutions express a range of adaptation-tracking needs. These include evaluating the effectiveness and efficiency of adaptation policies and ensuring institutional coordination and policy coherence. While private-sector actors constituted a sizable portion of this needs assessment, their needs mainly concern access to better physical data. Notably, the private and public sectors both exhibit a strong inclination to have a more coherent way of representing risk as impact and damage costs, and to make these estimates relevant to the country or businesses involved to improve their understanding of adaptation and encourage adaptive actions. We also observed agreements on the importance of using both quantitative and qualitative measurements among both public and private stakeholders, and on assessing adaptation results and evaluating changes in risk and resilience.

Despite their differences in tracking needs, we identified negligible conflicts between public- and private-sector needs and gaps for adaptation tracking, since this study included only needs and gaps that stakeholders considered important.

In doing so, we did not assess factors that were considered unimportant or not mentioned in relation to adaptation tracking. We observed that most of the articulated needs and gaps reflect an interest in understanding the state of adaptation of a country, policy, projects, business or institutions through tracking, rather than using the results for comparisons between countries or across time.

Specific to our assessment, the definitional fuzziness around adaptation created a significant methodological challenge in assessing adaptation tracking needs and gaps. It is not always clear how stakeholders define adaptation within their organizations. As discussed in section 2.3.1, we also observed that stakeholders conflate adaptation needs with adaptation tracking and MRE needs. Since this study did not assess what stakeholders consider *un*important for adaptation tracking, it is plausible that when an adaptation tracking need is not articulated by a stakeholder, it means either that the stakeholder has overcome the challenge and therefore no longer views it as a gap for their organization, or that they simply feel it is inconsequential for tracking purposes. Therefore, it is important in future to carefully distinguish needs from gaps. An adaptation tracking need is something that stakeholders deemed it important to include in MRE, regardless of whether they have the capacity to execute such measurements themselves, whereas an adaptation tracking gap occurs when stakeholders deemed a measurement important enough to include, but could not undertake to conduct it themselves. Though in the phrase 'needs and gaps' the two notions are often discussed together in documents and conversations, more careful distinctions should be made in future studies.

We also discerned three challenges associated with designing an operational framework for adaptation tracking through this study. The first is the difficulty in distinguishing adaptation from other activities on the ground. This was especially evident in private-sector interviews, where stakeholders stated that they could not distinguish adaptation actions from mitigation actions or clearly differentiate climate change-related risks from other environmental and/or non-environmental risks. This lack of distinction means it is difficult to catalogue what is and is not adaptation, an obstacle when undertaking assessments of the success or failure of adaptive actions alone from a progress monitoring and evaluation perspective. Secondly, regarding the needs to assess policy coherence and evaluate institutional coordination, it is not always clear how stakeholders define adequate coherence or coordination. While mention is made of mainstreaming, there is no clear articulation of what a mainstreamed policy or an action looks like and whether and how to monitor and evaluate a policy that has been mainstreamed. Finally, while stakeholders stated that it is important to assess the effectiveness and efficiency of adaptation activities, it is unclear how to measure and attribute an outcome – e.g. as increased resilience – to one or a set of policies when measuring the progress of adaptation results that encompass a large geographical region at a single point in time.

Our aim in conducting this stakeholder needs assessment is to inform the development of comprehensive, coherent, comparable and consistent frameworks for adaptation tracking. To date, adaptation tracking frameworks remain under-theorized, poorly conceptualized and logistically intractable. Reliable and rigorous methods of measuring and attributing decreased vulnerability and/or risk or increased resilience to specific policies or actions remain a difficult challenge to address. Similarly, increased precision in outcome and impact evaluation at the resolution desired by many stakeholders will continue to remain elusive and may not even be possible given the complexity and stochasticity of climate risk attribution. Moreover, producing a clear articulation of an operational definition of 'adaptation' remains a real challenge for adaptation tracking, yet our needs assessment clearly highlights the imperative of developing frameworks that reconcile the importance and nuances of mainstreaming, tokenism, maladaptation and symbolic actions. Notably, these aspects of adaptation tracking remain among those most frequently stated in our needs assessment, highlighting a substantial disconnect between the needs mentioned by stakeholders and what it is reasonable or feasible to expect in the short to medium term. These theoretical and methodological challenges are exacerbated by the limited availability of data covering large areas and rigorous reporting standards. The development of an operational adaptation tracking framework therefore requires balancing higher level indicators that cover a wide number of jurisdictions and organizations with in-depth investigation of substantive adaptation progress.

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Development of universal metrics for adaptation effectiveness

Abstract

Adaptation to climate change in developing countries is increasingly supported through international climate and development financing. In contrast to mitigation, where the effectiveness of policy action can be measured through the metric 'tonnes of CO_2 equivalent reduced,' there is no universally accepted metric for the assessment of adaptation effectiveness. Without such a metric, adaptation finance vehicles such as the Adaptation Fund or the Green Climate Fund encounter challenges when trying to compare the effectiveness of their adaptation projects. This also presents difficulties when it comes to allocating their funds efficiently. Initial experiences with adaptation funding show a tendency to avoid final impact metrics. This might lead to a backlash against adaptation funding by electorates in industrialized countries if adaptation funding cannot show clear results. Universal metrics can be developed either top-down, based on common metrics used or defined by policy-makers, or bottom-up, based on stakeholder consultations within communities. We use the former approach and assess two possible candidates for generic effectiveness metrics that are in common use among policy-makers: (1) economic benefits, and (2) disability-adjusted life years saved (DALYs), widely used in public health policy analysis. While these two indicators for Saved Wealth and Saved Health cover a large range of adaptation project benefits, further indicators of the environmental, social and cultural impacts of adaptation projects may have to be assessed or covered in a no-harm assessment. Uncertainties encountered in applying these metrics include the long-term horizons of climate change and uncertain links between commonly reported intermediate indicators and our metrics and ideas for handling them, e.g. the use of regularly updated methodologies and agreed climate and economic models.

1. Introduction: the belated emergence of adaptation policies and finance

The development of adaptation policies and their recognition in international climate policy has lagged almost two decades behind those of mitigation policies. The Kyoto Protocol of 1997 did not address adaptation to any extent. Gradually, however, since 2000 adaptation to climate change has become more central under the UNFCCC, particularly under the Bali Action Plan of 2007 and the Copenhagen Accord of 2009. Nonetheless, on the level of the climate policy regime as such, only the Paris Agreement has formally placed adaptation policies on the same level as mitigation policies in its Article 7. This lag can be attributed to the belief that successful mitigation would eliminate the need for adaptation, while successful adaptation might create pressure not to undertake mitigation (Kates, 2000, p.6).

While since the Copenhagen conference of 2009 the issue of international climate finance has been at the forefront of international negotiations, policy-makers have repeatedly stated that the share of adaptation in climate finance should increase and become comparable to that of mitigation. Various dedicated vehicles, such as the Least Developed Country Fund (LDCF), the Special Climate Change Fund (SCCF), the Adaptation Fund (AF) and the Pilot Program for Climate Resilience (PPCR) under the Climate Investment Funds, have been introduced over the last fifteen years. However, the few estimates that have been made (e.g. Hall, 2017, p. 42) see adaptation receiving less than 20% of the total funding available. Two linked key challenges in allocating funds to adaptation are the difficulties the international community has experienced in defining successful adaptation and in providing clear guidance with regard to universal metrics for assessing proposals for adaptation projects 'ex ante' and evaluating their success 'ex post'. From an economic point of view, it would be desirable to maximize the adaptive benefit achieved by a dollar of climate finance (both globally and inter-temporally, based on agreed discounting). This article brings earlier discussion (Stadelmann, Michaelowa, Butzengeiger-Geyer & Köhler, 2014, Köhler & Michaelowa, 2013) into the context of the Paris Agreement.

2. The hodgepodge of current assessments of adaptation projects

A review of the relevant literature shows that there is no agreement on adaptation indicators. Bours, McGinn and Pringle (2013) and Arnott, Moser and Goodrich (2016) both provide overviews of a vast number of indicators for the assessment of adaptation activities, showing there is no strong agreement over the existence of a few common indicators. As Hall (2017, p.43ff) poignantly points out, there are many approaches to defining adaptation, and many observers equate adaptation with development assistance or see strong overlaps between them (see the review article by Sherman et al. (2016), on this topic). Representatives of development agencies tend to like such definitions, as they fit their world views, and they can increase their potential sources of funding. Sovacool and Linnér (2016) rightly stress the importance of interest groups in respect of adaptations that might lead to project designs being distorted and money wasted. Böckmann (2015) illustrates the challenges involved in evaluating the health benefits of adaptation, stressing uncertainties and suggesting finally that 'qualitative approaches, and context mapping' (p. 66) will make it more difficult to select projects objectively, as subjective interpretations of how to assess indicators will matter.

Currently, the different finance vehicles for adaptation all have their own approaches to assessing adaptation. The GEF Secretariat uses a full adaptation funding cost approach under the adaptation-focused funds it manages (Least Developed Countries Fund, Special Climate Change Funds), but for the costs it funds it does not use any related cost-effectiveness indicators (GEF, 2008). The AF applies a wide array of criteria, including economic, social and environmental benefits, cost-effectiveness and arrangements for management and monitoring, but does not rank or weight them (AFB, 2010). The GCF has vacillated over the indicators to be used in assessing adaptation projects. While the adaptation performance measurement framework contains five agreed indicators, only twelve indicators are listed, i.e. are subject to further discussion (GCF 2014, 2016a, 2016b; see also Table 1).

Many GCF indicators are simply framed in terms of the number of beneficiaries and assets protected, without looking at the characteristics of the beneficiaries or the assets. There is no agreed methodology for calculating the indicators, this being left to the project proposers. Given the key role of the GCF in disbursing international climate finance, this state of affairs is highly disturbing. If ad hoc decisions on adaptation projects continue to be made, a campaign by interest attacking the GCF for wasting taxpayers' money in general might have devastating impacts. Its effects might exceed even those of the media

Table 1. **GCF adaptation performance measurement framework**

☑ = Decided ☐ = Noted, but further refinement needed

Expected result	Indicator * = Core (adopted) or Proposed
Paradigm-shift Objective	
Increased climate-resilient sustainable development	☐ Degree to which the Fund is achieving a climate-resilient sustainable development impact
Fund-level Impacts	
	☑ Total number of direct and indirect beneficiaries; number of beneficiaries relative to total population
1.0 Increased resilience and enhanced livelihoods of the most vulnerable people, communities and regions	☐ 1.1 Change in expected losses of lives and economic assets (US$) due to the impact of extreme climate-related disasters in the geographical area of the GCF intervention
	☐ 1.2 Number of males and females benefiting from the adoption of diversified, climate-resilient livelihood options (including fisheries, agriculture, tourism, etc.)
	☐ 1.3 Number of Fund-funded projects or programmes that support effective adaptation to fish-stock migration and depletion due to climate change
2.0 Increased resilience of health and well-being, and food and water security	☑ 2.1 Number of males and females benefiting from introduced health measures to respond to climate-sensitive diseases
	☑ 2.2 Number of food-secure households (in areas and periods at risk of climate change impacts)
	☑ 2.3 Number of males and females with year-round access to reliable and safe water supply despite climate shocks and stresses
3.0 Increased resilience of infrastructure and the built environment to climate change threats	☐ 3.1 Number and value of physical assets made more resilient to climate variability and change, taking into account the human benefits (reported where applicable)
4.0 Improved resilience of ecosystems and ecosystem services	☐ 4.1 Coverage and/or scale of ecosystems protected and strengthened in response to climate variability and change
	☐ 4.2 Value (US$) of ecosystem services generated or protected in response to climate change
Project and Programme Outcomes	
	☐ Number of technologies and innovative solutions transferred or licensed to promote climate resilience as a result of Fund support.
5.0 Strengthened institutional and regulatory systems for climate-responsive planning and development	☐ 5.1 Institutional and regulatory systems that improve the incentives for climate resilience and their effective implementation.
	☐ 5.2 Number and level of effective coordination mechanisms
6.0 Increased generation and use of climate information in decision-making	☐ Proposed: 6.2 Use of climate information products/services in decision-making in climate-sensitive sectors
7.0 Strengthened adaptive capacity and reduced exposure to climate risks	☐ Proposed 7.1: Use by vulnerable households, communities, businesses and public-sector services of Fund-supported tools, instruments, strategies and activities to respond to climate change and variability
	☐ 7.2: Number of males and females reached by, or total geographical coverage of, climate-related early-warning systems and other risk-reduction measures established and strengthened
8.0 Strengthened awareness of climate threats and risk-reduction processes	☑ 8.1: Number of males and females made aware of climate threats and related appropriate responses

Source: adapted from GCF (2014)

Table 2. Key advantages and disadvantages of universal metrics for adaptation

Issues	Advantages	Disadvantages
Political	Reduces risk of scandals due to squandering of money allocated to adaptation.	Access to adaptation money is less easy for entities with low capacity than under the current approach, as a specific type of assessment skill is required to project and monitor these indicators. Funds may concentrate in well-managed countries, which may be seen as inequitable.
Ethical	Transparent criteria for projects. Avoidance of ad-hoc allocation of funding to powerful and highly visible groups.	Value judgments may be contested (Hinkel, 2008; Klein, 2009). Funding may not go to the poorest but to those with a significant amount of assets.
Economic	Ex-ante identification of promising projects, as well as ex-post monitoring (Noble, 2008) and ex-post adjustment (Hallegatte, Lecocq & de Perthuis, 2011).	Measurement of indicators is uncertain (Hallegatte et al., 2011; Hinkel, 2008), potentially distorting the allocation of spending towards projects where it is easy to monetize benefits.

campaign against the Clean Development Mechanism in the mid-2000s, which made policy-makers wary of the Mechanism and reduced their commitment to buy or allow private players to use CDM credits. This thus contributed, along with the financial crisis, to the crash in the prices of emissions credits after 2011.

3. The need for a universally accepted metric for adaptation

The history of mitigation policies, especially their international market mechanisms, shows clearly that commonly agreed metrics and methodologies for calculating the indicators are a precondition for both policy-makers and the general public trusting the policy instrument. In order to ensure that adaptation projects and policies gain credit in the opinion of both, generally agreed metrics of the 'adaptive benefit' that projects can generate, as well as evaluation and reporting with regard to these metrics, would be helpful. Activities whose results cannot be measured and compared will usually have difficulties in securing funding when priorities for the spending of public budgets are set.

There has by now been roughly a decade of discussion about such metrics at the project level, but the debate has not yet become politically important enough for decisions to be taken internationally. A 2008 workshop on adaptation metrics scratched the surface and concluded that good adaptation metrics should be comparable but also context-specific and should be developed through participatory processes (IGES and World Bank, 2008). A UNFCCC (2010a) review of approaches to assessing the costs and benefits of adaptation options found only two approaches that clearly compare costs and impacts: cost-effectiveness and cost-benefit. The UNFCCC (2010b) clearly showed the wide range of approaches used to evaluate adaptation projects. Under the Paris Agreement, periodical stock-taking is planned that covers progress made with adaptation, but the necessary metrics or indicators have not yet been defined. This situation is similar to the early days of assessing mitigation effectiveness, when the metrics to compare the effects of different greenhouse gases were contested.

In this regard, the question of universal metrics for adaptation arises. We define universal metrics as those that can be applied to all sorts of adaptation projects, compared to context-specific indicators, which are only applicable to specific projects.

Table 2 lists the advantages and disadvantages of universal metrics for adaptation, distinguishing political, ethical and economic issues. The advantages are mostly concentrated in the effectiveness area, while the disadvantages relate to uncertainty over the robustness of the indicators, reflecting especially incomplete knowledge of climate change and its impacts, as well as the influence of other socio-economic variables on adaptation outcomes.

4. Key elements of a universal metric for adaptation: economics and health

In assessing the effectiveness of adaptation projects, three existing approaches stand out: vulnerability, cost-benefit and cost-effectiveness.

Regarding the first approach, many different vulnerability indicators exist,[1] but politically so far it has not been possible to agree on a specific set of indicators, partly because vulnerability is considered to differ locally. The second approach calculates the economic benefits of adaptation projects, ultimately defining a benefit-cost curve that is comparable to a marginal abatement cost curve for mitigation (ECAWG, 2009). However, such cost-benefit analyses neglect non-monetary benefits such as health. The third approach, which is widely used in public health, can mitigate this shortcoming by identifying the least-cost method of reaching a prescribed target or risk reduction level (see e.g. Detsky & Naglie, 1990). Clearly, cost-effectiveness in terms of meeting one target is not fully fit for purpose if a project has more than one policy goal or success indicator. The cost-effectiveness and vulnerability assessments can become very similar if the former is evaluating the cost of improving a specific aggregate vulnerability metric.

A universal metrics should include elements of all three approaches. One critical aspect is to have a non-monetary indicator that addresses the health benefits of adaptation projects, as any monetary valuation of human life and human health is fraught with ethical and political challenges. The purely economic perspective is represented by Fankhauser and Tol (1998), who suggested that the 'values of a statistical life', as shown by willingness to pay for life insurance, should be used as an indicator for lives lost due to climate change. The difference between such values in developing and industrialized countries is huge and generated strong political controversies during the drawing up of the 2nd IPCC Assessment Report. Fearnside (1998) therefore suggested separating human lives from property values. We follow his argument here by proposing two different indicators for monetary and human life or health-related benefits. There are also arguments for separate indicators for the environmental and cultural benefits, but we have not found any simple aggregate indicators for these areas.

4.1 Saved Wealth (SW)

Adaptation projects can protect, among other things, productive assets and other forms of property against destruction by climate change impacts. Our indicator covers all assets under the term 'wealth' that are thus saved by the adaptation project. Obviously, for a very rich person the loss of a small share of his or her wealth may be less relevant than the loss of a high share of very small assets in the case of a poor person. Thus, it might be more appropriate to calculate Saved Wealth on a relative than on an absolute basis.

As a starting point for assessing 'Saved Wealth', the baseline development of wealth throughout the lifetime of the adaptation project needs to be determined. This requires an understanding of the development of the economic situation and population in the project area. As explained in detail in Stadelmann et al. (2014), this wealth can be subject to both extreme meteorological events and slow onset impacts that are triggered by climate change.[2] Assessments of extreme impacts are based on a frequency distribution function of climate change impacts for the duration of the project, while assessments of slow onset impacts are based on non-discrete projections based on historical data and models accounting for future changes. The losses in wealth due to the climate change impacts can now be fully or partially prevented by the adaptation project, both during and after the project lifetime. This requires a good understanding of how the adaptation project will function.

4.2 Saved Health (SH)

Health benefits can be operationalized through the concept of Disability Adjusted Life Years Saved (DALYs), used in public health policies and promoted by the World Health Organization (WHO, 2017a). Diseases, lasting disabilities and deaths can be made comparable through the indicator of years lost due to disability and early death, using the following formula:

$$DALY = N \cdot L + \sum_i I_i \cdot DW_i \cdot D_i$$

Where:

N: Numbers of deaths
L: Standard life-expectancy at age of death (in years).
I_i: Cases of disease / injury i
DW_i: Disability weight of disease / injury i.
D_i = Average duration of disease / injury i (years)

The weight factor DW ranges from 0 (perfect health) to 1 (dead) and has been estimated by the World Health Organization (WHO, 2017b) for many different diseases.

[1] Among others, these include the Disaster Risk Index (UNDP), the Disaster Deficit Index (IADB), the Vulnerability Reduction Assessment Scorecard (UNDP) and the Impact Vulnerability Index.

[2] Ideally, one would differentiate between extreme events that are part of natural climate variability and extreme events that are triggered by climate change. For the status of the detection and attribution of specific events, see Herring et al. (2016); for a broader review, see Stone and Hansen (2016).

For each extreme event specified in the frequency distribution, the health impacts are assessed, ideally by looking at historical analogies. On the basis of the frequency distribution of the events, the total DALY loss under the baseline will be calculated. Subsequently, the effect of the adaptation project for each extreme event in the frequency distribution will be estimated in terms of DALYs. They will then be summed up according to the frequency distribution.

The GCF (2014) has considered the use of DALYs, and some project proposals have tried to calculate DALY benefits.

5. Dealing with uncertainty?

Any estimate of project benefits ex ante is fraught with uncertainties. Uncertainties arise due to the counterfactual character of the baseline, the inability to predict the course of climate change and a lack of understanding over whether the anticipated project outputs will actually accrue.

5.1 Where do we stand in the results chain?

The famous 'results chain' of development cooperation tries to determine the link of project outputs to outcomes and finally to impacts. The further down the results chain, the less clear is the link between a result and the project, as it becomes overlaid by many other influences. Therefore, the universal indicator approach is particularly well suited for adaptation projects that focus on short-term rather than longer-term impacts.

As the experience of developing mitigation policies has shown, it is important to have a clear understanding of the relationship between the outputs and outcomes of a project. A renewable electricity generation project will not mitigate greenhouse gases by itself, but only if it replaces fossil fuel-based electricity. A capacity-building project may only have very indirect mitigation benefits. Over the past twenty years, policy-makers have improved their understanding of the respective stability of relations between intermediate outputs and outcomes on the one hand and final impacts on the other. A similar learning process for adaptation projects is required in order to improve understanding of which intermediate outputs and outcomes are more likely to lead to the desirable adaptation impact in the long term.

A critical issue that needs to receive much greater attention in the long run is the issue of maladaptation. A project may appear to be hugely successful during its lifetime, but continued climate change may subsequently lead to a disaster. An example would be an irrigation system designed to cater for the flow of glacial meltwater during the growing season being enhanced by climate change over a number of decades. Once the glaciers have vanished, the irrigation system would be significantly oversized and thus could no longer operate effectively.

5.2 Reducing uncertainty in the future

For each sector affected by climate change and in need of adaptation (e.g. coastal infrastructure, agriculture, water, forests, health etc.), and potentially for specific interventions in these sectors, specific methodologies to determine Saved Wealth and Saved Health should be developed. This could be akin to the baseline and monitoring methodologies applied under the CDM. In some cases, only minor adjustments to existing methodologies would be required for new methodologies (e.g. the methodology for coastal protection through the construction of a dyke is similar to that for coastal protection through mangrove rehabilitation), while in other cases new methodologies would have to be developed. So far, methodologies have been developed and published for the following project types:

- Adaptation of coastal zones to rising sea levels (see Köhler & Michaelowa, 2013). This methodology reflects already observed and predicted climate change impacts. Both past adaptation measures and autonomous adaptations expected during the project's duration are part of the baseline. Baseline data include the project lifetime, population in the start year, total project area and the damage frequency distribution curves for infrastructure (dyke damages), loss of private property (for residents located in front of the dyke), erosion and salinization.

- Irrigation technology in the agricultural sector (see Michaelowa, Köhler, Friedmann, Dransfeld & Tkacic, 2016). In the baseline scenario, irrigated land in Kenya remains extremely limited, as modern petrol or diesel pumps are unaffordable. Baseline wealth losses are calculated using FAO data on crop varieties, yields and price trends. The health-loss baseline builds on a frequency distribution of the food supply, along with its nutritional values.

6. Application of the Saved Wealth / Saved Health framework to concrete projects

It is worth highlighting that the quantification approach can be applied either during the planning stage of a project,

Table 3. **Data for baseline determination in the Vietnam coastal protection case**

Parameter	Value	Source
Project country	Vietnam	Project document
Project region/community	Au Tho B village	Project document
Project start year	2007	Project document
Total project area in ha	439.28	Project document
PLT (project lifetime in years)	20	Assumption
POP (population in start year) in project area	700 (1277 for erosion)	Project document
PGR (POP growth rate per year)	1.06%	Vietnam, 2008-2010, World Bank
LE: life expectancy at birth	74.2	Default value, Vietnam
WPCB: baseline wealth USD per capita/yr	1222	Vietnam, 2007, World Bank
IGR: income (GDP) per capita growth rate (%/yr)	5.9%	Vietnam, 2006-2010, World Bank
AA: autonomous adaptation	10%	default value
D: discount rate of existing wealth per capita	0.04	half of average inflation rate

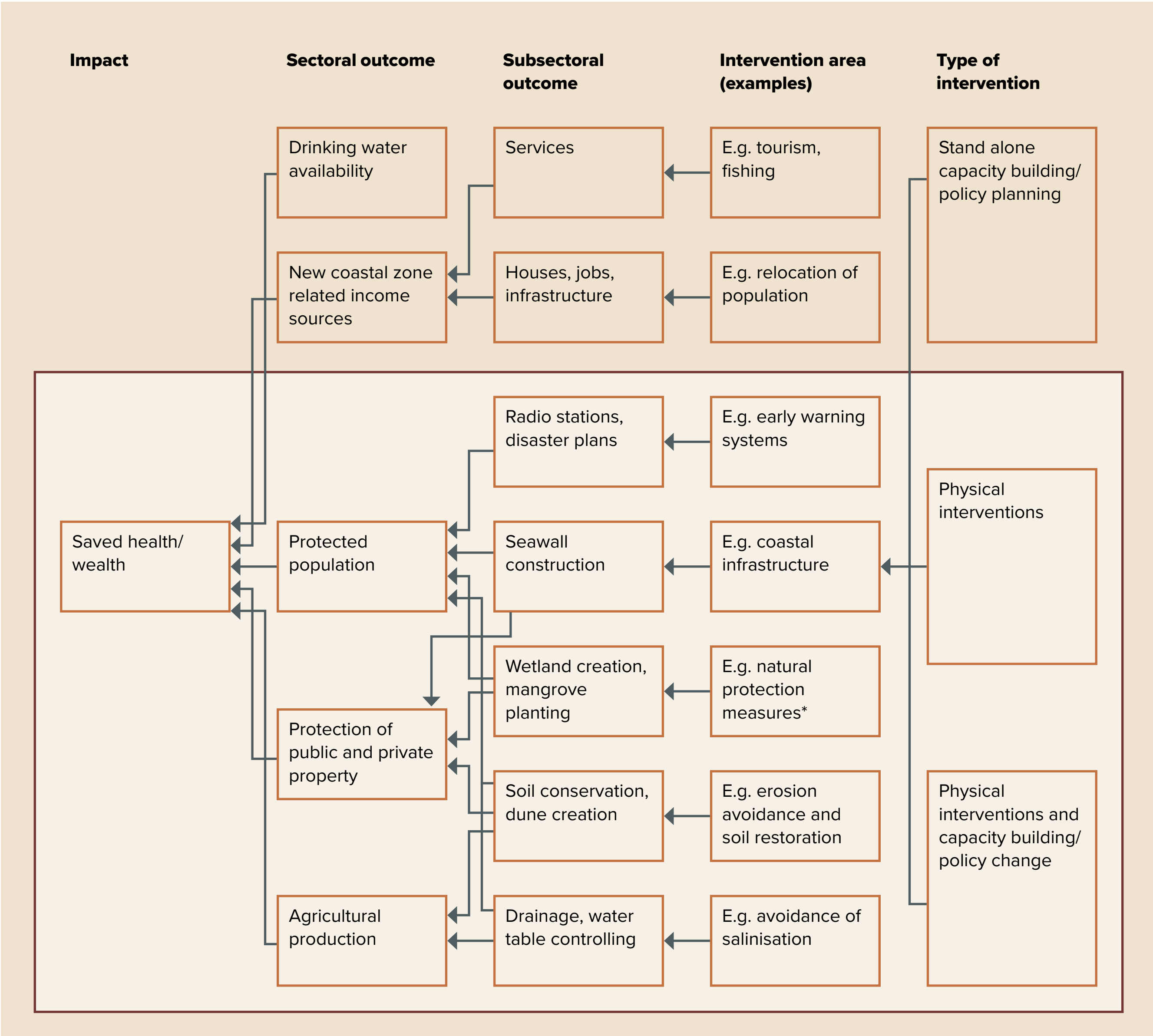
Source: Köhler and Michaelowa (2013, p. 20)

as a comparison tool for different projects (ex-ante), or to evaluate the impacts of adaptation activities that are being or have already been implemented (ex-post). If used ex-ante, the assessment can provide clear guidance for an investment decision, as it is possible to compare directly the adaptive benefits of different projects.

We have developed a detailed Saved Wealth / Saved Health methodology for a coastal protection project in Vietnam (Köhler & Michaelowa 2013). The application followed a four-step approach, which is not new as such, but has not been used in the context of a universal adaptation metric before. First, the applicability and methodological boundaries are defined. In the Vietnam case, for instance, the developed methodology aimed to evaluate projects designed for flood prevention and flood mitigation in coastal zone areas that are affected by climate change. The methodology covers physical interventions such as coastal infrastructure, natural protection measures, erosion avoidance, soil restoration and avoidance of salinization. Secondly, the baseline scenario is derived, that is, it represents the business-as-usual situation in the project area, including the impacts of climate change, but excluding the proposed project interventions.

The data shown in Table 3 are then fed into the damage frequency distribution curve with the probability of each event class occurring. A similar approach is undertaken for health losses, which in the case of flooding means deaths, injuries and diarrhoea from drinking polluted water. This reflects already observed and predicted climate change impacts over the project timeframe. Thirdly, a project scenario is described that helps to adapt the local population to the impacts of climate change (see Figure 1). Specific formulas are developed to calculate the health and wealth losses under the baseline and project scenarios. Finally, given the necessary input information, the model shows how much total wealth and health is saved due to the project scenario.

Figure 1. **Approach to assess the adaptation benefits of a coastal protection project**



* Includes wetland protection

For the Vietnamese project, the first project scenario (dyke upgrade) would have resulted in no disability adjusted live years (DALYs) avoided and saved wealth of just USD 0.5 million, while the second project scenario (mangrove rehabilitation) would have resulted in 421 disability adjusted live years avoided and saved wealth of over USD 2.3 million (Köhler & Michaelowa 2013, p. 27).

In its current form, the Saved Wealth / Saved Health approach is no panacea and faces a number of challenges. Critical issues that need to be addressed in the future are the robustness of the damage distribution function, the period(s) for which parameter values are calculated, and how adjustments to the adaptation approach can be taken into account. An important challenge is the level of disaggregation of the methodologies: the approach can only become universally applicable if it is shown that it functions for a broad range of adaptation activity types. Testing the approach for many different adaptation activity types is important in order to understand the level of transaction costs generated and decide whether current, more diffuse adaptation metrics remain more attractive due to their low assessment costs. Moreover, testing the monitoring of ongoing adaptation activities for a longer period is important in order to understand whether the approach is consistent over time. Given that the assessment of mitigation activities was able to achieve this, there should be no insurmountable barriers in the case of adaptation. Ideally, a large climate finance institution would act as the frontrunner in this regard.

7. Recommendations for climate finance institutions

Given the current 'Wild West' of adaptation project proposal assessments, applying a 'Saved Wealth / Saved Health' approach would lead to a marked change in assessment procedures, as it would allow projects to be compared with respect to specific indicators. A critical precondition for this would be to make sure that not only outputs but also outcomes and particularly impacts are measured in the 'results chain' model of evaluation. This may be easy in specific cases, e.g. infrastructure projects with a short-term impact, but possibly more difficult for soft capacity-building measures that aim at longer term adaptation impacts. These will be hard to determine due to the 'attribution gap' between outputs and actual longer-term impacts.

The attribution gap and the longer-term uncertainty may be among the reasons why international adaptation funds and programs have refrained from using universal impact indicators so far. Furthermore, adaptation projects may be seen as too heterogeneous for the application of common indicators. So far, adaptation funding has never been exposed to a real confidence crisis like that experienced by the CDM. Adaptation funders should not assume that such a 'benign' state will continue forever. With growing experience with the implementation of adaptation projects failures will occur, and the general public will start asking how the effectiveness of adaptation interventions can be assured. Moreover, these demands will extend to a call for indicators to increase the comparability of projects and to identify whether a project is performing well or not.

We nonetheless recommend that policy-makers, including decision-making bodies in international climate funds, do not take the easy way out of assuming that universal metrics will never be applicable to adaptation projects. At least for projects with shorter-term benefits (e.g. infrastructure projects), universal impact indicators should be feasible. By using tailor-made methodologies for specific project types combined with a four-step approach, universal impact metrics can at least be measured for such short-term projects, and then compared with the impact of similar interventions.

In order to make the impact of adaptation projects more comparable with regard to universal metrics, a generic agreement on the part of the climate finance institutions on several issues would be desirable. Forecasts of economic development and population specifying the wealth accumulated in a project area should be aligned with data on baseline health status. For instance, climate finance institutions could agree to use the population and growth projections developed under the new IPCC Shared Socioeconomic reference Pathways (SSPs). In order to assess the baseline impact of climate change, disaggregated climate models and frequency distributions of extreme events would also be desirable. This would be akin to mitigation regulators agreeing default emission factors for certain technologies. Methodologies for assessments of Saved Wealth and Saved Health should be developed for the key types of adaptation projects. Ideally, in accordance with Article 7 of the Paris Agreement, an exercise should be started to develop common metrics for adaptation not only for climate finance, but also in the context of the Nationally Determined Contributions. By means of such an approach, the phase of 'intense experimentation' proposed by Arnott et al. (2016, p.391) could probably be shortened to the extent necessary to avoid a backlash against adaptation funding that cannot clearly show its longer-term benefits.

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SECTION B

Practical experiences and lessons


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Developing meaningful local metrics for climate adaptation: learning from applying the TAMD framework at local scales

Abstract

Many countries are now developing local level climate change plans at various scales, as well as national climate change plans and results frameworks. The move toward (Intended) Nationally Determined Contributions or (I)NDCs and National Adaptation Plans or NAPs will accelerate this trend. This paper analyses experiences of developing climate adaptation metrics for local government and community planning in several countries using the Tracking Adaptation Measuring Development (TAMD) framework. The paper explores the metrics that have been developed in these contexts and shows how aspects of institutional capacity, resilience and well-being have been captured through participatory indicator development. The paper analyses what has been learnt about developing adaptation metrics in different contexts and how different metrics may be aggregated and/or compared. Finally, it considers how these processes can be linked into local and national plans and strategies.

1. Introduction

A variety of metrics applied at different scales have emerged over the past decade through increasing experience in the monitoring and evaluation (M&E) of climate adaptation (Bours, McGinn & Pringle, 2014, 2015; Fisher, Dinshaw, McGray, Rai & Schaar, 2015; Stadelmann, Michaelowa, Butzengeiger-Geyer & Köhler, 2014). These have largely focused on either the processes of adaptation or the results (often the number of beneficiaries targeted), and at different points in time. These emphases have emerged because of demands for accountability from funding agencies anxious to be able to demonstrate the impacts of their funding on adaptation, as well as from national governments developing climate change or adaptation plans and strategies and wanting to build results management into them. What have been slower to emerge are frameworks and metrics to help facilitate learning about adaptation at different scales. Several authors have noted the different incentives behind results management and learning (Anderson, Khan, Fikreyesius & Gomes, 2014; Roehrer & Kaoudio, 2015).

Some adaptation M&E approaches have sought to address the cross-cutting challenges that local and national actors need to take into account when considering which metrics to choose to assess, compare and aggregate results (reviewed in Fisher et al. (2015) and Bours et al. (2014)). These are: (a) the time frames of adaptation are very long and thus difficult to measure within traditional five-year government planning cycles or political mandates; (b) the endpoint is also unclear and may change over time; (c) there is uncertainty regarding trends in climate change and their local impacts. Climate trends are not yet clear in many cases, and so planners need to adapt to a range of possible scenarios, avoiding being 'locked-in' to future impacts until further evidence is available; (d) the data may not be available on climate trends, or the climate risks may change over the period of the adaptation efforts, meaning that trends in indicators need to be interpreted in the context of a shifting baseline; and (e) the multi-sectoral nature of adaptation responses presents challenges for data collection and for assessing effectiveness across several domains, as well as the potential trade-offs and synergies between them.

This paper discusses the experience of applying a particular approach – the Tracking Adaptation Measuring Development framework – to local projects and adaptation-related investments (Brooks, Anderson, Burton, Fisher, Rai, & Tellam, 2013; Anderson et al. 2014; Brooks & Fisher, 2014). The TAMD approach was developed specifically in response to the challenges identified above and to enable local and national governments to learn from and improve their adaptation efforts. We first outline the TAMD framework and its application in several local contexts before discussing lessons learned and ways forward for adaptation metrics locally.

2. Assessing institutional capacity, resilience and well-being: looking at the TAMD framework

There are three main components to the TAMD framework (Figure 1): an (iterative) assessment of institutional capacity for climate risk management (CRM) that results in adaptation interventions (Track 1); a theory of change linking this or other activities to changes in resilience and well-being; and indicators to assess either resilience outcomes or well-being and developmental outcomes in the context of observed changes in climate hazards over time (Track 2).

TAMD is intended to be a flexible framework for evaluating adaptation and adaptation-relevant development interventions in diverse situations. It can be modified for different contexts and types of adaptation. The framework can be used retrospectively, in real time, and prospectively. TAMD explicitly addresses the assessment of outputs, outcomes and impacts, thereby seeking to go further than many existing or emerging adaptation M&E approaches. The following section draws on Brooks and Fisher (2014).

Track 1 captures the institutions, policies and capacities for climate risk management that are needed for adaptation and other interventions. For example, these could be a set of national capacities needed to manage climate risks in the national climate change strategy, or the institutional capacities a village committee needs to deal with local climate risks with the support of district and national institutions. Track 1 has a set of nine scorecards (see Table 1), which can be adjusted for different contexts.

Several methods are used to fill in the scorecards. These can be self-assessment by the key individual in the institution involved, expert assessment by an external individual who knows the context well, or a series of semi-structured interviews with key stakeholders, which are then aggregated into a set of scores by an external facilitator. It is important to establish and agree the scale for analysis with the individuals who will be carrying out the assessment in order to decide

Figure 1. The TAMD framework (Brooks and Fisher, 2014)

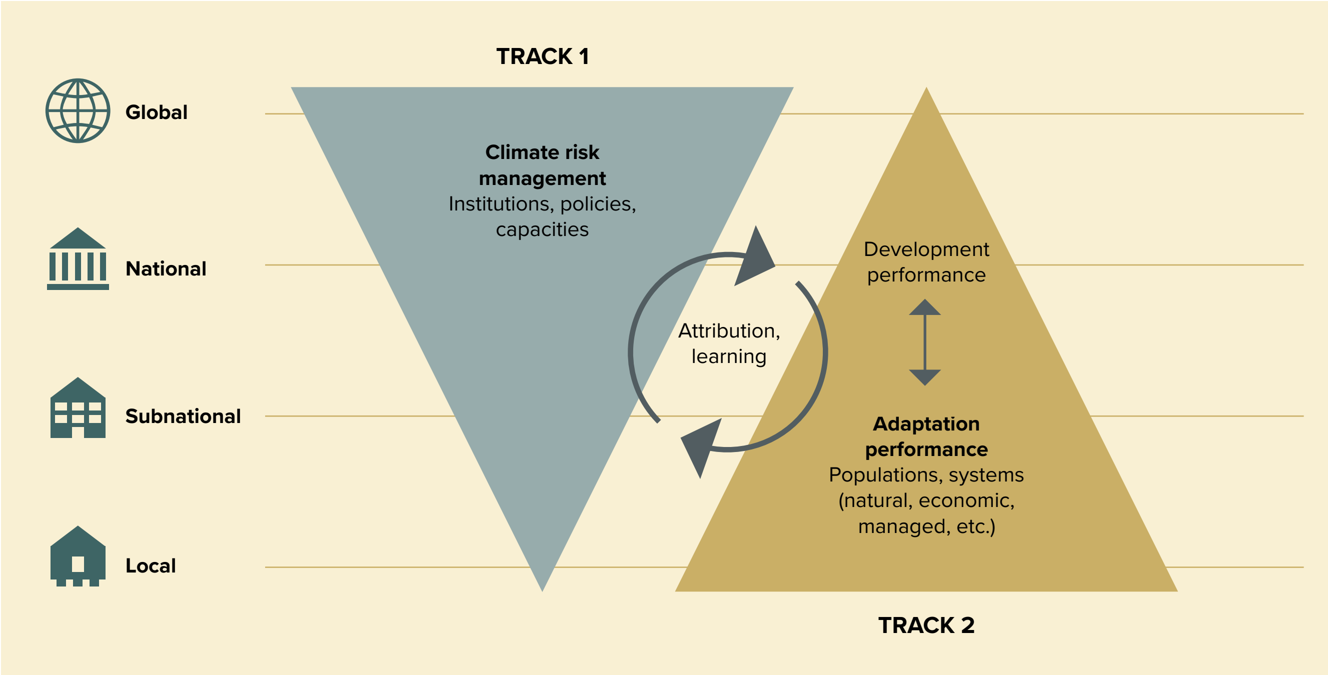


Table 1. Dimensions of climate risk management

Dimensions of climate risk management
Integration of climate into planning
Institutional coordination for integration
Budgeting and finance for climate integration
Institutional knowledge and capacity
Use of climate information
Planning under uncertainty using appropriate methodologies
Participation of relevant stakeholders in national planning
Awareness among stakeholders

what each question means in that context. Rai, Brooks, Ponlok, Baroda and Nash (2015) discuss how this was done in Cambodia defining scales that showed what progress on each dimension meant for specific ministries and what constituted a yes, no or partial score for each dimension. In Nepal, a five-point scale was developed for local village and district authorities to provide greater nuancing on each dimension (Pokhrel, Shresthra, Fisher & Devkota, 2014). In cases where different experts have filled in the scorecards (for example, stakeholders across local governments, or local project facilitators working in different regions), a series of meetings need to be held to discuss the results for each institution and ensure that the ranking has been applied evenly between contexts. To ensure comparability, it is crucial that full explanatory notes and evidence are provided for why certain scores have been given, and what has led to a change in a score over time. This will give any aggregation greater transparency.

A theory of change[1] connects the activities to the anticipated changes to a policy or programme through a set of causal mechanisms. In the TAMD framework, this can take place between Tracks 1 and 2, i.e. connecting climate risk management to changes in resilience, or it can take place within one track. Once a theory of change has been established, TAMD provides a framework for exploring the links between CRM, resilience and well-being or developmental outcomes. This can be done by locating these elements of CRM, resilience and well-being, and the relationships between them, on the TAMD tracks – in other

[1] See: SEA Change Guidance Note 3, Theory of Change approach to climate change adaptation programming http://www.seachangecop.org/node/2933, for more details of this approach.

words, by defining a pathway across the TAMD framework – and then collating and generating the evidence to test the theory of change.

Within Track 2, interventions should improve the underlying capacity of households, communities or other systems to anticipate, avoid, plan for, cope with, recover from and adapt to (climate-related) stresses or shocks. Such improvements may be characterized as outcomes in project or programme contexts. Improvements in resilience and adaptive capacity, as well as reductions in vulnerability, are outcomes representing intermediate goals that should ultimately improve human well-being and reduce the costs of damage to assets, livelihoods and lives from climate-related stresses and shocks. In government systems, improvements in human well-being and reductions in costs in terms of assets, livelihoods and mortality rates are generally referred to as developmental outcomes. In the language of programmatic interventions[2], they are generally referred to as impacts. These include common development indicators relating to the aspects of health, nutrition, poverty and economic status, education, assets, livelihoods and lives, and they also relate to longer-term changes.

Track 2 encompasses both changes in resilience (the capacities to absorb, adapt to, transfer and anticipate climate shocks and stresses) and improvements in well-being (more general development results). Indicators representing these two different types of adaptation results may be useful for different audiences. For example, local government planners may use local resilience indicators for each community linked to the adaptation interventions they are implementing, but county government planners with a broader remit and longer term planning horizons may track related well-being and impact indicators. Well-being indicators over a certain time frame need to be considered in the context of changing climate hazards.

3. Applying the TAMD framework in local contexts

The TAMD framework has been applied in a variety of setting and scales. In this paper, we look at the application at the local level in three main domains: in decentralized climate funds, local adaptation planning guidelines and local programme assessments respectively.

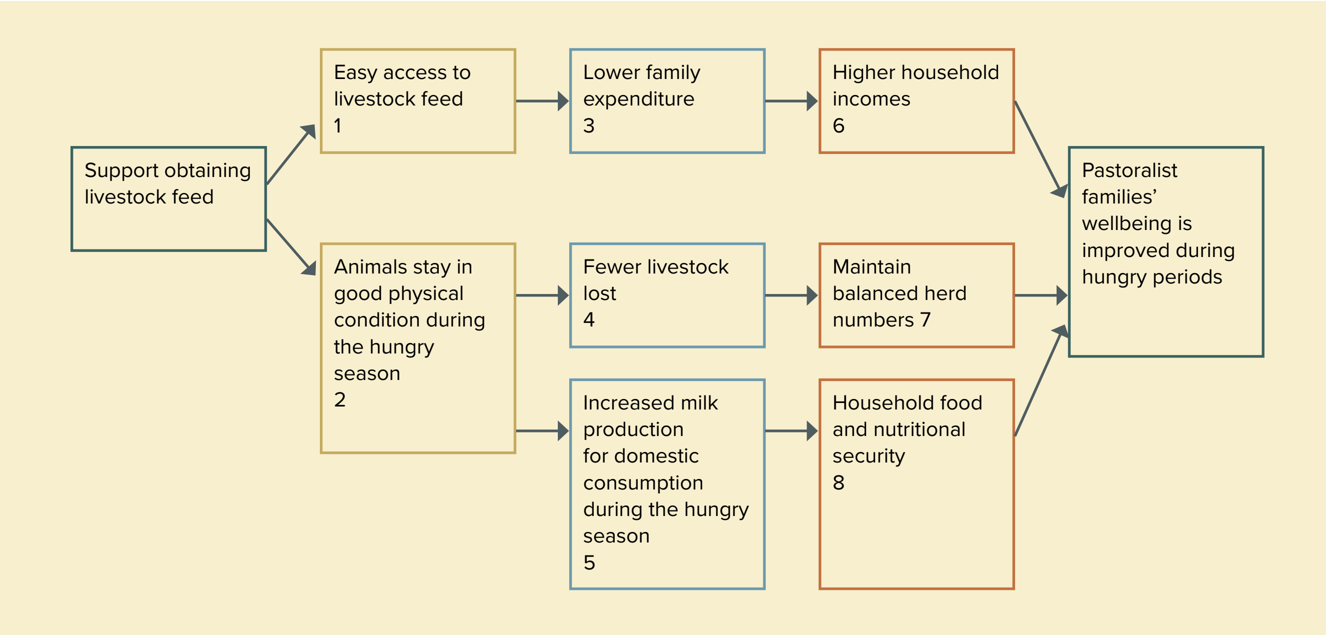
3.1 Decentralized climate funds

TAMD is being applied to decentralized climate-fund systems in Kenya, Tanzania, Mali and Senegal (Karani, Kariuku & Osman, 2014; NEF, 2016a, 2016b). These systems have been developed in coordination with development partners with the aim of creating channels to allow climate finance to be allocated to and spent by sub-national or local governments in the future. The decentralized climate funds allocate finance for local public goods investments that build the resilience of local communities through local committees and according to community priorities. The approach has four dimensions: setting up a local-level climate-change fund; putting in place local adaptation planning committees; integrating participatory planning tools and climate information into planning; and strengthening monitoring and evaluation to track the progress of resilience-building investments at the community level.

In each case TAMD has been applied slightly differently, but generally local committees have used versions of the scorecards to assess their own institutional performance and identify gaps where they need to invest in institutional capacity. These scorecards have also been used to monitor the performance of the funds and the institutional processes that have been put in place. The results were displayed through graphs and spider diagrams, and they provided useful points of discussion for learning and reflection amongst local stakeholders. The main areas for improvement were found to be around the use of climate information and integration into planning. Local theories of change and indicators of resilience and well-being were developed for each investment made in public goods to determine what the success of each adaptation investment looks like and how it can be measured and assessed (see Figure 2). The following example shows the theory of change for an investment facilitating the availability of livestock feed in Mali. This can be linked to resilience to climate change, as livestock have less to eat during periods of drought and unexpected seasonal weather. This input helps local communities to weather fluctuations as they occur. Livestock that are better fed and have more options for feed will be more robust in resisting these fluctuations in the longer term. This means that communities reliant on livestock for milk also become more resilient during these periods, with enhanced food security and ultimately better well-being.

[2] By programmatic interventions, we mean specific programmes and projects on adaptation that are outside regular government policies. They could be designed and implemented by development agencies, MDBs or NGOs with varying levels of government involvement.

Figure 2. Theory of change for the livestock-rearing system in the semi-humid zone in Douentza cercle, Mopti region, Mali (NEF, 2015)



Indicators of resilience

1. Availability of animal feed
2. Physical condition of livestock
3. Reduced cost to household of livestock feed compared to past years
4. Number of livestock lost in lean periods
5. Milk production available for domestic use

Indicators of well-being

1. Household income
2. Household nutritional status
3. Herd numbers

Data to monitor these aspects have either been collected by local communities or government M&E officers who are part of the adaptation planning committee, or are monitored through the committee's annual visits to the investments. In each case, the committee at county or district level draws up an M&E plan for data collection and monitoring investments. The county or district committee also plays a role in aggregating the results so that they can assess the overall improvements in an area that come from all the different investments. In Kenya, this was achieved by developing a county-level theory of change for how investments were building resilience (Karani et al., 2014), where possible indicators are linked to those in local development plans and/or national strategies. There are as yet no mechanisms to feed the results from the local climate funds into national adaptation M&E frameworks, but it is hoped that this will be developed as the local climate funds mature and as links are made with international climate finance flows such as the Green Climate Fund.

3.2 Local adaptation planning guidelines

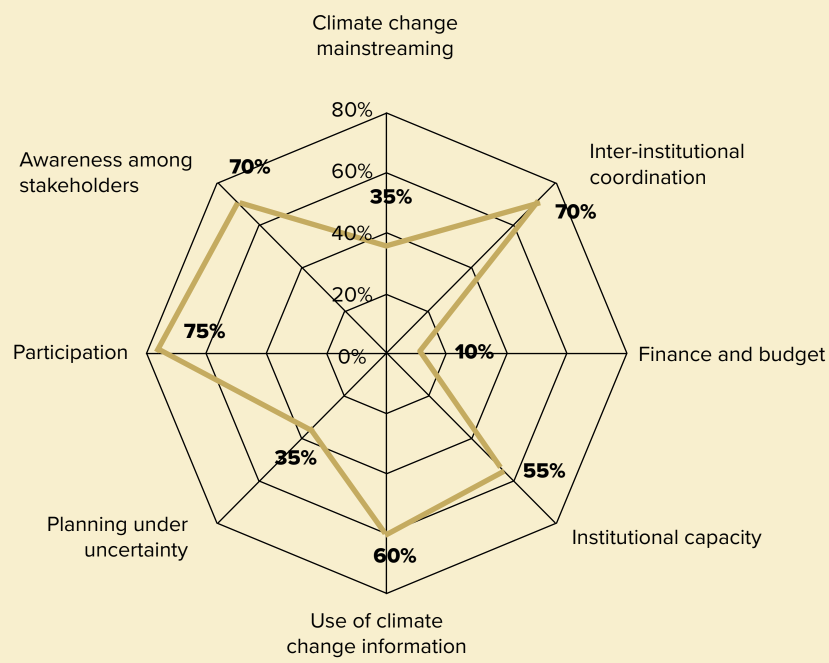
In Mozambique a team from the International Institute for Environment and Development (IIED) and the Africa Climate Change Resilience Alliance (ACCRA) has worked with government partners to integrate the TAMD framework into Local Adaptation Plans (LAP). The LAP process is a general local planning framework that supports local government stakeholders in working on their main climate-related vulnerabilities and adaptation priorities through a structured process in order to draw up a local plan. The TAMD approach to M&E was added to the LAP process to support local stakeholders in monitoring and evaluating their efforts after they had chosen their adaptation activities. This approach was first piloted in Guijá District and subsequently integrated into other districts. The steps in applying TAMD are integrated into the ten-step methodology for LAPs that has now been adopted in Mozambique (Artur, Karani, Gomes, Malo & Anlaue, 2014). Three aspects of TAMD were integrated into the ten-step process: the institutional scorecards, theories of change, and indicators of resilience and well-being. The LAP guides the district technical staff in following the existing processes to monitor the work around adaptation, and it also informs the national framework through its strong links with district development plans. The data will be regularly tracked through government monitoring systems using existing available data both locally (inputs/outputs) and centrally (outcome/impact).

First, to assess institutional needs and performance around climate risk management, institutional scorecards were adapted for Mozambique through stakeholder workshops and then used at the district level. The scorecards helped highlight where support might be needed to improve climate risk management, as well as being used to create a baseline to compare future improvements. The results from Guijá District show finance, climate change mainstreaming and planning under uncertainty to be the key limitations in current climate risk management and potential areas for work under the LAPs (see figure 3). However, there is also a high level of awareness among stakeholders and good participation, while the capacity to understand climate change issues and the use of climate information are both fairly strong.

Secondly, the theories of change that were developed at the community level were integrated into the process to help elucidate the links between planned activities in the LAP and its improvements in promoting resilience and longer-term well-being. Following agreement on key interventions to be undertaken under the LAP, the IIED/ACCRA team asked community participants in plenary to present interventions, outputs, outcomes and impacts, as well as indicators for each level. A higher level (district-level) theory of change was then developed with government officials to present an overall vision for the district, strengthened by the community inputs. In Guijá District, three groups were guided in developing a theory of change, each based on strengthening respectively flood-control infrastructure (dykes and river banks), livelihoods and coping strategies, and the local early warning system. The three strands were then put together to develop the overall theory of change for the district.

Thirdly, following an assessment of climate vulnerability and a theory of change process, the team identified and included Track 2 indicators for adaptation and development performance in consultation with district staff.

Figure 3. District of Guijá: institutional scorecard results (Artur et al., 2014, p. 33)



Source: Governo de Guijá (2014)

3.3 Programme assessments

In Ethiopia, in collaboration with the Ministry of Agriculture, the TAMD framework was used to carry out a retrospective assessment of the contribution of the Sustainable Land Management Programme-1 (SLMP-1) to the climate resilience of smallholder farmers and local communities. Here, institutional scorecards were applied at the national level.

In order to identify the changes in adaptation and development performance (Track 2) from the activities of the SLMP-1, a number of indicators were developed with focus groups in different local areas. The indicators created to assess adaptation and development performance fell into two categories. The first category was based on resilience around soil and water conservation. To assess longer term changes in well-being and development outcomes, indicators were also developed for five forms of livelihood capital (physical, natural, social, financial and human), which were identified through focus-group discussions with local people in SLMP-1 areas. In addition, climate data analyses were carried out for each district to interpret changes in Track 2 indicators within the contexts of climate variability and hazards.

Analyses of observed climate (rainfall and temperature) showed that the most frequent climate-related hazards are floods, which exacerbate soil erosion and degradation, and hail storms. Rainfall is becoming highly variable, with more frequent extremes occurring, a trend observed across most of the selected areas. Although temperature has been slightly increasing at two sites, the increases were not statistically significant. The TAMD assessment considered the results in respect to adaptation and development performance against these climate data by means of a qualitative contextualization of climate. It concluded that the period from 2006 to 2012 saw a particularly high number of days with heavy rainfall while SLMP-1 was being implemented. The conclusion was therefore that, despite climate variability and significant risks of flooding, gains have been made in development outcomes.

4. Learning about adaptation metrics and measurement from applying TAMD

The basic premise behind the TAMD framework is that better climate risk management (CRM) improves resilience, reduces the losses from climate hazards and improves human well-being and development outcomes. The framework is not static, and its context-specific application has led to different experiences in the development of adaptation metrics and measurement. The previous section has outlined three practical ways to develop local adaptation metrics using the TAMD framework. We now go on to reflect on lessons learnt from the application of TAMD in respect of decentralized climate funds, local adaptation planning guidelines and programme assessments.

4.1 Theories of change and metrics of resilience and well-being

Too often people rush to the indicator-identification stage before considering the theory of change regarding how an activity is building resilience to climate change. They are therefore willing to take pre-defined indicators as proxies, following the logic of Lewis Carroll's *Alice in Wonderland* that 'If you don't know where you're going, any road'll take you there', or in this case, 'If you don't know what adaptation should look like, then any indicator will do.'

The theory of change process was important in helping stakeholders make explicit links between planned activities, climate risks and outcomes. This facilitated process helped address a particular issue with adaptation metrics, namely how the activities directly relate to building resilience and the climate risks of that local context. In some contexts, we found it helpful to use a table to develop the theory of change, as the more free-flowing diagrams were too challenging for those who were being introduced to these ideas for the first time. The tables displayed linear results in the form of chains of outputs, outcomes and impacts in the context of a specific climate risk. Many of the local resilience and well-being indicators identified through participatory processes related to development challenges and poverty levels. Through the theory of change process, however, an explicit link was made with the climate challenge in that area that provided a climate lens on more traditional development indicators that were identified. Some indicators, such as increased celebrations and festivals in an area of Kenya, were very contextual and linked to local understandings of how extra resources could be spent if communities were more resilient to climate shocks.

4.2 Adapting indicators to local contexts

We found it was important for scorecards to be adapted to the local context in terms of which questions were appropriate for that level of jurisdiction, as well as in respect of resources and existing capacity. Many of the stakeholders in the local examples above developed their own scales for what progress would look like at the local level, meaning that targets were ambitious but appropriate, and aligned with local priorities. The first five indicator areas remained the same for the institutional scorecards, which allowed some comparison, though the actual scales within them differed. In some cases, use of climate scenarios and information about uncertainty were not applicable to local-level actors, this being a national-level responsibility. Therefore, we replaced these domains with more enabling capacities such as the learning and flexibility of processes. We also found that the process of developing scales and scoring the indicators, usually through interactive meetings, helped embed the analysis and results within local institutions and created more ownership of the results. Indicators for resilience and well-being were defined by local actors and representatives of communities. Again this helped build ownership of their utility in assessing the effectiveness of interventions, rather than it being just a reporting tool. This also allowed local actors to make links with their district plans where possible, as in the case of Mozambique, where the development indicators in the LAPs were linked to those in the district development plans, for which data was already being collected on an annual basis.

4.3 Integrating gendered differences

A key lesson from applying the local tools was the need to integrate gender concerns more explicitly and to consider the gendered dimensions of climate change within the scorecards, theories of change and local indicators. The initial framework provides guidance on this aspect by asking who is affected and whose resilience is being improved, but through local application we found that this would be more strongly integrated into the process if more vulnerable groups such as women or those from particular ethnic groups or livelihoods were explicitly identified. This was important, as the planning approaches discussed above are designed to empower vulnerable communities. Hearing the voices of women and learning about their needs in terms of resilience is an important part of that process and part of promoting gender equality. In Mali and Senegal, we developed a new scorecard that assessed the general role of women in planning including their involvement in planning for climate change. Questions were also added into the theory of change tool and resilience indicators to ensure that impacts on women had been considered. The scorecard considered the role of women in planning for climate change as a part of a wider set of questions exploring the role of women in general development planning and local institutions. This was because we recognized that women's involvement in all aspects of local decision-making is a complex one, and that to isolate this in terms of climate change alone would miss aspects of the local context and gender relationships, as well as potentially miss small incremental improvements. For example, if women's involvement in local planning is minimal, but civil-society women's groups are strengthened through a project or capacity effort and able to advocate women's needs more effectively (even if not directly related to climate resilience), this represents an incremental step towards greater gender equality in climate risk management in the long-term. Equally, if the local adaptation planning committee has two female representatives out of twelve members, this still represents relative progress that needs to be captured.

4.4 Local M&E plans and data collection

An important dimension of developing local adaptation metrics is the feasibility of any data collection and clarity on who will carry it out. In the local pilots we found it was essential to develop local M&E plans stating who would collect data, when and at what level, as well as how this would be resourced. The focus was on collecting data on key dimensions of the process indicating that the activities and their intended outcomes were on track without developing overly arduous data requirements. In the early piloting work in Kenya, research teams identified around twenty indicators for each theory of change. However, over time it became clear that this was too much to collect, and in Mali and Senegal teams limited this to between three and five essential indicators. Within these monitoring processes, there is also the potential to look at one dimension or issue in greater depth that might be important for resource allocation decisions or for testing a particular local approach.

4.5 Contextualizing results with climate data

In the work in Ethiopia, local research teams tried explicitly to consider the climate challenge as part of their assessment of an intervention success in building capacity. The climate observation data across Ethiopia is relatively good due to the availability of over 1,200 functioning weather stations. There is discontinuity in historic weather data, but records can be sourced easily from the National Meteorological Agency. Although socio-economic data on households and communities are not located on a central database, the government institutions that own the data are willing to share them on an ad hoc basis. This made partial contextualization of the results possible in Ethiopia, this not being possible in the other local applications of TAMD.

Climate data in Ethiopia were used to support and triangulate community narratives of the hazards they had experienced and to contextualize changes in outcome data on well-being. For example, the success of the measures addressing flooding put in place by SLMP-1 could be contextualized by adjusting the number of flooding incidents and related losses of productivity and assets against the climate challenge level as represented by the incidence and frequency of days of heavy rain (Awraris, Endalew, Guerrier, & Fikreyesus, 2014). This experience demonstrated the utility of using climate data as part of an assessment of adaptation metrics, even if the data quality is only sufficient to do a qualitative contextualization or is used to develop explanatory narratives (see Brooks & Fisher, 2014). It is a useful exercise to triangulate community narratives of climate hazard with the available data, but these exercises are only possible with climate data available at the right scale, and this is often missing.

A major lesson here is that, without the contextualization of results by means of the available climate data, little can be concluded about how effective adaptation is in fact in the longer term. It could have been concluded, for example, that minimal improvements in key indicators were a result of poor performance, until these results were understood within a context of increasing hazards over the time period of the project.

5. Comparing and aggregating metrics

A key challenge in developing adaptation metrics is deciding the level at which they can be aggregated and reported to provide meaningful, real-time input into decisions. The methods described above are contextualized to fit local realities, and whilst necessary to provide meaningful metrics locally, this provides further challenges in aggregating and comparing results.

The scorecard methodology does provide comparable results among similar institutions as long as the scales are carefully calibrated and detailed enough to do robust scoring, and provided the scoring is triangulated with several actors and any relevant documents. This has meant that in Mali, for example, we have been able to compare climate risk management capacities in three local authorities in the district of Mopti and identify which need more targeted support, and to do a similar comparison of eight local authorities in Senegal. The focus on adjusting the scorecards to the local and national contexts implies that they are less useful for making international comparisons, but this can be done by comparing progress in each indicator domain (such as integration, budgeting, or the use of climate information), rather than aggregating or comparing absolute scores. As progress on climate risk management is quite specific to the national context and specific climate challenge, it is unlikely that indicators within specific domains could fulfil the objectives of being useful locally for planning and learning, as well as providing an international data set of the current state of climate risk management.

The focus on relative changes over time, rather than aggregating or comparing absolute values, is also a strategy that can be applied to aggregating or comparing results in respect of resilience and well-being. Again in the case of Mali and Senegal,[3] changes in resilience are calculated using four indicators: self-assessment on a resilience scale, seasonal access to and quality of key resources (adapted for context), improved techniques and/or behaviours adopted, and the governance of key resources. While the specific indicators that make up the assessment of resilience in two areas might be different (for example, if one community is concerned about domestic water as a key resource and another about grazing lands), the results can be compared and aggregated as changes to a resilience score over time. The danger of doing this over the longer term is that it can ignore any climate events that may have had an impact on trends. Ideally, therefore, this needs to be combined with at least a qualitative contextualization of any particular shocks or stresses.

Another way to aggregate local adaptation metrics is to link them to district and national plans, which provides a system of data collection and analysis through which they can be aggregated. We saw this in the case of the Mozambique LAPs, where the link with district plans was strong. In Kenya, the links between local indicators and national monitoring were less clear, as the mechanisms by which this information would be fed into the national climate change strategy were still under development (Karani et al., 2014).

One challenge in focusing over-much on how results will be compared and aggregated is that this tends to move the focus away from how the results can be used locally to inform and improve decision-making. It may be that these metrics

[3] This work is part of the Near East Foundation (NEF)-led consortium in the BRACED programme, a DFID-funded programme on building resilience to climate-related extreme events and disasters that brings with it certain requirements for resilience measurement.

are actually different, and it can be useful to identify clearly whether they are intended for learning or for aggregation at different scales: this would determine what emphasis was appropriate.

6. Ways forward

In conclusion, local metrics for adaptation need to be contextualized to take account of local realities, and M&E systems need to provide ongoing evidence that can support local decision-making and resource allocation regarding effective and efficient adaptation options. Our experience with the TAMD framework shows a set of metrics on climate-risk management, and outcome-based indicators supported by a theory of change provide sufficient data to make these decisions on resource allocation and performance when supported by local plans and resources for regular data collection. Some of these metrics linked to longer-term well-being need to be contextualized with climate data to ensure that the results are not misinterpreted. By applying the framework, we have recognised the importance of clear, simple tools with limited data requirements and explicitly including differentiated impacts among more marginalized groups such as women in the tools and scorecards.

We have also identified a number of ways in which results can be compared and/or aggregated. One of these is through scorecard measurements where these refer to similar institutions at the same scale. Another is by comparing or aggregating relative changes or trends as opposed to absolute values. This means that metrics can still be adapted to local contexts, but can also be assessed at different scales. Thirdly, integrating or linking adaptation metrics to local plans provides a mechanism through which they can be aggregated and monitored on a regular basis.

Finally, we argue that it is important to be clear on the objectives of any local metrics. Whilst having a national or global picture of adaptation progress is important, the metrics that can provide this picture may not be those that are most useful locally in supporting learning and decision-making on effective options. Given this, it is important to clarify why metrics are being developed and how the data will be used so that they can be most useful to the appropriate stakeholders.

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Designing, setting up and implementing a climate change adaptation monitoring and evaluation framework: concrete examples from Madagascar

Abstract

Madagascar is among the countries that are most vulnerable to the impacts of climate change. Accordingly several adaptation initiatives are currently being implemented on the island. Experiences gained from the design and implementation of three ongoing adaptation projects highlight key challenges and provide some lessons learned, including best practices and successes, in the development and practical use of Monitoring and Evaluation (M&E) frameworks and metrics for adaptation. This article is based on such experiences from adaptation projects funded by different donors, with a particular focus on Madagascar, from which concrete examples are provided.

This article discusses the use of M&E frameworks, tools, metrics and indicators to measure the successes of adaptation projects in Madagascar and the level of achievement of planned adaptation outputs and outcomes. The article also provides insights and lessons learned from the processes and approaches underlying the identification and selection of the metrics that are best suited to individual adaptation projects.

The article first contextualizes three case studies and outlines their respective M&E frameworks. It then analyses the M&E challenges, as well as successes, faced by each project, and assesses the extent to which the chosen metrics have been successful in measuring adaptation impacts. The final section presents some conclusions and lessons learned that might be helpful in defining M&E frameworks for adaptation projects.

1. Introduction

With an area of 587,000 square kilometres and a 5,600 kilometre coastline, Madagascar is the fourth largest island in the world. It experiences an extremely varied climate due to its geographical location, landform, maritime influences and wind conditions. With 70-75% of the population living in rural areas, agriculture, livestock and fishing predominate in its economy. Climate variability and climate change are affecting agro-climatic conditions, making Madagascar one of the most vulnerable countries to climate change impacts.

As a commitment to tackling climate change impacts and increasing the country's resilience, Madagascar ratified the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol in 1998 and 2003 respectively. It completed its Climate Change National Adaptation Programme for Action (NAPA) in 2006. In 2010, the government created a Climate Change Directorate within the Ministry of Environment and Forests, which later became the National Climate Change Coordination Office, and adopted a National Policy to Fight Climate Change (*Politique nationale de lutte contre le changement climatique* – PNLCC). One of the policy's five areas of focus is to strengthen measures to adapt to climate change, taking into account the real needs of the country. Madagascar has also adopted a climate change strategy specific to the agriculture sector, the National Strategy on Climate Change: Agriculture, Livestock, and Fishing Sectors 2012-2015 (*Stratégie Nationale face au Changement Climatique: Secteur Agricutlure, élevage, et pêche* 2012-2015). In 2015, it established its Intended Nationally Determined Contributions under the Paris Agreement, which it ratified in 2016.

As part of these efforts, the country has developed several adaptation initiatives, which are currently being implemented on the island. The Adaptation Fund is financing the project '*Promoting Climate Resilience in the Rice Sector through Pilot Investments in the Alaotra-Mangoro Region*' (AF-Rice) to address the vulnerability of rice-farming systems to erratic weather patterns and identify promising pathways to increase the resilience of rice-farming (Baastel, 2013). This project, which started in December 2012, focuses on increasing the climate resilience of the rice sub-sector. These interventions are divided into three components: i) increasing scientific and technical capacity at the government and non-government levels; ii) developing an adapted and resilient rice-production cycle; and iii) leveraging policy changes. A baseline assessment was conducted in August 2013 in which the project results framework, including outcome and output indicators,[1] were refined. In November 2015, a mid-term review assessed progress with project implementation and the level of achievement of the project's objective after three years of implementation.

The Least Developed Country Fund (LDCF) is providing funding for the implementation of the project '*Adapting coastal zone management to climate change, considering ecosystem and livelihoods*' (PAZC), which seeks to reduce the vulnerability of coastal zones to climate variability and climate change through institutional capacity-building, concrete coastal adaptation interventions and the integration of climate change into policy and planning (C4 Ecosolutions, 2016). This project was developed in 2013-2014 to address the climate-related problems that are being experienced by local communities in Madagascar. Implementation started in May 2015, and a baseline assessment was conducted in November 2015 to update the project results framework and develop the outcome and output indicators further.

The LDCF is also funding the project '*Enhancing the adaptation capacities and resilience to climate change in rural communities in Analamanga, Atsinanana, Androy, Anosy and Atsimo Andrefana*', vulnerable communities that need help in coping with the additional risks posed by climate change and variability for livelihood opportunities (GEF, 2016). This project was drawn up in 2015, with implementation starting in early 2017. A project results framework and associated outcome and output indicators were created as part of the project's design.

These three initiatives are being carried out by the National Climate Change Coordination Office, in close coordination with others. The experiences gained from the design of each project and their different stages of implementation highlight key challenges and provide some lessons learned, including best practices and successes in the development and practical use of M&E frameworks and metrics for adaptation.

[1] Cf. definitions below.

Box 1. Vulnerability indices used in the PAZC and 'Enhancing the adaptation capacities and resilience to climate change in rural communities' projects

1. PAZC: Change in the average climate change Vulnerability Index proxy for targeted regions (Atsinanana, Boeny, Menabe and Vatovavy Fitovinany)

This index proxy is a composite of seven environmental and socio-economic indicators, chosen to reflect the sensitivity and adaptive capacity of the targeted communities:

- Sensitivity: i) Change in vegetation cover; ii) Number of livelihood sources; iii) Livelihood production type (subsistence, semi-subsistence, commercial, fully commercial).
- Adaptive Capacity: iv) Awareness of adaptation (including coastal deforestation and sustainable land management); v) Information on climate change (including methods for adaptation); vi) Benefits from coordination mechanisms for adaptation planning at the regional level; and vii) Benefits from integrating climate change into the Regional Development Plan.

This is a perception-based index, data being collected for the seven indicators through interviews and focus groups with households and regional staff; no direct measurements are performed. Numerical scores for each indicator (between 0 and 3) and then for sensitivity and adaptive capacity (between 0 and 1) are calculated. The score for each indicator is calculated by the evaluators using a simple scale designed as part of an interview protocol. The vulnerability is then the difference between the sensitivity score and the adaptive capacity score. The project seeks to reduce the vulnerability index score by 0.1.

2. Enhancing the adaptation capacities and resilience to climate change in rural communitites: Vulnerability index of target communities

This index is based on the Vulnerability Reduction Assessment (VRA) methodology described in the UNDP Guide to the Vulnerability Reduction Assessment (Droesch et al., 2008). The VRA is based on a composite of four indicator questions, tailored to capture locally relevant issues that are at the heart of understanding vulnerability to climate change. Responces to the questions take the form of a numerical score, provided by the respondents during community meetings and focus groups.

The four VRA indicators include: (i) vulnerability of livelihood/welfare to existing climate change and/or climate variability; (ii) vulnerability of livelihood/welfare to developing climate change risks; (iii) magnitude of barriers to adaptation (institutional, policy, technological, financial, etc.); and (iv) ability and willingness of the community to sustain the project intervention. Local stakeholders and project beneficiaries answer all questions on a scale of 1 to 5, generating a numerical score, with other qualitative data being based on the discussions leading to the score. The scores for each indicator question are then aggregated on a numeric vulnerability index. Generally speaking, the project is looking for a one-point reduction in the vulnerability index for each community.

2. Identifying a set of indicators for monitoring and evaluating climate change adaptation

The definitions of the terms 'indicator', 'measure' and 'metric' vary across agencies and are often used interchangeably, though there are subtle differences:

- A measure is a value that is quantified against a standard.
- According to OECD (2002), an indicator is: 'A quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, to reflect changes connected to an intervention, or to help assess the performance of a development actor'. Outcome indicators are used to monitor progress towards individual project outcomes and, in combination, towards the overarching project or programme objective (e.g. to increase resilience or reduce vulnerability). Outcome indicators are informed by output indicators, which reflect the specific attributes of the desired outcome and build on data provided by their monitoring. Essentially, output indicators produce useful information on activities and achievements that affect outcomes.
- Metrics are a method or unit of measurement of a specific indicator.

Different sets of metrics were identified as the basis for measuring and monitoring the level of achievement of the three adaptation projects in Madagascar just mentioned, collecting lessons learned and aggregating adaptation impacts achieved on the ground nationally. The metrics used included:

- Vulnerability indices, such as levels of vulnerability and proxies for vulnerability (see Box 1).

- Institutional capacity scores, calculated, for example, for a committee to effectively identify, prioritize, implement, monitor and evaluate adaptation strategies.
- Extent of the adoption of or level of access to climate-resilient practices.
- Percentage of change in productivity, yields, access to water, etc.
- Number of hectares of ecosystems restored (such as mangrove or forests).[2] percentage of change in land covered by biomass.
- Level of climate change awareness-raising and number of people trained.
- Number of plans developed and/or implemented with climate change being mainstreamed; number of sector-based adaptation action plans.
- Number of technical norms reviewed or revised to accommodate climate change.

Generally indicators and targets were first identified during the project design phase. These were then refined during the baseline assessment in the early stages of the project's implementation and aligned where appropriate with relevant M&E practices at the donor or government level. Since, for reasons of clarity and efficiency, a limited number of indicators was considered preferable, the initial set of indicators was assessed against SMART[3] criteria (C4 Ecosolutions, 2016), along with the following additional criteria:

- Their neutrality (i.e. not indicating a specific direction). For instance, one indicator proposed originally was the 'percentage increase in water availability in all seasons'. This was rephrased as 'percentage of change in water availability in all seasons', so as to make it neutral and not indicating a specific direction (Baastel, 2013).
- The extent to which the indicators allow the monitoring of all the proposed outputs to achieve the outcomes identified. The assessment looked at whether the proposed original indicators covered the different components of an output. For example, one original indicator was 'the timely availability of climate information, including flood early warnings', for an output targeting the dissemination of updated dynamic agricultural calendars and climate early warnings. The proposed indicator therefore failed to describe how updated and dynamic agricultural calendars would be disseminated. This was rephrased as the 'frequency of dissemination of updated dynamic agricultural calendars and climate information including flood early warnings in the three project sites' (Baastel, 2013).
- The extent to which the indicators describe how achievement of the results will be measured, i.e. their accuracy in describing adaptation outcomes. For example, one original indicator was the 'number of resilient rice models developed' for an output targeting the selection and publication of only one Integrated Resilient Rice Model (IRRM). This indicator therefore failed to describe how achieving the output will be measured. This was rephrased as the 'number and type of technical guidelines for IRRM developed and publicized based on the best available technologies and techniques' (Baastel, 2013).
- The extent to which the indicators are measured and monitored easily and cost-effectively, and to what extent data collection is technically feasible. For instance, one original indicator was 'the percentage change in water quality (e.g. reduction in turbidity, pollutant content, microbial content, sediment content)'. This was found to be measurable at a reasonable cost, but collecting data could be quite challenging. It was therefore decided to conduct specific water-quality assessments during the project's lifespan by means of an MoU with the competent sub-national institution (Baastel, 2013).
- The extent to which the indicators are measurable at all project sites (i.e. the availability of field data for all sites). For instance, one original indicator was the 'percentage of land surface covered by forest tree canopy'. Approximate tree coverage value could be assessed in one project site, but proved impossible in another because deforestation was occurring in small plots in the middle of a forest in a very mountainous area, and there was no possibility to obtain an overview of the whole area except through aerial photos. This indicator was therefore rephrased as the 'number of trees planted and surviving' (Baastel, 2010).

[2] For ecosystem services project component and/or ecosystem-based adaptation projects.

[3] SMART stands for:
Specific. The indicator is clear and captures, without ambiguity, the essence of the desired result.
Measurable. The indicator is reliable and provides a clear measure of results. It describes how achieving the result would be measured. Each variable mentioned in the indicator statement should be measurable with reasonable cost and effort, and the indicator should be capable of being disaggregated according to gender.
Attainable. The indicator provides a clear direction of the anticipated change, and a baseline (current) value could be provided for each and every variable in the indicator statement (apart from Yes/No indicators).
Relevant. The indicator captures the essence of the desired result and is formulated to take into account the target groups' needs and expectations.
Time-bound. A target with a specified timeframe can be set for each variable in the indicator statement (apart from Yes/No indicators).

Table 1. **Criteria used to finalize revision of selected indicators**

M&E Framework components	Criteria
Baseline data	Are baseline data available for each indicator?
Indicator targets	Are targets realistic and achievable? Do the targets specify an achievement date?
Data sources and means of verification	Do data sources include the individuals, groups, organizations and/or publications from which performance data can be obtained? Are data sources appropriate to informing the indicators? Are data sources diverse, credible and reliable?
Responsibilities	Does the person in charge of collecting the data for a specific indicator have the capacity to collect, manage, validate and analyse the required data?

- The extent to which the indicators are clear and easily understood by the different actors, avoiding any confusion that may arise during data collection.
- The extent to which the indicators are gender-sensitive and reflective of gender (where appropriate), such as 'Number of people trained (gender disaggregated)'.
- The extent to which the indicators have been disaggregated according to age and social condition (where appropriate).

Once the baseline data had been collected, the final revision of the initial set of indicators was made using the criteria listed in table 1

Table 2 shows some of the outcome and output indicators that were selected for each of the three projects mentioned above.

Most of the indicators developed and now being used in the monitoring and evaluation of adaptation projects in Madagascar were selected *using the Global Environment Facility (GEF) Adaptation Monitoring and Assessment Tool (AMAT) (GEF, 2014)*. This tool is based on the revised results framework of the GEF Adaptation Programming Strategy 2014-2018 (GEF, 2014), which provides a list of the proposed indicators for objectives and outcomes[4] that can be adapted to both national and local project contexts.

3. Successes and challenges in monitoring and evaluating climate change adaptation impacts at the project and national levels

3.1 AF-Rice project

Most of the indicators for the AF-Rice project were measured during the project's mid-term review (MTR), which provided quantitative and qualitative data and showed the progress made towards most of project outputs and outcomes. An assessment was made of the level of achievement of project outcomes and outputs using outcome and output indicators selected during the baseline assessment. The MTR used the Performance Measurement Framework (PMF),[5] also developed during the baseline assessment, to present the results achieved and to summarize progress towards achieving the adaptation outcomes and objectives.

However, some indicators were difficult to measure during the MTR phase due to a lack of data. These included percentage of change in rice yields at all three project sites, changes in erosion rates and percentage change in water quality. Although linked to project activities and influenced by project outputs, these indicators depend on the capacity of stakeholders not necessarily directly involved in project implementation to collect data in the field. For example, the percentage change in water quality for irrigation purposes

[4] Objective 1: reduce the vulnerability of people, livelihoods, physical assets and natural systems to the adverse effects of climate change. Objective 2: strengthen institutional and technical capacities for effective climate change adaptation. Objective 3: integrate climate change adaptation into relevant policies, plans and associated processes.

[5] The Performance Measurement Framework (PMF), which is based on the Project Results Framework, is the key internal management tool to be used to manage the collection, analysis and reporting of the performance data needed to support the monitoring and evaluation functions. It captures key elements of the expected results of a project by outlining the proposed program indicators for each results level, targets, baselines, frequency of data collection, data sources and methods, as well as responsibilities for data collection and consolidation.

Table 2. **Sample of outcome and output indicators selected for the PAZC, AF-Rice and 'Enhancing the adaptation capacities and resilience to climate change in rural communities' projects**

Project	Outcome indicators	Output indicators
PAZC	Institutional capacity score of Regional Integrated Coastal Zone Management (R-ICZM) committees to effectively identify, prioritize, implement, monitor and evaluate adaptation strategies and measures	– Number of climate change vulnerability risk analyses, maps of flood-prone zones and crop models updated for each project region – Number of mandates for R-ICZM committees in targeted coastal regions developed and updated to promote planning for climate change adaptation in ICZM sectors – Number of ICZM strategies developed
	Type and number of infrastructure items strengthened and coastal ecosystems better managed to withstand the effects of climate change, thereby reducing the vulnerability of local communities	– Number of (ha) of degraded mangroves restored – Number of sector-based action plans developed and implemented to improve livelihoods under conditions of climate change at project intervention sites – Length of sea wall (km) constructed or rehabilitated in Manakara to manage the effects of climate change
	Climate change integration score of revised strategies and frameworks, and recommendations developed through the LDCF project for laws using Indicators 12 and 13 of the GEF/LDCF Updated RBM Framework for Adaptation to Climate Change	– Number of government officials trained nationally and regionally in: i) identifying climate risks; ii) identifying best practice options for adapting to these risks; and iii) integrating the adaptation interventions into development planning – Number of people from NGOs and the private sector trained in: i) participating in regional adaptation planning processes; and ii) integrating climate change considerations into their activities – Number and type of regional development plans and strategies updated to integrate climate change adaptation
AF-Rice	Percentage of farmers with access to selected and publicised Integrated Resilient Rice Model (MIRR)	– Number and type of technical guidelines for MIRR developed and publicized based on best available technologies and techniques
	Percentage of change in rice yields at all three project sites	– Number and types of climate-resilient rice varieties tested and selected at each project site – Annual quantity and quality of adapted certified seeds produced and distributed at each project site – Number of farmers who apply updated fertilization guidelines at each project site – Number of farmers trained in integrated pest management at each project site – Percentage of change in water availability to water-users associations in all seasons
	Percentage change in land covered by biomass and in overall productivity (rice, vegetables and livestock) at project sites	– Number of ha reforested at each project site – Number of farmers and land or forest users trained in sustainable agro-forestry and land management at each project site – Percentage change in erosion rate – Percentage change in water quality (e.g. reduction in turbidity, pollutant content, microbial content, sediment content)
	Number and types of technical norms and standards in rice cultivation reviewed and modified nationally to take climate change into account	– Number and types of activities identified and implemented for scaling up and replication from MIRR application in broader Alaotra basin and in other regions – Number and types of recommendations for reform of rice policy made
Project 'Enhancing the adaptation capacities and resilience to climate change in rural communities in Analamanga, Atsinanana, Androy, Anosy and Atsimo Andrefana'	Number of people trained to identify, prioritize, implement, monitor and evaluate adaptation strategies and measures	*Output indicators have not been defined, as the baseline study has not yet been conducted*
	Sub-national plans and processes developed and strengthened to identify, prioritize and integrate adaptation strategies and measures	
	Number of people and geographical areas with access to improved climate information services	
	Population benefitting from the adoption of diversified, climate-resilient livelihood options	
	Type and extent of assets strengthened and/or better managed to withstand the effects of climate change	

should be measured by the Regional Directorate of Water, Sanitation and Hygiene, which is not directly involved in the project management. The same applies to the percentage change in rice yields, which should be monitored by the Regional Directorate of Agriculture and Rural Development. Such data are not collected on a regular basis and are therefore not systematically available for M&E purposes. Monitoring responsibilities should be shared between sectors, ministries, agencies, etc., but in general this is not the case due to weak communication between ministries and weak institutional coordination bodies, among others. Coordination between stakeholders is often challenging, and monitoring lies with the specific project management team.

The MTR (C4 Ecosolutions, 2016) also showed that the scope for measuring some indicators (e.g. the geographical scale for measurement purposes, the number of people in targeted communities) was lacking. The challenge is to define clearly the exact geographical scope of the planned activities and the exact number of beneficiaries, including the direct and indirect beneficiaries, that will be reached. While ideally such issues should be addressed in a project's design or baseline assessment phase, an M&E framework should nonetheless remain flexible and progressive during its implementation to allow for further updates. On-going monitoring is the key to a successful M&E system. However, this requires dedicated human resources and time, as well as a dedicated M&E budget that is sufficient to ensure effective M&E.

3.2 PAZC project

Responsibilities for collecting data in the field and for aggregating them at the project to national levels need to be well defined. This is essential for projects such as PAZC, which is being implemented in four distinct regions and involves a large number of stakeholders, including officials, civil society and other beneficiaries. A specific M&E strategy was developed during the first year of the project's implementation, building on work conducted during its baseline assessment. This was successful for day-to-day monitoring and for defining specific data-collection and data-aggregation responsibilities and frequencies. This M&E strategy allows the project management team, using the periodic monitoring of output and outcome indicators (quarterly or annual), to collect quantitative and qualitative data to report on progress made in achieving the planned project adaptation outputs and outcomes. The project's MTR will be conducted in 2017, its terminal evaluation taking place in 2020; these will provide some insights and lessons learned regarding the indicators to be used to measure progress in achieving its planned adaptation outcomes, for example, reductions in vulnerability and the rehabilitation of coastal protection infrastructure.

PAZC uses 'change in the average climate change vulnerability index proxy for targeted regions' as a high-level metric within its M&E framework to measure progress towards the project's adaptation objectives (Box 1). This proxy index is a composite of seven environmental and socio-economic indicators selected to reflect the sensitivity and adaptive capacity of the targeted communities. This perception-based indicator was chosen because local quantitative data is difficult to collect in Madagascar and not reliable. Ideally, vulnerability indices should be measured first during the project's baseline assessment, then if possible at the MTR stage, and finally at the end of the project. For PAZC, baseline data for the vulnerability proxy index has been collected from the targeted municipalities and the exact approach and methodology to be used to inform this indicator has been described. Scores for the seven indicators were compiled in a single file which also contained a detailed list of informants. However, these data are too recent to enable reflective assessment of how successful they might be at measuring the level of achievement of the planned objectives. Monitoring of the proxy index is likely to be quite complex, costly and time-consuming and would best be conducted by an experienced M&E 'expert'. The baseline assessment was carried out through focus groups involving specific individuals at specific sites. For purposes of comparison, the M&E expert who will conduct the terminal evaluation will need to use the same level of representativeness or use a similar sample in terms of informants, interview protocols, etc. Alternatively a retrospective baseline could also be created using a wider sample, but this would be costly and time-consuming. This would also be reliant on the perception of the assessors; the same individual may not be involved in the baseline assessment, MTR and final evaluation. The weighting of the seven indicators composing the index (see above) and their level of importance in different contexts and sub-groups would also have to be assessed. More perspective is therefore needed in Madagascar to determine exactly how metrics of this type can provide accurate assessments of the levels of adaptation outcomes achieved.

Such vulnerability proxy indices have also been used in similar projects in the Comoros[6] and Guinea Bissau.[7] In the Comoros, the VRA was informed during the baseline assessment, but the MTR was not able to monitor it due to the low number of activities that had been implemented. In Guinea Bissau, the baseline value was not assessed for the VRA, and it was therefore not possible to compare the VRA score at mid-term with that at the project design phase. Proxy indices used in other contexts were therefore difficult to monitor over time and did not provide an assessment of the level of adaptation outcomes achieved as expected.

Several output and outcome indicators have been identified for the institutional and policy aspects, which are the core components of the three projects described in this article. Indicators based on the number and type of policies, strategies and/or plans revised, updated, developed and/or implemented to integrate climate change adaptations are generally effective in measuring the overall commitment to put in place legal and institutional tools to respond to climate change. However, a true assessment of the 'extent' and quality of such mainstreaming will not necessarily be reflected in these indicators. Doing this would require a qualitative and ultimately subjective assessment which goes beyond the seemingly simple quantitative metric of the indicator. Again, indices such as 'institutional capacity score of R-ICZM committees to effectively identify, prioritize, implement, monitor and evaluate adaptation strategies and measures' can provide a sound assessment of capacities built, awareness raised and institutional/policy contexts strengthened. However, as for the vulnerability indices, such metrics are based on a composite of indicators and can be quite complex to monitor and measure. Again, this would best be conducted by an expert using a similar methodology and approach in the baseline assessment.

For ecosystem-based adaptation projects or project components, the indicators used include the percentage changes in land covered by biomass and in forest cover. Although these indicators are useful and could be successful in measuring ecosystem health and/or the services provided by the ecosystems, they can be difficult or costly to monitor using satellite imagery, GPS position mapping, etc.

[6] The indicator used was: 'Degree of vulnerability of men and women living in pilot sites to climate change risks on the availability and quality of water'.

[7] The indicator used was: VRA score at village level, measured at project inception, MTR and terminal evaluation.

4. Conclusions and lessons learned

This article has described the metrics developed for three adaptation projects that are currently being implemented in Madagascar. These include indicators to measure project outcomes and outputs, such as vulnerability indexes, institutional capacity score, level of adoption of resilient practices, change in production assets, level of CC awareness-raising and the number of plans with CC mainstreamed developed and/or implemented.

Adaptation metrics are context- and country-specific; universal 'one-size-fits-all' metrics either do not exist or have to be adapted to the circumstances of each context and country. Measuring, aggregating and comparing climate change adaptation needs and results across activities, countries and sectors is therefore challenging. Program-level indicators, such as those developed in the GEF AMAT, which informed the definition of most of the indicators used in adaptation projects in Madagascar, provide the conditions for this aggregation. Being disaggregated, these indicators become country-and/or context-specific (and thus not necessarily fit for aggregation), such as the indicator measuring the 'institutional capacity score of R-ICZM committees to effectively identify, prioritize, implement, monitor and evaluate adaptation strategies and measures', which was adapted from indicator 10 of the tracking tool provided by the GEF (2014). Simple quantitative indicators are less challenging in measuring and aggregating climate change adaptation results across projects and countries, though their scope is limited, and they cannot reflect all the different dimensions of adaptation projects. Furthermore, experiences in Madagascar show that monitoring some of the indicators can be quite challenging due to methodological, financial, time and institutional constraints, as well as scale definition and data aggregation issues. This is especially the case for qualitative indicators or composite indicators such as vulnerability indices.

At the project level, the key to effective M&E of climate change adaptation is a robust M&E strategy that includes the definition and use of a detailed Performance Measurement Framework (PMF). The PMF is the key internal management tool to be used in managing the collection, analysis and reporting of the performance data needed to support the monitoring and evaluation functions. This should include identifying outcome and output indicators, defining their baselines and targets, specifying data sources and means of verification, determining the frequency of and responsibility for data collection, agreeing on data aggregation protocols (i.e. from the grassroots to the national levels) and reporting frequencies and standards. The M&E strategy should also cover the collection of the relevant baseline data and the methods and approaches to be used. In addition, monitoring responsibilities should be specified and formalized through specific agreements or memorandums of understanding with stakeholder groups.

Further lessons are likely to be learned during the ongoing implementation of Madagascar's adaptation initiatives, especially when the three projects described here have come to an end. In the meantime, it is hoped that the experiences gained to date will be helpful in defining M&E frameworks for adaptation projects elsewhere.

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Setting up a national monitoring system for climate change impacts and adaptation

Abstract

The German Adaptation Strategy (DAS) deals with impacts of climate change on nature and society, outlining preliminary options for adaptation to climate change in 15 action fields. An indicator-based monitoring system has been established to track developments in climate change impacts and the adaptation process on the basis of existing monitoring data in order to provide insights into the past as well as the present situation and to support political decision making. The indicator system comprises 102 indicators. The first indicator-based monitoring report on DAS was published in May 2015 as part of the first progress report on DAS (UBA, 2015). The report will be updated every four years. In addition to the indicator-based monitoring, regular and systematic evaluation of the national adaptation strategy is on the way. It is intended to evaluate adaptation work in Germany on the strategic and operational level as well as the targets achieved. Results are foreseen for 2019. The focus of this article is to explain the political context in which the indicator-based monitoring is established as an instrument to foster the adaptation process and to illustrate how the indicator system and the monitoring report were set up.

1. German strategy for adaptation to climate change (Deutsche Anpassungsstrategie, or DAS)

In December 2008 the German Government adopted the German Adaptation Strategy (DAS) to deal with the impacts of climate change on nature and society, and to outline preliminary options for adaptation to climate change in fifteen action fields. Climate adaptation and climate mitigation are both integral parts of Germany's climate policy. The DAS represents the national framework for a wide-ranging process of adaptation at the social level (Bundesregierung, 2008).

In general, to achieve these strategic objectives, it is considered essential to sensitize the wider public to the impacts of climate change and the need for adaptation. More specifically, there is also a need to improve the knowledge base of all stakeholders in order to develop understanding of the opportunities and risks involved in climate change and to support decision-makers in shaping their adaptation strategies, setting priorities and planning the most appropriate action to be taken. To improve this knowledge and the associated information base, the federal government has developed the following main tools:

- An indicator-based monitoring system has been established to track developments in climate change impacts and the adaptation process on the basis of existing monitoring data in order to provide insights into both past and present situations. The first report was presented in 2015. The impacts of climate change are so wide-ranging that almost no segment of social, political and economic life will remain untouched in the years to come. Therefore, indicators were developed for each of fifteen action fields. The regular updating of the time series will enable monitoring and recording developments across multiple reporting periods. The description of observed changes is to help strengthen awareness among players or agents of the vital need to take climate change into account in all long-term planning processes and to prioritize action for the most obvious problems.

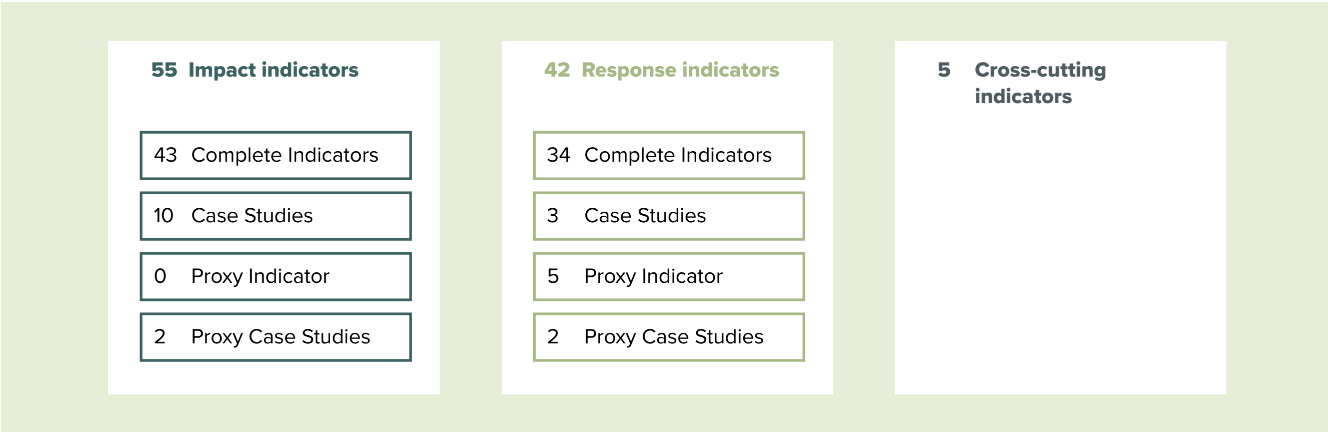
- A cross-sectoral and methodologically consistent vulnerability analysis has been developed by a network of national authorities on the basis of climate projections and socio-economic scenarios (Buth et al., 2015). The vulnerability analysis considers the impacts of climate change in both the near future (the period from 2021 to 2050) and the distant future (the period from 2071 to 2100). It provides information on future developments and seeks to determine which regions are particularly vulnerable to climate change, both geographically and with respect to the type of vulnerability. This helps focus adaptation activity on those regions and sectors which will be the most vulnerable in the future.

- Adaptation Action Plans. In 2011 the first Adaptation Action Plan (APA I) was launched as a step towards translating the DAS targets into specific activities. APA I was developed in dialogue between various federal ministries and closely coordinated with the federal *Länder*, municipalities, scientists and community groups. A second Adaptation Action Plan (APA II) was published together with the DAS Progress Report in 2015.

Both tools, indicator-based monitoring and consistent vulnerability analysis contribute to the Progress Report on the DAS strategy, which will be updated on a regular basis in future. The first progress report was published in 2015 (Bundesregierung, 2015). It also includes a report on the implementation of the first Adaptation Action Plan of 2011 (APA I) and its update (APA II). The progress report states that these tools (vulnerability analysis, indicator-based monitoring and Action Plan) are to be updated on a regular basis. The next progress report, in which the DAS strategy will be evaluated, is to be published in 2020. Future evaluations will look at the policy impacts of implemented adaptation. The indicator-based monitoring reports of 2015 and 2019 will provide, among other things, the basic information required for the planned evaluation, as well as information on the development of climate change impacts and adaptation.

The focus of this article is to explain the scope of the indicator-based monitoring system within the DAS and describe how it was set up. The first indicator-based monitoring report on the DAS was published in May 2015 as part of the first progress report on the DAS (UBA, 2015). The indicators summarize the developments on the national level regarding climate change impacts and the adaptation measures introduced thus far. The first monitoring report provides reference points for subsequent reports which can be used to assess future developments in comparison with the past. The monitoring indicators are each presented on a double page of the DAS monitoring report. The description is phrased in layman's terms, the timelines are interpreted,

Figure 1. Composition of the DAS Indicator Set



background information is supplied, and the potential limitations with regard to the communication value of the indicator are explained.

2. DAS Monitoring System

The development of a monitoring system for DAS was initiated in 2009. In accordance with the mandate provided by the national adaptation strategy, the system was designed as an observation tool for the consequences of and adaptation to climate change in the Strategy's fifteen action fields: 1) Human Health, 2) Construction, 3) Water Regime, Water Management, Coastal and Marine Protection, 4) Soil, 5) Biological Diversity, 6) Agriculture, 7) Woodland and Forestry, 8) Fisheries, 9) Energy Industry (Conversion, Transport and Supply), 10) Financial Services Sector, 11) Transport and Transport Infrastructure, 12) Trade and Industry, 13) Tourism, 14) Spatial, Regional and Physical Development Planning, and 15) Civil Protection.

On the basis of the selected indicators, the role of the monitoring system is to demonstrate the ways in which climate change impacts on the environment and society (based on impact indicators) and the manner in which adaptation will take place in Germany (based on response indicators). One essential prerequisite for indicator-based monitoring is the use of datasets which extend as far as possible into the past and, above all, will continue into the future to make sure that the times series can be regularly updated. However, this means that the monitoring system cannot illustrate all the essential developments because the necessary timelines or data are not always covered or not collected in a way that ensures their availability in the long run.

Currently, the indicator set comprises 102 indicators, 55 of which are impact indicators, 42 response indicators. Five indicators span several action fields ('cross-cutting indicators'); they represent overarching activities carried out on behalf of the federal government and are intended to support the process of adapting to climate change (see Figure 1 and the overview of indicators in table 1 at the end of this document).

The range of the Indicator System is restricted by two major constraints. One objective was to ensure that all DAS action fields were provided with indicators, while, data permitting, the most important climate change consequences and adaptation activities were to be illustrated in the individual action fields, complete with indicators. On the other hand, a clear principle was laid down that the federal monitoring system should not supplant any sectoral or theme-specific reporting systems or reports submitted by the individual *Länder* (states) of the Federal Republic. The number of indicators was limited intentionally in order not to lose the broad thematic overview by introducing too many detailed descriptions.

Of these 102 indicators, fifteen have been designed as so-called 'case studies' owing either to a lack of data sources at the federal level or to the complexity of data processing, which has been possible so far only for single *Länder* (e. g. the calculation of heat-related mortalities). On the basis of specific datasets of limited geographical scope, the case studies demonstrate the kind of statements that could be generated nationally if the necessary data were available. The presentation of a case study presupposes that there is a clear and predictable time perspective for the nationwide availability of data as a basis for generating an indicator that can be regularly updated.

In addition, in the absence of more accurate or appropriate data or information, seven indicators were categorized as so-called proxy indicators, which, in their proposed form, represent a mere approximation to the indicator subject. Proxy indicators need to be developed further by being refined in conceptual and/or methodical terms in order to improve their significance (cf. also EEA[1]). However, a clear perspective for improving data availability or methodology is not an essential requirement. In the Monitoring Report, proxy indicators place greater emphasis on explaining the subject field represented by the indicator, and less on interpreting the content of the indicator values and their development.

The monitoring system was designed so that it could be revised regularly. The reason for this was basically that the wide-ranging field of themes requiring adaptation is still relatively new and therefore highly dynamic regarding the accumulation of new insights and strategies. These new developments may from time to time necessitate the revision of existing indicators or the incorporation of new ones. Besides, there may be improvements in respect of data sources or foundations. It is therefore crucial to check for development potential before carrying out any updating of the indicator-based monitoring report.

The series of data contained in the DAS monitoring system are updated at regular intervals. As of 2015, the Federal Government will publish a DAS monitoring report every four years.

3. Development of the monitoring system: criteria for selection of indicators

The selection of indicators was guided by the following criteria:

- *Thematic focus.* Does the indicator enrich the broad thematic spectrum of the indicator system?
- *Causal relationship with climate change.* Is the indicator closely associated with climate change? Does a particular impact indicator reflect the consequences of climate change, or is it influenced by many other factors? Does a response indicator provide information about adaptation activities?
- *Data availability.* Is the indicator based on existing data? Are these data collected in the same way over time?
- *Transparency of calculation.* Is the indicator generally understandable for the public?

Each of these criteria is discussed in detail below.

3.1 Thematic focus

The wide gamut of themes, combined with the need for a manageable set of indicators, required the setting of theme-specific focal points. In order to limit the effort expended on the development of indicators, these focal points were set quite early in the process, being prioritized in discussions with theme-specific experts in the course of working-group sessions or individual interviews. A starting point in setting the theme-specific focal points was to come up with a kind of thematic framework for each action field which was divided into two levels: thematic fields and subthemes. This structure was made up of (sub-)themes addressed in the DAS strategy or obtained from researching the literature. Thematic fields and subthemes that frequently feature as the subjects of political papers or scientific studies in the context of climate change were prioritized. This prioritization took into account that the broad thematic spectrum of climate change impacts and adaptation activities is represented by the selected thematic fields and subthemes within each action field.

This prioritization of thematic fields and subthemes was adopted methodologically as a binding decision for the following process. This means that the first criterion for an indicator to be discussed further is that it refers to one of these prioritized thematic fields and subthemes. For this reason there was, for example, no discussion about an

[1] EEA Glossary: Proxy data: data used to study a situation, phenomenon or condition for which no direct information – such as instrumental measurements – is available (definition source: Kemp, David D. 1998, The environment dictionary, London: Routledge) http://glossary.eea.europa.eu/terminology/concept_html?term=proxy%20indicator

indicator for skin cancer because the thematic field of health risks due to increasing UV radiation had not been prioritized within the human-health action field.

3.2 Causal relationship with climate change

Based on this pre-selection of thematic fields and subthemes, the causal relationship with climate change and adaptation was again analysed in the context of the indicators. The impacts of climate change on the conditions and developments observed in the environment and society are usually difficult to differentiate from other, non-climate influences (e.g. societal). Therefore observed changes do not always allow immediate interpretation with regard to the consequences of climate change. It was therefore decided to take a pragmatic approach to structuring the monitoring system: the influence of climate change must be assessed as 'relevant', i.e. the observed environmental or social changes are frequently discussed and described in respect of their causal relationship with climate change. It is not essential to provide a tangible quantification of the proportional impact which climate change has to these changes. If, through increasing scientific insight or simply observation of the ongoing development of the data series, it later becomes clear that the impact should be assessed as less important than originally thought, this kind of observation may be incorporated subsequently by adapting the indicator selection accordingly.

3.2.1 Challenges defining indicators for climate change (impact indicators)

It is desirable to have a very close connection between climate change and impact indicators. This can be assumed for indicators such as 'Phenological changes in wild plant species' (BD-I-1), 'Flooding' (WW-I-3) and WW-I-4 'Low water'. With regard to agricultural crops, it was therefore decided not to depict the influence of climate change on the yields of agricultural crop plants in terms of actual yields but with respect to interannual fluctuations in yields (indicator LW-I-2 'Yield fluctuations'). This decision was taken because actual yields depend on numerous non-climate factors, not least the framework conditions derived from grant policies. In contrast, fluctuations in yields from year to year are much more strongly influenced by weather conditions (Gröbmaier, 2012; Zebisch et al. 2005). With respect to the 'Human Health' action field, discussion focused on an indicator for heat-related mortalities. It transpired in the course of this discussion that, methodologically speaking, it is extremely challenging to attribute mortalities directly to heat waves. In this case it was not possible to generate a nationwide indicator. Instead, a case study was developed (Indicator GE-I-2 'Heat-related mortalities') using data from the State of Hesse to exemplify a methodologically pure derivation of heat-related mortalities. This case study might be extended to the Federal Republic as a whole, but this would require further clarification of the methodological aspects, as well as significant additional effort and expenditure.

3.2.2 Challenges defining indicators for adaptation (response indicators)

The pragmatic approach was also adopted in developing the monitoring system in respect to 'Adaptation' (response indicators). So far very few measures have been conceived and implemented explicitly as adaptation measures. This is why the responses have been interpreted quite broadly. A crucial requirement is that, in the judgment of experts in the relevant action fields, the measures or actions support the adaptation to climate change in general, i.e. they must help to reduce vulnerability or contribute to increasing the capacity for adaptation. The original motivation for taking a specific action might therefore have differed from a motivation which prompted an action taken for adaptation to climate change. By the same token, the response indicators do not necessarily refer to the measures listed in the DAS, Action Plans I + II or the 2015 DAS Progress Report because some of the activities undertaken to support adaptation were initiated even before the DAS was adopted.

For example, the heat-warning service of the German Meteorological Service (GMS), whose data underpin the impact indicator 'Heat stress' (GE-I-1), was set up in 2005 as a result of the impact of a heat wave in 2003, i.e. before the DAS was adopted. Likewise, the Pollen Warning Service, also run by the GMS, which provides daily forecasts of the eight most important types of pollen in allergological terms (Indicator GE-R-3 'Information on pollen'), is also independent of the increased problems relating to the rise in pollen burdens as a result of climate change. In view of the altered circumstances, it is nevertheless a suitable instrument for supporting people with pollen allergies. The situation is similar with regard to the two response indicators FW-R-2, 'Financial support for forest conversion', and FW-R-3, 'Conversion of endangered spruce stands', both covered by the action field 'Woodland and Forestry'. The restructuring of non-native spruce monocultures by converting them to more mixed woodlands was already being driven forward in the 1990s. Severe hurricanes, such as Vivian (1990), Wiebke

(1990) and Lothar (1999), caused widespread storm damage, especially in pure spruce stands, thus demonstrating that such stands are too vulnerable. The restructuring of forests is now also under intensive debate and being driven forward as a response to climate change.

3.3 Data availability for indicators

An essential prerequisite for indicator-based monitoring is the use of datasets that extend as far as possible into the past and, above all, will continue into the future. Data on indicators must also be collected frequently enough to be useful to decision-makers. Only pre-existing data sources were used in generating the DAS indicators.

In view of the wide range of fields affected by climate change and the wide range of DAS themes, it goes without saying that the data used in generating the indicators has also been drawn from a multifarious pool of data. In addition to data collected by government agencies, some non-agency data were used as well. For example, the data used for calculating indicator GE-I-3, 'Ragweed-pollen related stress', was generated from measurements taken by the Stiftung Deutscher Polleninformationsdienst e.V., while the data used for generating indicator EW-I-3, 'Reduced power generation due to ambient temperature in thermal power plants', were derived from VGB PowerTech e.V., the European Association for the Generation of Heat and Power. Non-governmental agencies have been willing to provide their data, but may require being paid for them. Opening up and utilizing a great variety of different data sources met with interest from various parties involved. By co-operating over the structure of the system, they were able to enhance their knowledge of existing data surveys.

3.4 Transparency of calculation

The indicator-based monitoring system and the monitoring report have been designed with interested public and politicians in mind, meaning that indicators were preferred that are relatively easy to calculate. The more complex a calculation, the more difficult it is to comprehend and interpret it.

4. Development of the monitoring system: working procedure

4.1 Inter-agency co-operation

In view of the wide range of themes covered by the DAS, it is essential to have inter-agency co-operation in both implementation and monitoring. This type of co-operation was already addressed in the development phase of DAS. Action Plans I and II were also drawn up in co-operation with various competent agencies. It was also considered imperative to structure the monitoring system from the outset of the development work to ensure the consistent and systematic incorporation of the latest theme-specific knowledge held by various agencies. This took place in two stages, first at the technical level, initially in co-operation with the highest technical authorities, and then at the political level, with participation of ministries in approving the indicators. In some cases technical feedback took place with regard to individual indicators through an exchange of communications with ministry representatives (Schönthaler & von Andrian, 2015a). The detailed discussions on the technical level resulted in a good political acceptance of the proposed indicator system. Only minor amendments were required in the course of the process of obtaining political agreement.

A comparable procedure was adopted for drawing up the first monitoring report and its inter-agency co-ordination. In this process, texts were first checked for theme-specific accuracy by competent experts involved in developing each indicator, followed by political approval. All texts explaining the indicator graphs and interpreting the timelines were presented to all the relevant agencies, thus providing opportunities to identify overlaps between different action fields. The approach proved equally successful in the case of the monitoring report because it resulted in an entirely manageable number of requests for text amendments.

In structuring the indicator system and generating the monitoring report, the Federal Environment Agency was supported by an external contractor. The contractor structured the approach to be taken, drew up detailed templates for theme-specific discussion, co-ordinated the submissions of more than four hundred contributors, and documented the interim results and final outcomes (Schönthaler & von Andrian, 2015a). The willingness of both agency and non-agency contributors to co-operate, and their confidence that a high-quality theme-relevant outcome was achievable, were enhanced primarily by the provision of clearly defined templates, such as a thematic structure for prioritization, ideas for indicators, drafts of indicator fact sheets and data fact sheets (see below). Compilation of the final documentation by a very small team (especially the data fact sheets and indicator fact sheets) ensured homogeneity and a high standard of quality.

From the very beginning, all the processes involved in indicator development were geared towards achieving a structure that would be sustainable over many years and that would facilitate regular updating of the monitoring report with inter-agency contributions. Apart from the direct result of these co-operative efforts, i.e. the indicator system and the first monitoring report, another equally important outcome has been the network of experts who bear theme-specific responsibility for individual indicators and also take ownership of any further developments of these indicators in the future. The procedures required and the standards to be maintained in the relevant documentation were laid down in an 'Organisation Manual' (Schönthaler & von Andrian, 2015b).

4.2 Success factors

The factors listed below proved essential in achieving broad agreement on indicators and on the monitoring report:

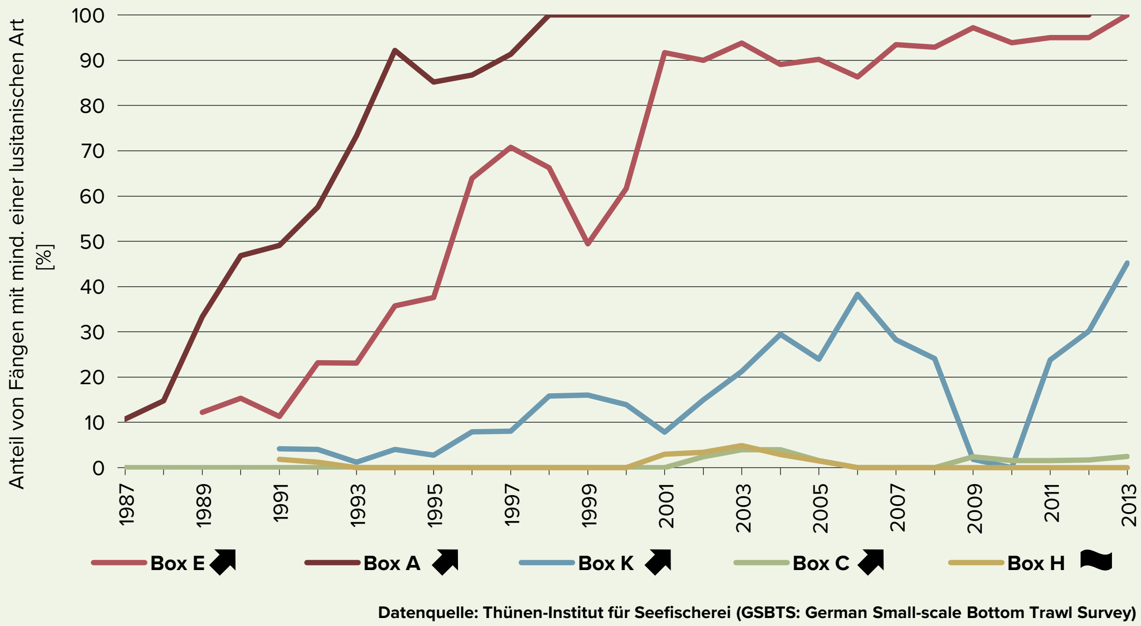
- Any contributions made by institutions and experts in developing the indicators and generating the monitoring report were always clearly identified in the published documents. As a result those concerned also take ownership of the outcomes, which at the same time implies that the same individuals will also take ownership of the further development of the monitoring system.
- The justification for selecting an indicator was always explained in detail, while any weaknesses inherent in the indicator and limitations regarding its interpretability were documented in indicator fact sheets. Any ideas for indicators which were not taken up were documented in so-called background documents incorporating each of the fifteen action fields in order to avoid having to repeat discussions and to record any potential links for developing the system further. This clearly shows the discussions held for each indicator and why one indicator was incorporated in the system whilst another was not. This painstaking process of documentation has been highly conducive to achieving both transparency and acceptance.
- Any data sources, along with any actions required to calculate indicator values, were documented in data fact sheets. The approach described above ensures that the entire process is completely transparent and open to scrutiny, from data collection to the generation of indicator graphics. This also makes updating the timeline considerably easier.
- Only pre-existing data sources were used. It was therefore not necessary to initiate any new surveys for the DAS indicators. The approach of using extant surveys to generate indicators has provided added value and in many cases additional arguments as well for retaining these programs. The approach is therefore also in the interest of institutions which have the remit for data collection.

5. Selected outcomes from the first DAS monitoring report (2015)

The first DAS monitoring report, presented in 2015, provides an overview of the ecological, economic and social consequences of climate change in Germany. It also points out areas in which adaptation is of particular urgency and highlights existing activities and developments in support of adaptation to climate change. It is summarized here to give the reader an impression of the content of a DAS monitoring report.

The monitoring report demonstrates that climate change is already happening in Germany. On the one hand, it is possible to observe continuous changes. Thus annual mean temperatures are rising, and the plant growth period has increased from a mean of 222 days from 1951 to 1980 to 230 days from 1983 to 2012 (see indicator BD-I-1, 'Phenological changes in wild plant species'). The start of flowering by wild plants and agricultural crop plants, monitored as part of the phenological observation network of the German Meteorological Service, has advanced for the whole duration of the growing season. For example, winter rape and apples now flower approximately twenty days earlier than in the 1970s (see indicator LW-I-1, 'Agrophenological phase shifts'). This has both positive and negative effects on agriculture, as although the early development of plants can indeed increase productivity, in, for example, apple cultivation, there is a greater risk of late frosts during the flowering season. The amount of insured hail-storm damage in agriculture has increased (see indicator LW-I-4, 'Hail-storm damage in agriculture'), and in the North Sea, there has been a continuous increase in the distribution of thermophilic species of fish (see indicator FI-I-1, 'Distribution of thermophilic marine species'; see also Figure 2), with consequences for fishery-related industries. There are also signs of problematic developments in water supplies (indicator BO-I-1, 'Soil moisture levels in farmland soil') and in respect of soil erosion (indicator BO-I-2, 'Rainfall erosivity').

Figure 2. Indicator FI-I-1, 'Distribution of thermophilic marine species': increases in Lusitanian fish species in catches from research areas in the North Sea.

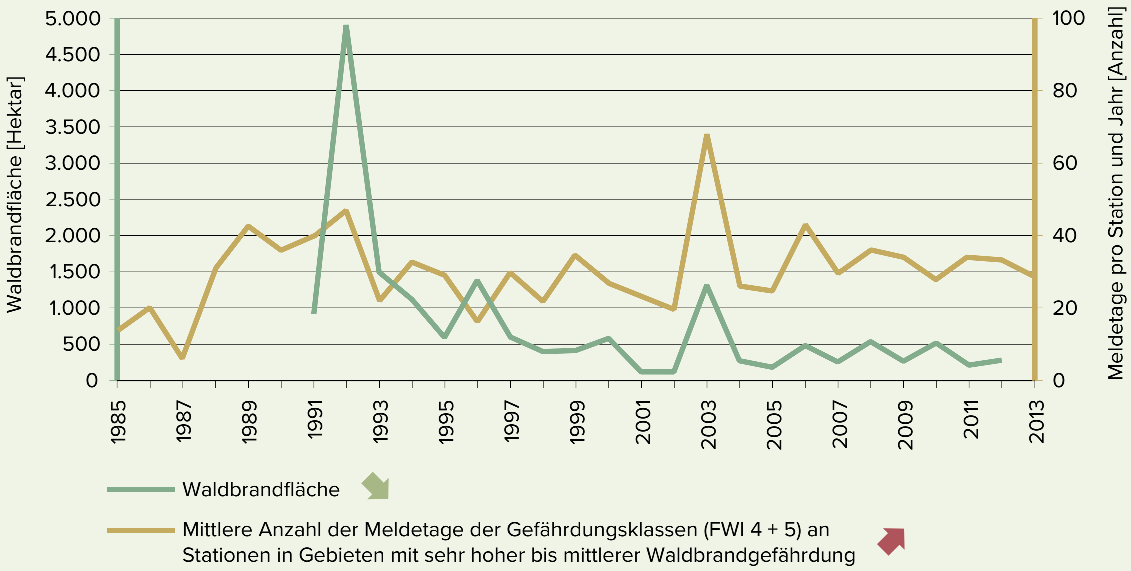


On the other hand, there has also been an increase in the occurrence of extreme weather events. The number of 'hot days' on which the highest measured temperature is 30°C or more has increased significantly (indicator GE-I-1, 'Heat stress'), increasing health risks and 'Heat-related mortalities' (GE-I-2). The rising frequency of storm events has conveyed an impression in forestry circles that periods without relevant impacts on forced harvesting as a result of wind-throw and other storm damage are becoming shorter and shorter (indicator FW-I-4, 'Damaged timber: extent of random use') thus affecting forest management. Such observations suggest that targeted measures should be taken in the areas affected in order to prevent or reduce adverse consequences. The progress made in converting forests to more stable mixed stands (FW-R-1) promises an improvement over the recent situation of forced harvesting.

However, it is surprising that in other areas the impacts of climate change have not yet been reflected in the data series or indicated in trends. The high-water index is calculated on the basis of selected watercourse levels. It is interesting to note that this index, despite listing at least one major high-water event per year (indicator WW-I-3, 'Flooding'), has not shown any significant trend since 1951. The low-water index (indicator WW-I-4, 'Low water') is calculated in a similar way. It is even more notable that this index shows a declining trend. Equally surprising is the decline in the extent of areas affected by forest fires since the 1990s (indicator FW-I-6, 'Forest fire risk and forest fires'; see figure 3) given the significant concurrent increase in (weather-related) forest fire risk. The situation is similar in respect of weather-related disruptions to the power supply (indicator EW-I-1, 'Weather-related disruption of power supply') and the weather-related unavailability of power supply (indicator EW-I-2, 'Weather-related unavailability of power supply)'. Here too no visible trends are evident, although it must be said that the timelines at present available (2006 to 2012) are quite short.

These rather unexpected developments can have a variety of causes. Adaptation measures or activities in support of the adaptation process that have already been introduced are

Figure 3. Indicator FW-I-6 'Forest fire risk and forest fires': increase in the number of days with (weather-related) high and very high risk of forest fire and reduction in forest fire areas



Datenquelle: Bundesanstalt für Landwirtschaft und Ernährung (Waldbrandstatistik der Bundesrepublik Deutschland), DWD (regionalisierter kanadischer FWI)

intended to impede adverse developments. This is why it seems safe to assume that the declining low-water indices are the outcome of a more targeted use of reservoirs and river dams in order to control discharge, as well as the outcome of more efficacious water consumption. As a result, less water is extracted from the water cycle for use by humans. The fact that, despite increasingly hot and dry weather conditions, there are not more instances of large-scale forest fires can be put down to improved forest fire prevention, along with early recognition of forest fires and alerting fire brigades. This seems to be facilitated by the proliferation of mobile phones and their use by visitors to forests. The stability of the power supply is due to the adoption of higher technical standards. As power lines are now increasingly laid underground, the risk of weather-related damage to electricity supply lines is likely to decline further. In fact this development is primarily due to the German public's increasing objections to above-ground power lines, but it is also conducive to adaptation. At the same time, it is conceivable that the specific design of an indicator may conceal actual developments that are in progress or mean that the indicator is unable to reflect them. For example, in respect of the flooding index and the low-water index (indicators WW-I-3 and WW-I-4 respectively), it is conceivable that the frequency or duration of flooding and low-water events occurring in the course of a year is actually increasing in terms of the water-level gauges selected. However, the indicator does not reflect this frequency or duration. In fact, as the indicator is 'initiated' by a single flooding or low water event, it is not able to cast light on this type of development.

In light of the above, it is possible to infer that the adaptation process is already making good progress in respect of the indicator concerned and that the situation, at least at present, seems to be 'under control'. On the other hand, it may also be necessary to develop indicators further if continued observation of the indicator graphics reveals a development which is either implausible or inexplicable, for example, because all projections show increasing risks of flooding, but the respective indicator does not reflect this.

6. Residual gaps in the monitoring system

It has not been possible to work out indicators for all thematic fields and sub-themes. The incorporation of case studies and proxy indicators has facilitated the bridging of some of these gaps, at least temporarily. However, it is essential to continue work on bridging these gaps more constructively.

The main gaps in the monitoring system are induced by:
- missing data in general,
- absence of data on the federal level,
- the great effort needed to focus indicators on the specific consequences of climate change.

The following examples illustrate these limiting factors.

6.1 Missing data

The DAS Monitoring System does not include any indicator on climate change impacts such as heat damage and the undercutting of road and railway infrastructure. Concrete pavement blow-ups in particular are a rather new phenomenon in Germany, because higher temperatures are now combining with the ageing of concrete pavements and sometimes insufficient maintenance. Data are not yet available to inform how many sections of road are affected in Germany.

Heatwaves influence animal health and productivity in animal husbandry, but information on the consequences of increasing temperatures for stables and animal transport is not available. Possibly data could be elicited from slaughterhouses or flaying houses, but the compilation of all this heterogeneous information will not be possible on the federal level.

The action field 'Trade and Industry' is very wide-ranging, consisting of a multitude of industries that may become affected by climate change in very different ways. Adaptation is carried out predominantly at the operational level, which makes it impossible to provide a nationwide overview. From the present-day perspective, it is therefore just as difficult to develop suitable indicators for this action field.

6.2 Absence of data on the federal level

With regard to the themes covered by the 'Water' action field, the problem is that, at the federal level, data are not available in a neatly packaged form. This is due to the fact that the competences, especially those for monitoring water bodies, essentially rest with the individual *Länder* of the Federal Republic. It was therefore not possible to do more than develop examples for individual *Länder* (e.g. the indicators WW-I-5, 'Water temperature of standing water', and WW-I-6, 'Duration of stagnation period in standing water').At the impact level, these case studies do not allow any more than the generation of very limited statements regarding the requirement for action at the federal level.

In respect to other important thematic fields or subthemes, owing to a critical lack of suitable data sources at the federal level, it was not possible to identify any leverage points for indicators. This is the case, for example, regarding the impacts of torrential rain and flash floods in urban areas. An indicator for the frequency and extent of overflowing drainage systems was discussed, but information is only available on the municipal level, which is precisely where this problem has to be managed.

6.3 Great effort needed to focus indicators on the specific consequences of climate change

As far as the 'Human Health' action field is concerned, it is particularly difficult to specify indicators, as human health is influenced by a notably complex set of factors, making the identification (by deduction) of the specific consequences of climate change almost impossible other than by expending considerable effort and resources.

For the 'Financial Services Industry' action field, there are still numerous uncertainties regarding how to assess the consequences of climate change. Consequently, the DAS strategy itself is limited to providing only a few specifications that might provide leverage points for the development of indicators. Lively discussions are thus going on regarding impacts of climate change on the insurance industry that can be illustrated by means of indicators. However, in banking circles, the physical risks relating specifically to climate change are still judged to be largely manageable. Bankers have not yet reached a consensus on how to weight climate-related risks compared to other factors and risks impacting on their business and the requirement for a specific risk management by money lenders and investors. It was hence impossible to identify any leverage points for meaningful indicators.

7. Public perceptions of the monitoring report and its application

Publication of the monitoring report in May 2015 was met with a considerable response from the public. Numerous press reports indicated widespread public interest. The subject was also commented on by associations in towns and communities, chambers of industry and commerce, representatives from agriculture and water-service providers (van Rüth, 2015). Since publication, the federal government has used the report as a basis for information (e.g. in August 2015 on the consequences of climate-change impacts on health[2]). It also replied to several questions in the Bundestag (the lower house of the German parliament), basing its responses on information from the DAS monitoring report (e.g. in February 2016 regarding the consequences of climate change for winter tourism in the German Alps and uplands). The *Bundestag's* scientific service used information for a study entitled *Extreme Wetter- und Naturereignisse in Deutschland in den vergangenen 20 Jahren* (Extreme weather events and natural events in Germany in the last twenty years). Schoolbook publishers are incorporating the results of the monitoring report in scheduled new editions.

Already, a year after its first publication, there are signs that good progress has been made on the path to achieving the goal set by the DAS monitoring report, namely to sensitize the wider public to the impacts of climate change and the need for adaptation. The report is highly regarded for the reliability of the information it contains. Its application and public perception suggest that it will become a respected source of information on the subject among a wide range of people who can make use of it.

8. DAS monitoring: a data resource for evaluating the adaptation strategy

In addition to the indicator-based monitoring, a regular and systematic evaluation of the national adaptation strategy is scheduled for the future. It is intended to document adaptation work in Germany, as well as the targets achieved, thus also maintaining the motivation of the actors and agencies involved.

Evaluation of the DAS will examine the adaptation process at the strategic and operational levels. One aspect of the evaluation is to examine the DAS process itself. The focal points of this process evaluation will be the development of the adaptation process, co-operation among various actors and participation. Another focus is to examine the state of implementation of the measures to be taken as set out in the DAS Action Plans. Another question is whether the principles of the DAS – self-provision and mainstreaming – have been put into action. The evaluation will also assess which short- and medium-term effects have been achieved by the measures set out in Action Plans. Finally, the evaluation will provide insights into the impacts of the DAS process on society, as well as elucidating whether the DAS process contributes in its entirety to strengthening adaptability to climate change and lowering vulnerabilities.

The DAS monitoring system will support this evaluation process (Bundesregierung, 2008) by providing a data and information source on the development of climate change and forms of adaptation. This sort of information is intended to be absorbed, in particular, by those parts of the evaluation that deal with the impacts of the adaptation process on society. The first monitoring report has set points of reference for various thematic areas, thus providing benchmarks against which the future development of climate change impacts can be assessed. This also makes it possible to trace back the efficacy of this political strategy.

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[2] https://www.bundesregierung.de/Content/DE/Artikel/2015/08/2015-08-20-klimawandel-gesundheit.html

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Table 1. List of indicators

No.	Indicator code (I= Impact) (R = Response)	Indicator title	Case study	Proxy
	Action field 'Human health' (GE)			
1	GE-I-1	Heat stress		
2	GE-I-2	Heat-related mortalities	X	X
3	GE-I-3	Ragweed-pollen related stress		
4	GE-I-4	Risks from oak processionary moth infestation		
5	GE-I-5	Pathogen carriers	X	
6	GE-I-6	Contamination by cyanobacteria of bathing waters	X	
7	GE-R-1	Heat-warning system		
8	GE-R-2	Success of heat-warning system	X	
9	GE-R-3	Information on pollen		
	Action field 'Construction' (BAU)			
10	BAU-I-1	Heat stress in urban environments		
11	BAU-I-2	Summer-related heat-island effect	X	
12	BAU-R-1	Recreation areas		X
13	BAU-R-2	Specific energy consumption for space-heating by private households		
14	BAU-R-3	Funding for building and refurbishment adapted to climate change		
	Action field 'Water Regime, Water Management, Coastal and Marine Protection' (WW)			
15	WW-I-1	Quantitative groundwater condition		
16	WW-I-2	Mean discharge		
17	WW-I-3	Flooding		
18	WW-I-4	Low water		
19	WW-I-5	Water temperature of standing waters	X	
20	WW-I-6	Duration of stagnation period in standing waters	X	
21	WW-I-7	Start of spring algal blooms in standing waters	X	

No.	Indicator code (I= Impact) (R = Response)	Indicator title	Case study	Proxy
22	WW-I-8	Marine water temperature		
23	WW-I-9	Sea level		
24	WW-I-10	Intensity of storm surges		
25	WW-R-1	Water-use index		
26	WW-R-2	Structure of water bodies		
27	WW-R-3	Investment in coastal protection		
	Action field 'Soil' (BO)			
28	BO-I-1	Soil moisture levels in farmland soil		
29	BO-I-2	Rainfall erosivity	X	
30	BO-R-1	Humus content of arable land	X	
31	BO-R-2	Permanent grassland		
32	BO-R-3	Organic soil areas		X
	Action field 'Biological Diversity' (BD)			
33	BD-I-1	Phenological changes in wild plant species		
34	BD-I-2	Community temperature index for bird species		
35	BD-I-3	Recovery of natural flooding areas		
36	BD-R-1	Consideration of climate change in landscape programmes and landscape framework plans		
37	BD-R-2	Protected areas		X
	Action field 'Agriculture' (LW)			
38	LW-I-1	Agrophenological phase shifts		
39	LW-I-2	Yield fluctuations		
40	LW-I-3	Quality of harvested products		
41	LW-I-4	Hail-storm damage in agriculture		
42	LW-I-5	Infestation with harmful organisms	X	X
43	LW-R-1	Adaptation of management rhythms		
44	LW-R-2	Cultivation and propagation of thermophlilic arable crops		
45	LW-R-3	Adaptation of the variety spectrum		
46	LW-R-4	Maize varieties by maturity groups		
47	LW-R-5	Use of pesticides		
48	LW-R-6	Agricultural irrigation		
	Action field 'Woodland and Forestry' (FW)			
49	FW-I-1	Tree species composition in designated Forest Nature Reserves	X	
50	FW-I-2	Endangered spruce stands		
51	FW-I-3	Incremental growth in timber		

No.	Indicator code (I= Impact) (R = Response)	Indicator title	Case study	Proxy
52	FW-I-4	Damaged timber: extent of random use		
53	FW-I-5	Extent of timber infested by spruce-bark beetle	X	
54	FW-I-6	Forest fire risk and forest fires		
55	FW-I-7	Forest condition		
56	FW-R-1	Mixed stands		
57	FW-R-2	Financial support for forest conversion		
58	FW-R-3	Conversion of endangered spruce stands		
59	FW-R-4	Conservation of forest genetic resources		
60	FW-R-5	Humus levels in forest soils		
61	FW-R-6	Forestry information on adaptation		X
	Action field ‘Fisheries’ (FI)			
62	FI-I-1	Distribution of thermophilic marine species		
63	FI-I-2	Occurrence of thermophilic species in inland waters	X	
	Action field ‘Energy Industry (Conversion, Transport and Supply)’ (EW)			
64	EW-I-1	Weather-related disruption of power supply		
65	EW-I-2	Weather-related unavailability of power supply		
66	EW-I-3	Reduced power generation due to ambient temperature in thermal power plants		
67	EW-I-4	Potential and actual wind energy yields		
68	EW-R-1	Diversification of electricity generation		
69	EW-R-2	Diversification of end energy consumption for heating and cooling		
70	EW-R-3	Electricity storage options		
71	EW-R-4	Water efficiency of thermal power plants		X
	Action field ‘Financial Services Sector’ (FiW)			
72	FiW-I-1	Claims expenditure and loss ratio in home owners’ comprehensive insurance		
73	FiW-I-2	Claims ratio and combined ratio in home-owners’ comprehensive insurance		
74	FiW-I-3	Incidence of storms and floods		
75	FiW-R-1	Insurance density of extended natural hazard insurance for residential buildings		
	Action field ‘Transport, Transport Infrastructure’ (VE)			
76	VE-I-1	Navigability of inland waterways		
77	VE-I-2	Weather-related road traffic accidents		
	Action field ‘Trade and Industry’ (IG)			
78	IG-I-1	Heat-related loss in performance		
79	IG-R-1	Intensity of water consumption in the manufacturing sector		

No.	Indicator code (I= Impact) (R = Response)	Indicator title	Case study	Proxy
	Action field 'Tourism Industry' (TOU)			
80	TOU-I-1	Coastal bathing temperatures		
81	TOU-I-2	Bed nights in coastal tourist areas		
82	TOU-I-3	Heat stress in spas used for their healthy climate		
83	TOU-I-4	Snow cover for winter sports		
84	TOU-I-5	Bed nights in ski resorts		
85	TOU-I-6	Seasonal bed nights in German tourist areas		
86	TOU-I-7	Holiday destination preferences		
	Cross-sectional theme 'Spatial, Regional and Physical Development Planning' (RO)			
87	RO-R-1	Priority and restricted areas reserved for wildlife and landscape conservation		
88	RO-R-2	Priority and restricted areas for groundwater conservation or the abstraction of drinking water		
89	RO-R-3	Priority and reserved areas for (preventive) flood control		
90	RO-R-4	Priority and reserved areas for special climate functions		
91	RO-R-5	Land used for human settlements and transport infrastructure		
92	RO-R-6	Settlement use in flood-risk areas	X	
	Cross-sectional issue 'Civil Protection' (BS)			
93	BS-I-1	Person hours spent dealing with damage from weather-related incidents		
94	BS-R-1	Information on how to act in a disaster situation		
95	BS-R-2	Precautionary measures for protection of the public		
96	BS-R-3	Training exercises		
97	BS-R-4	Active disaster protection workers		
	Cross-cutting indicators (HUE)			
98	HUE-1	Manageability of climate change impacts		
99	HUE-2	Usage of warning and information services		
100	HUE-3	Federal grants for promoting research projects on climate change impacts and adaptation		
101	HUE-4	Adaptation to climate change at local authority level		
102	HUE-5	International finance for climate adaptation		

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Development of national and sub-national adaptation metrics: Lessons from Kenya

Abstract

Kenya has made progress in developing national and sub-national adaptation metrics since 2011 by designing a national system that can aggregate sub-national adaptation data through the Monitoring, Reporting and Verification (MRV+) system. MRV+ is a component of the National Climate Change Action Plan (NCCAP) developed in 2013. However, this system has not been fully operationalized because the required legal provisions were enacted retrospectively through the Climate Change Act (2016).

This delay in the roll-out of MRV+ provided an opportunity for the refinement and testing of adaptation indicators sub-nationally through a feasibility study conducted in Isiolo County. The study provided lessons that were used to produce a refined set of adaptation indicators for the National Adaptation Plan (NAP) in 2016.

This paper outlines the development of national and sub-national adaptation indicators in Kenya. It also compares sub-national adaptation indicators in Kenya with those in Uganda, Mozambique and Tanzania and finds that, due to the development deficit these countries are experiencing, their adaptation metrics are similar to their respective development metrics.

The development of adaptation metrics both nationally and sub-nationally takes time and involves many different processes and consultations with various stakeholders. The latter's knowledge and skills in climate change adaptation need to be built up first before they can design appropriate adaptation monitoring and evaluation systems.

Countries in the process of developing adaptation metrics nationally sub-nationally levels can gain from the experiences outlined in this paper, such as ensuring that the required policies and laws are in place before a national adaptation monitoring and evaluation (M&E) system is rolled out in order to enhance implementation, to ensure that adaptation indicators are linked to development indicators to promote government ownership and easy data collection and aggregation nationally, and to put in place an adaptation M&E capacity-building programme for government officials who will be using the adaptation M&E system for reporting.

1. Introduction

1.1 Background

Kenya began developing climate change policies in 2010 when its National Climate Change Strategy (NCCS) was launched. This sets out the framework within which climate change should be mainstreamed into the government's sector plans. In 2013, the National Climate Change Action Plan (NCCAP) was launched, its main objective being to operationalize the NCCS with specific costed mitigation and adaptation actions across different government sectors. The monitoring and documentation of progress and the benefits of mainstreaming climate change in the various sectors required the development of a monitoring system. As a result, a National Performance and Benefit Measurement Framework (NPBMF) was drawn up forming part of the National Integrated Monitoring and Evaluation System (NIMES). Its goal is to mainstream climate change data collection into national government data-collection processes.

The NPBMF incorporates the measurement, reporting and verification (MRV) of greenhouse gas (GHG) emissions in respect of mitigation activities and the M&E of adaptation activities. Since the system combines adaptation and mitigation functions, it is referred to as the MRV+ system (see Figure 1).[1] MRV+ will function through a three-stage process of data measurement and the monitoring, verification and reporting of results, as described below:

- **Measurement, monitoring (and evaluation)**. Data and information will be gathered and fed into the system and then quality-assured before being released for evaluation purposes.
- **National verification**. The data will be analysed to produce results that will need to be cross-checked and verified to ensure they form a realistic estimate of the outcomes being monitored.
- **Reporting**: Once the results have been verified, they can then be packaged and used for reporting to both internal and external audiences.

Internally, different government sectors are expected to use this system to report their climate change activities through their performance contracting mechanisms.[2] Externally the government is expected to use its climate change data to report to the United Nations Framework Convention for Climate Change (UNFCCC).

In summary, the system will be used to inform and guide the Kenyan Government in the implementation of concrete climate change response actions (both adaptation and mitigation actions), whether in the form of policies, projects, programmes or business ventures. It will also be used to fulfil Kenya's international reporting obligations to the UNFCCC through its National Communications (NCs) and Biennial Update Reports (BURs), as well as demonstrating Kenya's climate finance readiness and providing a strong platform for attracting international climate finance flows from multilateral and bilateral development partners.

2. Development of the national adaptation M&E system

2.1 MRV+ system adaptation indicators

The design of national adaptation metrics in MRV+ was based on the Tracking Adaptation and Measuring Development (TAMD) concept of Brooks et al. (2013). The TAMD methodology describes the development of indicators that reflect institutional adaptive capacity (measuring top-down climate risk management processes) and vulnerability (measuring bottom-up adaptation/development performance). TAMD therefore focuses on the measurement of adaptation benefits derived from both planned adaptation activities or development activities implemented by development agencies. The TAMD concept was also used to develop national adaptation metrics because it provided a framework that could be used to aggregate data from the sub-national level to the national level.

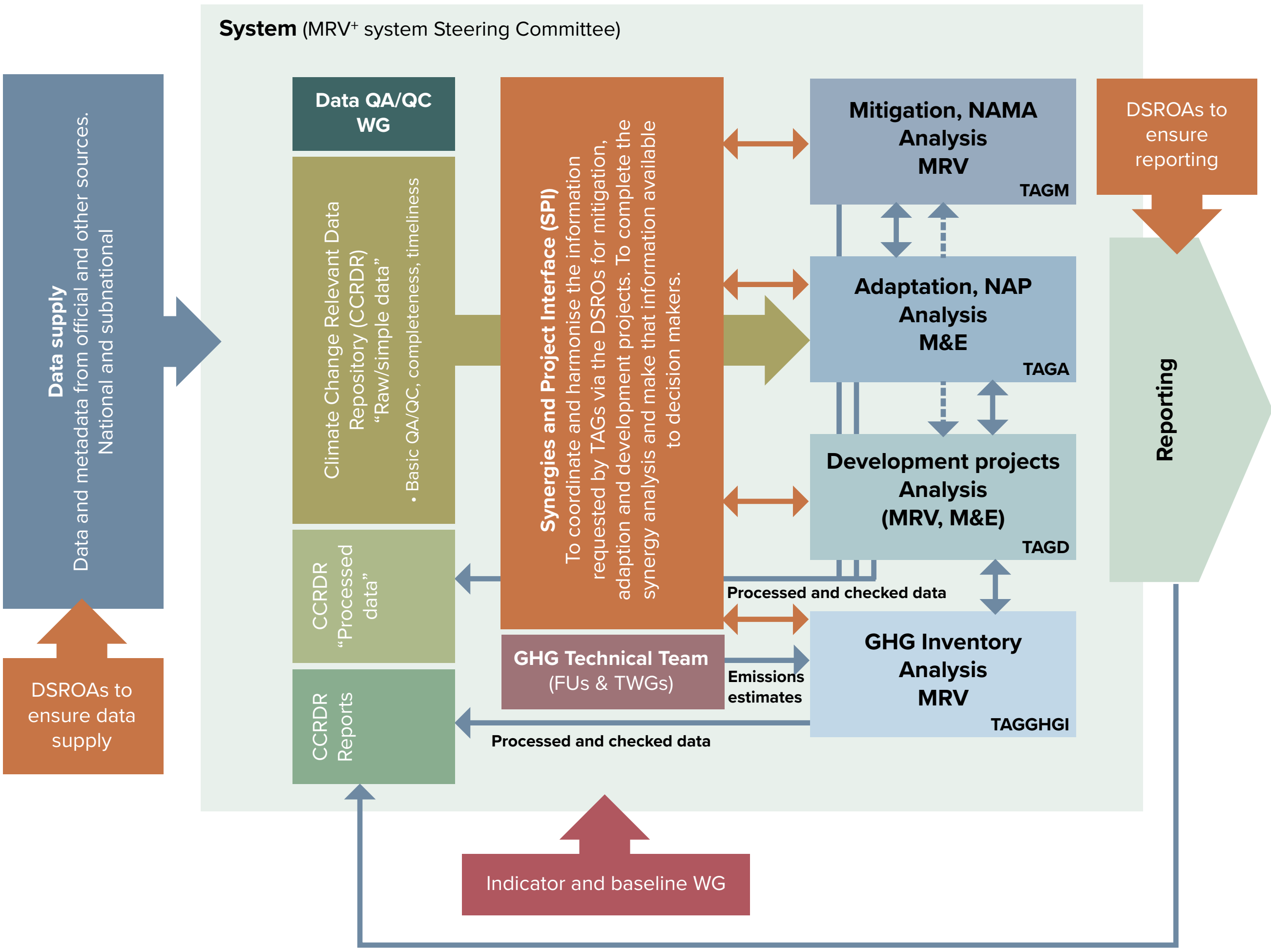
In designing the national adaptation metrics, a participatory approach was used. Therefore, stakeholders across different sectors suggested that other criteria should also be considered to ensure that the MRV+ system is responsive to different users. The additional criteria include the following:

- MRV+ needs to be based on an integrated rather than risk-based approach to adaptation, combining the measurement of both national and county-level indicators.

[1] For a full description of the system, refer to the Kenya National Climate Change Action Plan (2013): http://www.kccap.info/index.php?option=com_phocadownload&view=category&id=40&Itemid=43

[2] The performance contract system is a management tool for measuring performance against negotiated performance targets. It is a freely negotiated performance agreement between the national government and public agencies. Its main objective is to improve efficiency and institutionalize a performance and results-oriented culture in the public service.

Figure 1. NCCAP MRV+ system



The system's core components are: Data Supply and Reporting Obligation Agreements (DSROAs); Climate Change Relevant Data Repository (CCRDR); Indicators and Baselines Working Group; Data and quality assurance/control (QA/QC) Working Group ; Technical Analysis Groups (TAGs) for Adaptation (TAGA), Mitigation (TAGM), Development (TAGD) and GHG inventory (TAGGHGI); Synergies and Project Interface (SPI); Green House Gases (GHG) Technical Team comprising Focal Units (FUs) and Thematic Working Groups (TWGs) for different sectors.

- MRV+ should measure progress towards increasing the resilience to climate change of some of the most vulnerable in society, as well as measuring progress nationally. This should be done by including specific indicators to measure the participation of these vulnerable groups in the planning, design and decision-making of adaptation- or development-related actions at the sub-national and national levels, as well as indicators to measure the adaptation benefits accruing to vulnerable groups from implemented adaptation or development actions.
- In the long-term it should accommodate community-level data in order to facilitate flows of information from communities to national government.
- It should be based on the use of existing frameworks as much as possible, in order to minimize additional demands on the institutions concerned.
- Existing adaptation-related indicators should be used as much as possible to minimize additional monitoring and evaluation workload on institutions.
- It needs to be flexible over time, recognizing that there would be changes to national and sectoral planning documents, changes in scientific knowledge and changes in prioritizing the adaptation actions to be implemented.

During the development of the MRV+ system, the National Adaptation Plan (NAP) had not been completed. Therefore,

Table 1. MRV+ indicators

National-level indicators (process indicators)	County-level indicators (outcome indicators)
1. % of classified roads maintained and rehabilitated 2. Number of people by gender permanently displaced from their homes due to drought, flood or rises in sea level 3. % urban households with access to piped water 4. Cubic meters per capita of water storage 5. % rural households with access to water from a protected source 6. Number of hectares of productive land lost to soil erosion 7. % of land area covered by forest 8. Number of urban slums with physical and social infrastructure installed annually 9. Number households in need of food aid 10. Number of county stakeholder forums held on climate change	1. % of county roads that have been made 'climate resilient' or that are not considered vulnerable 2. % of people by gender in the county permanently displaced from their homes as a result of flood, drought or rises in sea level 3. % of water demand that is supplied in the county 4. % of poor people by gender in drought-prone areas of the county with access to reliable and safe water supplies 5. % of total livestock numbers killed by drought in the county 6. % of area of natural terrestrial ecosystems in the county that have been disturbed or damaged 7. % of poor farmers and fishermen in the county with access to credit facilities or grants 8. % of population by gender in areas subject to flooding and/or drought in the county who have access to climate information on rainfall forecasts 9. Number of ministries at county level that have received training for relevant staff on the costs and benefits of adaptation, including valuation of ecosystem services 10. % of new hydroelectric projects in the county that have been designed to cope with climate change risk

adaptation indicators were formulated using national and sectoral indicators identified in planning documents. In total, 62 national-level process-based indicators were identified from planning documents. A total of 28 county-level, outcome-based indicators were also identified. Process-based indicators seek to monitor key stages that lead to choices about end points or outcomes and that should inform and justify decisions. Outcome-based indicators seek to monitor explicit end points or outcomes and should focus on the long-term effectiveness of decisions. As the list was still extensive, stakeholders decided to prioritise ten national-level and ten county-level indicators using the following criteria:

- *The measurability of the indicator*. Those indicators that could be measured using few data sets and for which data are or could be easily accessible were favoured over those that did not have these characteristics.
- *The scope for cross-sectoral benefits from the adaptation actions underpinning the indicator*. For example, a climate-resilient road network was considered particularly important because of its importance to the economy in general, as well as the movement of agricultural produce to market and tourism in particular.
- *The number of process indicators covered*. Indicators that could be used to reflect progress with a large number of the national (process) indicators that underpinned them were favoured.
- *The number of Kenyans that could potentially benefit from adaptation actions underpinning the indicator*. Indicators measuring progress with institutional adaptive capacity that has the potential to benefit large numbers of people were favoured.

The final set of indicators proposed in MRV+ is shown in Table 1. However, these were further refined in the NAP (2016) as shown in Table 2, as stronger links were needed between the national and county indicators for ease of data aggregation.

2.2 National Adaptation Plan Indicators

MRV+ development was completed in 2013, that is, before the completion of the NAP in 2016. During the latter process, collection of adaptation data based on the MRV+ indicators in Table 1 had not yet been operationalized due to the lack of an enabling policy or law at the time. Therefore, this delay provided a window to refine further the initial indicators proposed in MRV+ with lessons generated from a feasibility study that tested the TAMD framework at the sub-national level of Isiolo County.

The feasibility study, implemented from 2013-2015, provided clearer insights into how sub-national governments would

Table 2. NAP indicators

National	Sector	County
• Human development index (HDI) • Percentage of climate-related national loss and damage in the public and private sectors • Population living below the poverty line • National vulnerability index	• Number of sectors planning, budgeting and implementing climate change adaptation actions • National and county performance contracting systems integrating climate change adaptation targets. • Amount of loss and damage from climate hazards per sector • Amount of private-sector financing for adaptation	• Number of counties that have integrated climate change adaptation into their County Integrated Development Plans (CIDPs) • Number of counties budgeting and implementing adaptation programmes • Number of national and county-level programmes/projects incorporating Ecosystem Based Adaptation and Community Based Adaptation approaches • Number of households with timely access to climate information • Number of infrastructure development cases and applications using climate-smart designs (energy, information, communication, technology, transport) • Number of people reached through climate change adaptation public awareness campaigns • Number of public servants trained in climate change adaptation • Number of functional climate change coordination structures • Percentage of population requiring humanitarian assistance

want to measure adaptation benefits. For example, sub-national governments were interested in using indicators that could measure progress in the implementation of climate change policies, strategies, institutional strengthening, public awareness and finance, amongst other things. In addition, the study also found that the adaptation indicators developed by sub-national governments were similar to the development indicators in their planning documents because the feasibility study area is located in a semi-arid zone which is prone to frequent episodes of drought. As a result, the development agenda of the sub-national government is mostly tied to increasing communities' resilience to drought, making the metrics of development similar to the metrics of adaptation. Further details of the study are provided in Section 3.

The study also improved knowledge about community perspectives on resilience and the type of adaptation metrics that would be beneficial to them, as the study was carried out in five communities in the same county, whose main climate hazard is drought. In these communities, the main livelihood strategy is pastoralism, where households own a mixture of cattle, goats and sheep for both food and trade. Therefore, the adaptation indicators preferred by these communities included measures of the availability of pasture, water, milk, meat and cheese, among other things, as shown in Table 3. Other results of the study and lessons learned have been documented in various publications.[3] A comparison of the indicators developed in this study with similar ongoing work in pastoralist communities in northern Tanzania show that pastoralists tend to develop similar indicators, as they are based on similar livelihood strategies.[4]

Therefore, the NAP indicators drawn up in 2016 considered how adaptation metrics developed sub-nationally could be aggregated nationally through similar parameters that considered different contexts in the 47 counties. This was a different approach to the initial MRV+ indicators, which were specifically for measuring targeted interventions at the national and county (sub-national) levels, and the NAP indicators presented in Table 2 replaced the earlier ones proposed in MRV+.

The development of NAP indicators by the Kenyan government was based on measuring the realization of Kenya's Vision 2030 through enhanced resilience across all sectors affecting all of its four pillars; foundations for national transformation, economic, social and political. In addition, the adaptation indicators were designed to assist in:[5]

3 See Karani etal. 2014, 2015 and 2017.
4 LTS 2017, District Adaptation Planning Committee (DAPC) and Divisional Adaptation Planning Committee (DvAPC) Tracking Adaptation and Measuring Development (TAMD) Trainings Report in Tanzania.
5 See Kenya National Adaptation Plan (2015-2030).

- Attracting international climate finance
- Evaluating adaptation policy, programme and project interventions (i.e. the intended objectives and outcomes of the adaptation activities)
- Informing future adaptation policy development
- Mainstreaming adaptation in development through links with related indicators
- Comparing adaptation achievements across sectors, regions and counties
- Communicating progress with adaptation to stakeholders and the general public
- Informing political climate change negotiations in the international arena
- Targeting, justifying and monitoring adaptation funding and programmes.

In order to aggregate data at the national level from the indicators in Table 2, a theory of change was developed depicting the desired adaptation changes in the four Vision 2030 pillars in order to achieve a climate-resilient economy. The theory of change captured county-, sector- and community-level adaptation benefits capable of aggregation nationally.[6]

Data resulting from activities under the national transformation and economic pillars will be aggregated through the performance-contracting mechanism, which is active at both county and national levels. This mechanism is agreed between the coordinating government institution and the government agency with specific performance indicators whose data are aggregated annually. Therefore, the system is expected to include the measurement of some adaptation indicators, depending on the institution's mandate.

Activities under the social pillar and political pillars are expected to mainstream climate change into county-integrated development plans, ultimately leading to climate-resilient county development. Therefore, data on the number of counties that are managing to mainstream climate change into their planning, budgeting and implementation processes across sectors will be aggregated nationally through the Ministry of Devolution and Planning.

However, it should also be noted that specific methodologies to measure the NAP indicators in Table 2 have yet to be developed. This is because the Climate Change Directorate (Ministry of Environment and Natural Resources), whose mandate includes the coordination of all climate change activities in the country, has yet to be provided with full capacity, as it only became a legal institution in mid-2016.

Nevertheless, for some indicators, such as measuring private-sector financing, the government is in the process of integrating a climate change budget code into the Integrated Financial Management Information System (IFMIS). This system will be used to track all climate finance being used in implementing climate change-related actions by both the public and private sectors (Republic of Kenya, 2016).

To measure loss and damage, the government usually conducts post-disaster needs assessments coordinated by the National Treasury. For example, the last post-disaster needs assessment was conducted after the last drought episode in 2008-2011.[7] The aim of the assessment was to develop a quantitative estimate of the impact of the drought on the socio-economic development of the country and to provide recommendations for the immediate recovery and long-term resilience-building of the country. It also introduced a methodology that could readily be used for the next assessment.

Two main methodologies were used in the assessment: the loss and needs assessment (DaLA) methodology developed by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC), as updated and expanded by the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR); and the Human Recovery Needs Assessment (HRNA) methodology developed by the United Nations (Republic of Kenya, 2012).

To measure the integration of climate change adaptation targets, the performance-contracting system is already in place, and the Climate Change Act (2016) provides a framework for integrating climate change targets into various sectoral policies and plans.

The National Vulnerability Index is expected to be a combination of climate indices (exposure), socio-economic data (adaptive capacity) and impact data (sensitivity). It builds on a study conducted by Mwangi and Mutua (2015) which developed vulnerability indices for Kenya using the International Panel for Climate Change (IPCC) methodology.

[6] Ibid.

[7] http://www.alnap.org/pool/files/kenya-pdna-final.pdf

The vulnerability indices were calculated using algebraic equations, and the Map algebra method was used to build a vulnerability model for spatial analysis. Exposure levels were deduced from temperature and rainfall trends, adaptive capacity was calculated from poverty and literacy levels, and impacts were calculated from bio-physical data on land use and agro-climatic zones.

Once the rolling out of the NAP is underway, gaps in data and methodology are expected to be identified by the Adaptation Technical Analysis Groups under the MRV+ system. The NAP has therefore provided for its revision in line with the revision of the government's medium-term plan every five years to ensure that the national adaptation indicators remain relevant to the context.

3. Feasibility study of adaptation m&e indicators at the sub-national level

The testing of adaptation indicators sub-nationally and the refining of the national adaptation indicators were key priority actions of the NCCAP (2013). Action 7 under MRV+[8] aimed to demonstrate the value of M&E and to assist with the rolling out of MRV+ across the relevant counties.

The UK Department of International Development (DFID-UK), through the International Institute of Environment and Development (IIED), provided funding for the feasibility study that was conducted in Isiolo County. Isiolo was also the first county to receive monies from DFID for the implementation of community-level adaptation interventions through a County Climate Change Fund (CCCF.)

The objectives of the study were:

- To demonstrate the application of adaptation M&E within the county, in order to facilitate roll-out across other counties
- To select suitable county-level (process) indicators in order to measure performance against agreed adaptation actions
- To agree on roles and responsibilities with respect to the collection of monitoring data against climate change adaptation indicators
- To identify relevant internal and external data sets for indicator measurement and to review data quality
- To collect baseline data and measure baseline values for all relevant process and outcome adaptation indicators
- To provide adaptation M&E training to county government staff.

Outputs included:

- An operational adaptation M&E framework for the target county
- Enhanced M&E capabilities
- A model for roll-out across other counties using lessons learnt.

The Tracking Adaptation and Measuring Development (TAMD) framework developed by Brooks et al. (2013) was used to develop the county-level adaptation indicators. Prior to the development of the indicators, resilience assessments had already been undertaken and adaptation actions prioritized by five communities, targeted by the CCCF. The adaptation indicators were also designed using a participatory approach involving the county government and communities. This is because perceptions of adaptation and/or resilience are usually subjective (Jones & Tanner, 2015). However, the authors also emphasise that subjective measurements of adaptation should be combined with objective measurements in order to produce realistic results. Therefore, there was a need to understand the perceptions of the county government and communities so that these could be translated into adaptation indicators and be incorporated into a robust adaptation M&E system.

According to Brooks et al. (2013), adaptation can be measured using four types of indicator: climate risk management (CRM) indicators, resilience indicators, well-being indicators and climate hazard indicators. In the feasibility study, CRM, resilience and well-being indicators were developed using participatory approaches due to the context of the study area. These indicators are explained in detail in sections 3.1, 3.2 and 3.3. In section 3.4 they are contrasted with indicators from Uganda, Mozambique and a pastoralist community in northern Tanzania.

3.1 Climate Risk Management indicators

The TAMD framework proposes CRM indicators for use by governments. These indicators measure risk management processes implemented by governments at different levels in order to create an enabling environment for adaptation and resilience-building by communities. The indicators proposed

[8] See NCCAP (2013), p. 224.

Table 3. Example of a CRM measurement tool.

NAME OF SUB-NATIONAL GOVERNMENT		No	Partial	Yes	Supporting evidence or narrative
Indicator	**Question**				
Institutional knowledge or capacity	Does planning involve individuals with some awareness of climate change?				
	Does planning involve individuals with formal training in climate change issues?				
	Is the integration of climate change into planning overseen by individuals with in-depth knowledge of integration and mainstreaming processes?				
	Are enough people with the required training involved in planning processes?				
Use of climate information	Does planning take account of observational data relating to climate trends and variability?				
	Does planning take account of climate forecasts, projections and information on responses, and is it readily accessible via information-sharing platforms or networks (e.g. for screening)?				
	Is sufficient access to climate information being provided by foreign and international organizations (e.g. IPCC, research bodies, academic institutions)?				
	Is the use of scientific information from external sources complemented by the use of domestically generated information including local, traditional and/or indigenous knowledge?				
	Does the capacity to interpret and use climate information (e.g. in scenario-planning, risk frameworks, vulnerability assessments) exist?				
	Are those with the responsibility and capacity to obtain and interpret climate information (risk frameworks, observational data, TMA forecasts) integrating the information with planning processes?				
	Are traditional and/or indigenous forecasting groups functional?				

by Brooks were reviewed by the Isiolo County Government officers and adapted as necessary. They include:

a. Extent of climate change planning in the county's development plan and sectoral plans
b. Amount of budget allocated to addressing climate change out of the overall county budget
c. The extent to which the county plans consider future uncertainties
d. The extent of institutional coordination
e. The level of climate knowledge in county institutions
f. The extent to which climate information is used in decision-making
g. The level of awareness of climate change issues among the county's residents
h. The level of participation by vulnerable groups such as the poor, women, the young and the disabled, among others, in county decision-making.

These indicators were then measured using a tool that comprised a checklist of questions administered to county government officials. This tool was used to collect baseline information and to monitor information during the study period. For example, the questions used to measure indicators (e) and (f) are listed in Table 3.[9]

[9] Refer to Brooks et al. (2013) for the full checklist of questions.

Table 4. Resilience and well-being indicators at the community level in Isiolo

Results	Indicators
Output level	• Number of constructed and rehabilitated water sources for livestock and humans • Number of trainings held for natural resource management committees • Number of veterinary laboratories rehabilitated
Outcome level (resilience)	• Quantity of livestock and number of households with access to water during the dry season • Number of months that water is available from the constructed or rehabilitated water points • Time spent trekking livestock to water points • Prevalence of livestock and human disease outbreaks per year • Number of hours spent fetching water at water point(s) for domestic and livestock use • Quantities of milk and meat produced per household per year
Impacts (well-being)	• Household expenditure patterns • Quantities of surplus food sold in the markets • Frequency of marriages and other cultural ceremonies held per year • Number of incidents of conflict • Number of families migrating due to climate hazards • Number of children born annually (more children means enhanced adaptive capacity for pastoralists) • Numbers of social buildings (schools, dispensaries, mosques, permanent settlements) constructed • Number of children enrolled and retained in schools • Presence of cheese in the market • Number of families on food relief • Quantity of livestock per household • Number of new businesses or small-scale traders in the market

3.2 Resilience indicators

The resilience indicators were developed using participatory approaches in five communities in focus-group discussions that took gender balance into account. Each community developed a theory of change and proposed indicators mostly related to their main livelihood strategy, namely pastoralism, which mainly involves livestock-keeping and nomadism and formed the outcome-level indicators listed in Table 4.

3.3 Well-being indicators

Well-being, according to the communities involved in the study, was mainly defined as having access to social services such as health and education, the holding of cultural or family activities that would normally not occur during a stress period, e.g. drought and famine, or the production of animal products for sale that would otherwise not be produced during a stress period. These indicators formed the impact indicators in Table 4.

A look at the indicators in Table 4 shows that they are not distinctly different from development indicators. According to Brooks et al. (2013), measuring well-being over time can be done using development indicators as long as the development indicators are normalized with climate data. The authors state that 'use of standard development indicators must therefore be complemented by considering how exposure to climate stresses or hazards might be changing, and whether changes in this exposure have played a role in poorer than-expected development performance'. This can be done by normalizing development data with climate data and supplementing the evidence with a qualitative analysis.

After the introduction of the CRM and of resilience and well-being indicators, baseline data were collected, followed by the monitoring of adaptation interventions in order to collect evidence of adaptation progress through an M&E plan. It was not possible to normalize the well-being indicators with climate data due to limited capacity in the county to do so in 2015. However, after the study, the Adaptation Consortium (a project under the National Drought Management Authority) designed a climate information services plan that was to be implemented by the Isiolo County Government in which observational networks would be strengthened in order to collect more reliable climate data. This would be analysed and disseminated systematically to communities and other stakeholders[10] in order to assist communities in making informed decisions on their livelihood strategies when faced with climate-related hazards and to assist in improving the design of adaptation interventions.

[10] http://www.adaconsortium.org/images/publications/CIS-Final-Circulation.pdf

Table 5. County-level adaptation indicators*

Results	Indicators
County Level Output	• Types and number of information and communication products • Percentage of population reached by climate information • Disaster Risk Reduction (DRR) department established and operationalized • Disaster policy document produced • Number of natural resource management (NRM) committees established • Number of NRM meetings held
Local/Ward Level Outcome (resilience)	• Operational county contingency and DRR fund • Number of projects targeting infrastructure and services on transport, health, water and sanitation, security, education, food security and income generation • Number of climate-change projects financed through budget allocation • Quantity of livestock with access to water and pastures during the dry season • Number of households with access to water during the dry season

*Karani et al. (2014).

With respect to the aggregation of data at county level, the county officers developed a county-level theory of change which combined the different theories of change of different communities. Indicators were then developed for the county-level theory of change in order to capture the main measures of resilience as perceived by the county government and communities. They developed criteria that could be used to collect and aggregate data, such as the ease of collecting information and existing development indicators that could be used to report adaptation benefits and whose data collection was done routinely.

Data on well-being were to be aggregated from adaptation interventions as measured through development performance indicators captured by the impact indicators shown in Table 4. Table 5 shows some of the county indicators developed for the output and outcome levels.

Three resilience indicators were to be aggregated with community-level data at the county level:

- Number of projects targeting infrastructure and services on transport, health, water and sanitation, security, education, food security and income generation
- Quantity of livestock with access to water and pasture during the dry season
- Number of households with access to water during the dry season.

These three indicators were seen as the most important measures of resilience by the county government and communities due to the prevalence of pastoralism in the county.

3.4 Experiences of other countries

The drawing up of resilience and well-being indicators using the TAMD framework also occurred in two other counties in Kenya (Kitui and Makueni) and in three other African countries, Uganda, Tanzania and Mozambique. Similar results were found of the measurement of adaptation benefits being similar to the measurement of development indicators when developed by communities and local governments. This may have been because the challenges and the development deficit faced by developing countries with regard to the provision of basic services, i.e. food, water, health, education and infrastructure are similar. Therefore, communities viewed adaptation from the perspective of development action first (see Table 6).

4. Lessons learned

During the development of Kenya's MRV+ and its feasibility study of adaptation M&E at the county level, a few lessons were learned, as outlined below:

- Availability of data sources at the sub-national level is an important criterion when choosing adaptation indicators nationally. Thus, using or modifying adaptation-related indicators from existing plans and strategies was the preferred approach, as mechanisms for data collection already exist within the national or sub-national governments and various sectors (Republic of Kenya, 2013).
- Participatory methodologies can be used to develop adaptation indicators with sub-national governments. This not only builds up their capacity in adaptation and

Table 6. **Resilience and well-being indicators from districts in Mozambique, Uganda and Tanzania**

Local government/country	Result level	Adaptation indicators
Guija (Mozambique)	Output	• Amount of water available per person per household • Number of households adopting climate change coping strategies due to drought risk • Number of households affected by floods
	Outcome (resilience)	• Number of cases of disease per year • Quantity and availability of crops produced locally for the market (according to the Agricultural Marketing Information System for crops) • Number of investors in the district • Number of households affected by floods and drought per event • Hours taken to fetch water
	Impact (well-being)	• % crop yield increase • % unemployment rate • % literacy rate • % disease occurrence • % water supply coverage • % increase in improved housing
Bulambuli (Uganda)	Output	• Number of households trained in the different skills required to cope with climate change • Number of patients reported with climate change-related diseases per year • Number of homes with granaries • Number of households engaged in alternative income-generating activities as compared to their main livelihood strategies
	Outcome (resilience)	• Quantity of crop yield per household per season • % increase in school-going children
	Impact (well-being)	• % reduction in child mortality rates • % household income from agricultural sales
Ngorongoro (Tanzania)	Output	• Number of district staff trained in climate change • Number of community members trained in climate change • Number of community planning systems in councils' standing committees identified, recognized and approved • Amount of special or discretionary funds for contingency planning for climate change hazards available
	Outcome (resilience)	• Number of climate change activities mainstreamed into district plans • Number of climate change activities mainstreamed into community activities • Number of decisions and actions made based on climate information • Number of community plans integrated into planning and budgeting processes • Number of community plans implemented in collaboration with district
	Impact (well-being)	• Number of community members able to afford social services • Quantity of livestock per household • Quantity of livestock that recover after a drought period

M&E, it also enhances ownership of the indicators as they are contextualized (Karani & Kariuki, 2017).

- It is important to develop costed adaptation M&E plans with sub-national governments that M&E officers can use to collect information on adaptation indicators systematically, as without additional funding allocations, data will not be collected. One advantage of this is the savings associated with climate losses in the medium to long term (Barrett, 2014).
- In developing countries adaptation action benefits are viewed in the same light as development benefits due to the development deficits. Therefore, adaptation at the sub-national level can be measured along with resilience and well-being or development indicators, as proposed

by Brook et al. (2013). The feasibility study implemented in Isiolo County and in the other countries showed that, irrespective of the method used to develop the indicators, all targeted groups identified the measurement of development indicators as a way of proving resilience in the long term (Artur, Karani, Gomes, Malo, & Anlaué, 2015; Karani, Kariuki, & Osman, 2014; Kajumba, Karani, & Fisher, 2016; LTS, 2015).

- Conducting a feasibility study of adaptation metrics sub-nationally can assist in fine-tuning the design of national-level adaptation metrics.
- Anchoring the adaptation metric system to a country's development vision and agenda enhances ownership of the system by its government.

5. Next steps

- In Kenya, the full operationalization of MRV+ has become required since the enactment of the Climate Change Act (2016) and completion of the Climate Change Policy. Various MRV+ elements have been tested, but a review of the testing results and possibly a redesign of the system should be considered so that it can be easily assimilated into the M&E systems of national and county governments.
- A sub-national adaptation system was tested with success in one county. This approach needs to be replicated in the other 46 counties, so that adaptation data and information are collected and aggregated against the national NAP indicators.
- The M&E capacities of various national and sub-national governments and sectors in indicator development, data collection, analysis and aggregation require to be built up, as they are still limited (Republic of Kenya, 2013). Furthermore, very limited funding is allocated to M&E sub-nationally, thus limiting the collection of monitoring and evaluation data. Barrett (2014) found that district M&E officers were allocated £350 per year for M&E. This allocation needs to increase if governments are to prove adaptation through robust measurements at the sub-national level.
- The National Drought Management Authority has embarked on developing an aggregation framework linking community adaptation data from the sub-national to national levels through the pilot study in Isiolo County. However, this is still work in progress and has yet to be subjected to stakeholder views and approval. Once this has been finalized, the framework will need to be tested, refined and implemented.

6. Global perspectives

Countries developing national adaptation M&E systems will need to take the following into consideration, in addition to the lessons learned as outlined in the previous section:

- Establish appropriate policies and legislation before the development of the adaptation M&E system to ensure that, after the design phase, it is rolled out in the shortest time possible.
- Build on existing national M&E functions. Do not create a parallel system of climate change M&E, as it is highly probable that resilience and well-being indicators will be similar to the development indicators that are already being measured, especially in developing countries. This will avoid duplication of data collection and aggregation processes.
- Allocate sufficient funds for investing in climate change M&E and the collection of localized climate data. Adaptation can be verified by comparing development outcomes and climate trends (Brooks et al., 2013). Therefore, without climate trend data, it will be difficult to normalize adaptation indicators, and it may not be possible to distinguish between development and adaptation benefits.
- Adaptation metrics should be developed during the planning and design stages of adaptation programmes and projects. This ex-ante M&E approach fits within the development evaluation approach described by Patton (2010) and the World Bank. This is because, despite the upfront investment costs, this method can be cost-effective in the long term because it allows for the adjustment and refinement of programmes before their implementation, and programmes are likely to be better targeted as a result (Karani, Mayhew, & Anderson, 2015). If this is done, adaptation data can be collected systematically throughout the period of the programme or project. The data can then be fed into the national aggregation system continuously to avoid data gaps and ensure timely analysis for purposes of informed decision-making by policy- and decision-makers.
- Adaptation metrics should always be reviewed and refined over time, as contexts are bound to change, and indicators should always be relevant.

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Measuring Adaptation Benefits: Technology Needs Assessments and their linkages to funding requirements

Abstract

With the 2015 Paris Agreement on climate change, countries have prepared their first Nationally Determined Contributions outlining the actions they are proposing to meet their climate targets. Most developing countries' Nationally Determined Contributions include technology-related components, and nearly all developing countries request support for technology transfer in order to meet their targets. To measure progress towards reaching each countries' targets and hence the ambition of the Paris Agreement, measurement and evaluation of the collective efforts of countries' will be carried out on a continuous basis through global stocktakes. As a result, the ability to measure and quantify the impacts of technologies for adaptation in the future will be even more pertinent. This paper analyses how countries currently measure the benefits of technologies for climate change adaptation in their national Technology Needs Assessments. This is compared to the Green Climate Fund's requirements in its Performance Measurement Framework as an example of what financiers and global investment funds consider. The analysis in the paper indicates that there may be a way forward in using Technology Needs Assessments to pave the way for accessing funding. Nevertheless, there is scope for adjusting the Technology Needs Assessments according to developments in the requirements of financial institutions, potentially easing the way for countries to prepare project proposals using TNAs.

1. Introduction

While the role of technology in achieving development objectives in a sustainable manner have been highlighted for many years (de Coninck & Puig, 2015; Traerup & Christiansen, 2014; UNFCCC 2008; UNFCCC 2001), the focus has traditionally been skewed towards technologies for the mitigation of climate change rather than adaptation. However, in recent years technologies for adaptation have been recognized as a cross-cutting tool through which to address vulnerability to climate change and increase resilience. Measuring the impact and effectiveness of technologies for climate change as an adaptation strategy or action nevertheless remains a challenge, not least in the light of adaptation as an inherently local phenomenon, as well as being highly contextual and often being made up of complex systems (Bours, McGinn, & Pringle, 2015).

Commitments to promote technology transfers to developing countries have been renewed at every COP to the Convention. In 2010 this level of commitment led to the establishment of the Technology Mechanism,[1] which aims to 'facilitate enhanced action' on technology development and transfer in order to support progress in climate change mitigation and adaptation. Related to this are numerous on-going initiatives in developing countries, including Technology Needs Assessments (TNAs), Low Carbon Development Strategies, National Adaptation Plans (NAPs) and Nationally Appropriate Mitigation Actions (NAMAs), financed by bilateral and multilateral organizations as well as, in some cases, developing country budgets.

Since the 2015 Paris Agreement on climate change, countries have prepared their first Nationally Determined Contributions (NDCs) outlining the climate actions they propose in order to meet their NDC targets. In a review of 71 developing countries' NDCs, Charlery and Traerup (forthcoming) revealed that most of these NDCs include technology-related components and that nearly all countries request support for technology transfers in order to meet their targets. To measure progress towards reaching each countries' targets and hence the ambition of the Paris Agreement, measurement and evaluation of countries' collective efforts will be carried out on a continuous basis through global stocktakes. As a result, the ability to measure and quantify the impacts of technologies in the future will be even more pertinent.

Adaptation initiatives often involve some form of technology, which is generally perceived as consisting not just of hardware components, i.e. material and equipment. However, different forms of knowhow and the skills to operate the technology, as well as the institutional capacity to make a technology work are also important constituents of a technology. For example creating awareness of the technology in the target user group is a non-hardware component of the technology (Nygaard & Hansen, 2015; Thorne, Kantor, & Hossain, 2007; UNFCCC, 2009; Morecroft & Cowan, 2010; Sovacool, 2011). Often, therefore a technology consists to a varying extent of all or nearly all these elements, hardware, orgware and software. Some technologies may nevertheless not even include hardware components, such as an alteration of existing agricultural practices or the creation of institutions to facilitate a new practice, such as a water users association.

This paper analyses how, in their national TNAs, countries currently measure the benefits of technologies for climate change adaptation when they evaluate and prioritize them. This is followed by an introduction to the Green Climate Fund's (GCF) Performance Measurement Framework. Based on these sections, we compare how information generated through a TNA supports the requirements for preparation of the GCF framework as an example of what financiers and global investment funds consider. The paper concludes by providing suggestions for potential ways to enhance efforts.

2. Technology Needs Assessments

TNAs were introduced under the UNFCCC Convention at COP-7, which defined them as 'a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties' and 'particularly developing Parties' (UNFCCC, 2001).[2] The TNA process includes a thorough identification and analysis of the barriers to upscaling the uptake of selected priority technologies and identification of the required conditions to enable this. As a final result of the process, countries prepare technology action plans (TAPs) setting out the road maps for the implementation of actions to create these enabling conditions and implementation of technologies (Nygaard & Hansen, 2015). The UN Environment Programme, through

[1] CoP 2010, Decision 1/CP.16. http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=18

[2] CoP 2001, Decision 4/CP.7, pp. 22-30. http://unfccc.int/resource/docs/cop7/13a01.pdf#page=22

Table 1. TNA guidance on indicators to measure the criterion 'Potential for vulnerability reduction' (Traerup & Bakkegaard, 2015)

Criterion: potential for vulnerability reduction	
Sector	**Indicators**
Water	• no. of households with access to clean water • area not damaged by flooding • increased capacity of water storage • no. of households with financial capability and social networks to cope with shocks
Agriculture	• no. of households not experiencing crop losses • no. of households not experiencing crop disease • extent of crop and livestock diversification • no. of households with financial capability and social networks to cope with shocks
Coastal	• area not damaged by flooding • no. of households with the financial capacity and social networks to cope with shocks
Health	• no. of households with access to health services • no. of health services available • extent of early warning systems for infectious diseases • no. of households with financial capability and social networks to cope with shocks

the UNEP DTU Partnership, has led the implementation of the global TNA project since 2009, since when more than fifty countries have prepared or in the preparation process of their TNAs and TAPs.

For each step in the TNA process, guidance and methodologies are available.[3] In prioritizing technologies, countries use multi-criteria analysis (MCA), which facilitates the participation of stakeholders and allows normative judgments to be made while incorporating technical expertise into the technology assessment (Traerup & Bakkegaard 2015). Evaluating and prioritizing technologies for adaptation using MCA usually involves combinations of indicators that are quantifiable and others for which quantifiable valuations do not exist (or for some reason are not possible). Hence, MCA allows for a unique mix of quantitative and qualitative indicators, with the result that the quality, form and format of information may even differ within the same assessment of technologies but between national processes. Wherever it is possible to quantify costs and benefits in monetary terms, this data should be included in the MCA. As an example of how the TNA guidebook on MCA provides guidance on criteria and indicators, Table 1 below shows the suggested indicators for the criterion 'Potential for vulnerability reduction'. According to the TNA guidebook, a criterion is understood as reflecting a group of indicators within the same 'category', whereas the indicator would be a measurable reflection of one aspect of the criterion. In a TNA process, most criteria are measured in terms of benefits, whereas the costs mainly figure in terms of capital investment and operating and maintenance costs.

In this TNA process, information on direct and indirect benefits is important, since it defines the potential of the technology against different indicators. It is necessary information for comparing and prioritizing technologies, as well as important information for the public and private technology suppliers and end users (Naswa, Dhar, & Sharma, 2017). Finally, for public funds, climate investment funds and other non-governmental financiers, measuring the benefits of the technology, its positive externalities and its macro-level potential for sustenance, replicability and transformational change are central to decision-making.

The identification and quantification of the benefits of technologies for adaptation across time and space is challenging due to the context-specific nature of adaptation itself (Callaway, Naswa, Trærup, & Bakkegaard, 2016). In practice, the full extent of the benefits is not known and often they pertain to the quality of life, which can be attributed to other developmental factors. For example, in its TNA Kenya identified 'Social benefits associated with social interaction for women and youth' as a benefit of adopting technologies for adaptation in the water and agriculture sectors. Water

[3] http://www.tech-action.org/Publications/TNA-Guidebooks

conservation technologies and climate-smart agriculture saves the time of women and young people, thereby providing them with more opportunities to engage in other productive activities, such as pursuing other economic activities, education and the like. In such situations, even the best estimates of the benefits and their attribution have statistical challenges. 'Improved health' conditions can also be an outcome of greater awareness and better access to health care, and not just access to food and water facilitated by the implementation of technologies for adaptation. These concerns are similar to those of adaptation more broadly and stem from the overlap in definitions of adaptation and technologies for adaptation.[4]

2.1 Reported Adaptation Benefits

As previously mentioned, the multidimensional definition of adaptation makes it equally difficult to measure or quantify the benefits or the contribution of a technology for adaptation to reducing vulnerability to climate change. However, bearing in mind that adaptation is not just local, but is a multi-level effort where there is feedback between these levels, this section considers how, in their TNAs, countries report on the envisaged benefits of technologies for adaptation. The approach is to provide insights into how countries see the auxiliary benefits of these technologies and to provide a better understanding of what these benefits are and how they can be measured.

Here we focus on the benefit indicators for specific technologies and present countries self-reported results in their TNAs. In a TNA process, countries use the indicators primarily for the MCA and for cost–benefit analyses to enhance understanding of the impact of the different technologies they are assessing. Generally, the indicators can be divided according to their social, economic and environmental aspects. For the economic benefits, examples of indicators reported by countries include the potential to improve farm incomes and catalyze private investments. To capture the environmental benefits, countries report on various indicators, such as the impact of the technology on groundwater, the impact on surface water, the ability to minimize flooding, the ability to minimize eco-system degradation, the impact on pollution, the contribution to the restoration of ecosystem services versus ex-situ conservation and so forth. Regarding the social aspects, countries evaluate technologies against indicators such as the impacts on health, job creation and community involvement.

In Tables 2 and 3 we provide an overview of countries' self-reported indicators for measuring the outcomes and impacts of introducing specific technologies (conservation agriculture and rainwater harvesting respectively) for adaptation. The indicators in the tables are countries' self-reported indicators, exactly as they are presented in countries' official TNA reports. We have grouped the indicators into the categories of social, economic and environmental impacts, but have otherwise left them exactly as reported by countries.

Looking at greater depth into the TNA reports and the indicators listed in the tables above, we observe some methodological challenges in operationalizing these indicators for further applications such as the measurement, aggregation and comparison of the benefits of technologies from adaptation. These challenges are as follows:

First, countries are struggling to find adequate data to reflect a base-line scenario vis-à-vis a scenario involving the introduction of the technology for adaptation. For example, data are needed from 1) business-as-usual farming and 2) improved farming using the technology in question. Finding all the data reflecting these scenarios in a relevant context can be more than challenging. Moreover, taking climate change into account when preparing these scenarios further complicates the process of finding data. Many countries have historical climate data, but they struggle to access climate models that are adequately downscaled to the local level. At the same time, such projections of the state of the climate are inherently associated with uncertainties. Hence the performance of technologies for adaptation, which will depend on the state of climate, is challenging to assess.

Second, countries find it difficult to assess which benefits are attributable to a particular technology (Vardakoulias, 2014). Even though the local contexts in which technologies are implemented differ, countries would still expect to see the same benefit indicators from the same technology. However, while the cost indicators are similar, the benefit indicators (with the exception of those that identify revenue streams)

[4] The Intergovernmental Panel on Climate Change (IPCC) defines adaptation to climate change as 'adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC 2001, pp 982). On the other hand, the IPCC defines technology as 'a piece of equipment, technique, practical knowledge or skills for performing a particular activity', and technology transfer as '...processes covering the exchange of knowledge, money and goods amongst different stakeholders that lead to the spreading of technology for adapting to or mitigating climate change'. Accordingly, technologies may be soft – such as training and information technology, or hard – such as wind energy and certain coastal protection technologies (IPCC 2000, pp 432). In this context, technologies may very well be part of most adaptation interventions.

Table 2. **Self-reported benefit indicators, conservation farming**

Impact area: Social
Better resilience to drought and flash floods
Increase in Yield
Increase in income
New job opportunities
Increase of farmers' incomes
Increased food production
Improvement of living standards
Upgrading the livelihood skills of farmers
Enhancing their resilience to climatic and external economic shocks
Maintaining the fertility of soil as the basis for maintaining and increasing productivity for achieving economic stability for the wellbeing of people
Improving health of people as a result of increased soil functionality and decreased inputs (mineral fertilizers, pesticides), which are leading to better quality of water and food
More people remaining in rural communities
Impact area: Economic
The cost of production is maintained as the inputs do not augment, as soil fertility and water content are preserved
The major saving will be in terms of reduced costs for tillage and land preparation for plantation
Reduced variable costs
Encouragement of private sector investments in production of agricultural crops
Increasing the sustainability of agricultural sector, including profitability
Reducing the dependence from non-renewable sources of energy and their derivatives (mineral fertilizers and pesticides) which the country has to import at the moment and in the future
Creating conditions for the development of small and medium enterprises
Impact area: Environmental
Soil is preserved from the adverse impact of climatic evaporation/ Preservation of soil water content and soil organic matter
Better nutrient use efficiency, and hence reduction of inputs and pollution.
Increased biodiversity in the soil. Reduced desertification
Increased sustainable use of natural resources through preventing soil degradation, soil and water pollution, preservation of biodiversity etc.
Higher carbon sequestration which allows to reduce global warming
Reduction of soil erosion and better storage of the soil moisture
Reduction of the pollution of ground water with nitrates
Reduction of GHG emission as a result of lower amount of burned fuel

Table 3. **Self-reported benefit indicators, rainwater harvesting**

Impact area: Social
Increase resilience to water quality degradation
Increase crop yields and opportunities to combine with other agricultural practices
Contribute job creation
Enhance growth of social structures and women empowerment
Diversifies agriculture water supply
Increase the income of farmers
Increase food production and productivity generally
Enhance availability and access to water
Improve living conditions of both pastoralists and farmers
Promote peace and stability
Strengthen the resilience of local communities to climate change
Additional water can encourage back yard farming
Increased awareness on adopting water conservation measures
Create employment opportunities for trainers to provide technical know how
Investment boost for small scale enterprises dealing with RWH systems
Reduce health risks to those who do not have/or have intermittent access to water
Reduce demand of treated water
Job creation for those in producing the systems
Investment potential for local enterprises in production of system and storage containers
Enhance availability for domestic and agricultural purposes
Increased economic opportunities, including kitchen gardens, poultry and zero-grazing
Impact area: Economic
Significant savings for farmers
Reduce public and private expenditure associated with water infrastructure
Impact area: Environmental
Potential to reduce soil erosion
Potential to reduce flooding
Enhance ground water quality
Reduce overexploitation of ground and service water
Reduce the pressure on surface and groundwater
Technology promotes self-sufficiency and has minimal environmental impact

for the same technology can be very different. For example, in its TNA report, Sudan identifies the elimination of conflict among tribal communities as a benefit of water conservation technologies. Yet although these reduce competition among users, many countries do not recognize this as a benefit. This is a benefit unique to the context of Sudan. This reflects the possibility that the objectives for which adaptation technologies are being implemented may differ.

Third, apart from the attribution of benefits to the technology, there is also ambiguity in the understanding of primary climate benefits and secondary non-climate benefits. In principle, non-climate benefits also add to resilience (Klein & Tol, 1997). Therefore, if youth from Kenya have more opportunities for interaction and time for education due to water conservation technologies, this also contributes to the community's overall resilience.

Fourth, the most common methodology for the aggregation of adaptation benefits is cost–benefit analysis. This approach places the cost and benefit indicators under a single measure, making it easy to aggregate and compare technologies. While the method has its merits, its overt focus on monetization makes it difficult to assess either the direct or indirect qualitative benefits. Consequently, countries identify many benefit indicators, though only including those measures that have explicit revenue streams or that entail some form of monetary saving or explicit damage that is avoided in their cost–benefit analyses. This makes the analysis inadequate, as many technologies for adaptation do not necessarily lead to revenue streams, monetary savings or explicit damage being avoided. For example, rock revetment, a technology prioritized by Mauritius, does not produce direct revenue streams or monetary savings. If a cost–benefit analysis only takes revenue streams into account, the analysis will not reflect the potential benefits of the technology. We do not dispute the relevance of cost–benefit analyses as such, but we do consider it essential to highlight the practical inadequacies of this method in assessing potential adaptation technologies as identified in a TNA process.

Two important reasons for countries facing these challenges are the inadequacy of the institutions that are looking into data availability, management and quality, and the limited capacities of consultants and institutions to carry out these assessments. Addressing these challenges to the measurement of benefits in order to explore the adaptation potential of technologies requires systematic approaches to the capacity-building of institutions and individuals.

Lastly, it should also be mentioned that uncertainties in the context of adaptation are much broader than just those associated with the changing climate and accessing and processing data. For example, risks and uncertainties may be associated with the implementation of technologies, with the result that implementation is not perfect.

A quick overview of the barriers to successfully upscaling the use of the prioritized technologies shows that most of these technologies face financial barriers (UNFCCC, 2016). In many cases, the country concerned acknowledges that a particular technology is important for managing climate-induced risks, but states that it cannot support the full-scale or large-scale implementation of the technology financially. Many of the activities listed in the TNAs are contingent upon receiving or accessing developmental finance or climate finance.

3. The Green Climate Fund's Performance Measurement Framework

Measuring the benefits of introducing the respective technologies for adaptation can be used as an argument for accessing funding for the project. From this standpoint, exploring the adaptation potential of technologies is a crucial step, as most funders and investors, whether a multilateral fund such as the Green Climate Fund (GCF), private-sector enterprises or public-sector funds, look for significant adaptation benefits or the 'Climate Impact Potential' that implementing technology projects may bring about. Co-benefits in the form of 'Sustainable Development Potential' or positive technological spill-overs are equally important. Therefore, the benefit indicators need careful scrutiny, and robust measurement methodologies in order to make them more relevant for accessing internal and external funding sources.

In this section, we present the GCF's investment frameworks and performance indicators for adaptation projects and compare and discuss them against the benefit indicators identified by countries in their national TNA reports. In the subsequent sections, we propose directions for how this alignment can be improved. In particular, we look at the GCF's performance indicators as an example of what donors are looking for when making decisions regarding funding allocations.

Table 4. Initial Investment Framework: indicative assessment factors (GCF, 2015a, 2015b)

Adaptation impacts	
Activity-specific sub-criteria	**Indicative assessment factors (including indicators)**
Contribution to increased climate-resilient sustainable development	Expected total number of direct and indirect beneficiaries (reduced vulnerability or increased resilience); number of beneficiaries relative to total population
	Degree to which the activity avoids lock-in of long-lived, climate-vulnerable infrastructure
	Number and type of institutions using climate information to inform policy and decision-making
	Expected increase in generation and use of climate information in decision-making
	Expected strengthening of adaptive capacity and reduced exposure to climate risks
	Expected reduction in vulnerability by enhancing adaptive capacity and resilience for populations affected by the proposed activity, focusing particularly on the most vulnerable population groups and applying a gender-sensitive approach
	Number of people affected by climate change related natural disasters (including deaths);
	Expected strengthening of institutional and regulatory systems for climate-responsive planning and development
	Expected strengthening of awareness of climate threats and risk-reduction processes
	Other relevant indicative assessment factors, taking into account the Fund's objectives, priorities and result areas as appropriate on a case-by-case basis

3.1 Investment Framework

The GCF evaluates the expected performance of project and programme proposals against its Investment Framework (GCF, 2015a, 2015b). Hence project proponents are expected to elaborate on each of the six components of which the Framework is composed. The components are as follows:

1. Impact potential: potential of the programme or project to contribute to the achievement of the Fund's objectives and result areas
2. Paradigm Shift Potential: degree to which the proposed activity can catalyse impacts beyond a one-off project or programme investment
3. Sustainable Development Potential: wider benefits and priorities
4. Needs of the recipient: vulnerability and financing needs of the beneficiary country and population
5. Country ownership, i.e. the embeddedness of the project within the larger policy framework of the country and its capacity to implement the proposed activities
6. Efficiency and Effectiveness: the economic and, if appropriate, financial soundness of the programme or project.

For adaptation projects, the core GCF indicator, akin to reductions of greenhouse gas emissions in mitigation projects, is 'the expected total number (or relative to total population) of direct and indirect beneficiaries'. In addition, the GCF uses a number of other indicators, called 'indicative assessment factors', in its Investment Framework. These are reflected in Table 4 below, but the GCF notes that '*not all indicative assessment factors will be applicable or relevant for every proposal*' (GCF 2015a, 2015b).

3.2 Performance Indicators

In addition to its Investment Framework, with related indicators, the GCF proposes indicative sets of performance indicators at the sectoral level, defined by itself. These are listed in Table 5. The performance indicators are designed to track how inputs (such as grants) lead to tangible outcomes (such as an increased uptake of climate-resilient crops) and to track the transformational impact on a sector (e.g. a more resilient agriculture sector). It is acknowledged that transformational impacts will not be achieved through GCF interventions alone, but would need additional efforts and commitments, e.g. from governments in establishing the enabling framework conditions. In outlining its performance indicators, the GCF recognises that 'establishing a meaningful indicator framework for adaptation, which

Table 5. **Extended and additional adaptation result areas and related performance indicators for GCF projects (GCF, 2014)**

GCF sector/result area	Performance indicators
For all result areas	• Number of food secure households • Perception of the timeliness, content and reach of early warning systems • Quality of regulatory environment put in place by the government to enable civil society and private sector adaptive interventions
Sustainable land-use management, agriculture and rural adaptation	• Number of food secure households • Mix of livelihood strategies/coping mechanisms • Areas of farmland made more resilient
Ecosystems and ecosystem-based adaptation	• Number and area of habitats restored or protected by funded activities
Climate-resilient infrastructure	• Value of infrastructure protected from rapid-onset events and slow-onset processes • Number of instances where infrastructure has been physically moved or built in less vulnerable location
People, health and well-being	• Perceptions of beneficiaries of their state of health and the level of climate-related risk to which they are vulnerable
Approaches to risk sharing and transfer (insurance related)	• Area of farmland made more resilient to climate change events • Number of food secure Households • Mix of livelihood strategies/coping mechanisms • Perceptions of beneficiaries of their state of health and the level of climate-related risk to which they are vulnerable

provides continuously good information at the relevant spatial and temporal scales, is difficult, even in advanced countries. A practical implication of such data constraints may be that most adaptation activities will usually need to incorporate data collection support into their design as a matter of course.' The indicators listed in Table 5 should be supplemented with additional measurable indicators and will depend on the specific nature of the suggested activity.

Other than the Investment Framework and its Performance Indicators, the GCF does not prescribe any indicators, and the methodology for assessing and reporting on the indicators is left open. This gives the project proponent an opportunity to consider project-specific indicators assessing how the project is contributing to climate vulnerability reduction and to enhancing sustainable development. In addition, it is not a requirement to have only quantitative indicators. A strong narrative of the expected co-benefits may supplement and further contextualize the idea in the project proposals for the GCF.

4. Linking Technology Needs Assessments with the Green Climate Fund Investment Framework

At its latest meeting, the Board of the Green Climate Fund (GCF) 'further requests the [GCF] Secretariat to continue to consider complementarity and coherence with other related technology initiatives and activities, including technology needs assessments and technology action plans' (GCF, 2017). In addition, the GCF encourages countries to use GCF readiness and project preparation facility resources to facilitate access to technologies, while the GCF Secretariat has highlighted the value of the information generated by the TNAs and the usefulness of the country-driven nature of TNAs in laying the basis for GCF projects. For example, based on its TNA, Mongolia has prepared two proposals, both of which have been approved by the GCF.[5] In this section we relate the indicators and information generated

5 1st programme, 'MSME Business Loan Program for GHG Emission Reduction' (USD 20 million), approved December 2016: https://www.greenclimate.fund/-/business-loan-programme-for-ghg-emissions-reduction?inheritRedirect=true&redirect=%2Fwhat-we-do%2Fprojects-programmes
2nd programme, 'Renewable Energy Program #1 - Solar' (USD 8.65 million), approved October 2017: https://www.greenclimate.fund/documents/20182/820027/GCF_B.18_04_Add.01_-_Funding_proposal_package_for_FP046.pdf/22483a80-d836-4872-8acf-3d4befe4109c

through a TNA to the six GCF Investment Framework components.

GCF Investment Framework Component 1. Impact potential: potential of the programme or project to contribute to the achievement of the Fund's objectives and result areas.
Most TNAs do not clearly distinguish between outputs, outcomes and impact indicators when assessing and prioritizing technologies. Nevertheless, the outcomes and impacts of technologies may be assessed and analysed in more detail at a later stage in the TNA process, and in some cases they may be reflected in the project ideas coming from TNAs where the project- or programme-level activities identified through TNAs are connected with outcomes and not only outputs. Nevertheless, a TNA usually focuses on several sectors for both adaptation and mitigation. This sectoral focus will allow a project proponent to use the information generated in the sector-specific section of the TNA in preparing a sector-targeted proposal to a GCF result area.

GCF Investment Framework Component 2. Paradigm Shift Potential: degree to which the proposed activity can catalyse impacts beyond a one-off project or programme investment.
So far the TNAs have not focused to any greater extent on the transformational aspects of the increased uptake and diffusion of a technology. In practice the technologies assessed in TNAs will be used in combinations with other interventions to create enabling framework conditions. For example, in its TNA, Pakistan identifies high-efficiency irrigation systems, drought-tolerant crop varieties, climate monitoring, forecasting and early warning systems as priority technologies for the agriculture sector, and surface rainwater harvesting and groundwater recharge as priority technologies in the water sector. In respect of sustainable agricultural development, there is no stand-alone project that can achieve this. Ideally, any approach to integrate these technologies comprehensively would be of a programmatic nature, and this has implications for transformational change. The contribution of a programme to increasing climate resilience and sustainable development are enhanced by treating the technologies as elements of a programmatic approach rather than as independent actions or projects.

GCF Investment Framework Component 3. Sustainable Development Potential: wider benefits and priorities.
TNAs do not limit themselves to quantitative descriptions, as they also include other than merely monetary benefits through qualitative measures. For example, in its TNA report, Ghana included as a criterion 'Extent to which technology is culturally and socially acceptable: considerations of indigenous knowledge and practices' in prioritizing technologies for adaptation in the water sector (Government of Ghana, 2012). As already mentioned, the GCF accepts narratives of these benefits and co-benefits and does not limit them by measurement. Hence TNAs can provide valuable information regarding assessments of impacts in terms of more qualitative indicators and aspects as such.

GCF Investment Framework Component 4. Needs of the recipient: vulnerability and financial needs of the beneficiary country and population.
A TNA provides background information on the vulnerability of the country and its key sectors for adaptation. In many cases this would be a good starting point of use in laying the basis for a GCF Investment Framework. The TNA typically builds on existing vulnerability assessments such as those provided in National Communications. To evaluate the level of exposure to climate risks and the degree of vulnerability, as suggested in the GCF indicative assessment factor for this component, seeking additional local and national resources than the TNA may also be recommended. However, references to the relevant document can be found in the respective sector sections of the TNA.

GCF Investment Framework Component 5. Country Ownership, i.e. embeddedness of the project within the larger policy framework of the country, and capacity to implement the proposed activities.
A TNA process has a high degree of country ownership, recognizing that the TNAs seek to align with other national processes and policy frameworks, and that the stakeholder-driven nature of TNAs ensure alignment with the expectations of potential beneficiaries (Haselip, Narkevičiūtė, & Rogat, 2015). In prioritizing technologies, countries identify criteria and indicators through stakeholder consultations and working group sessions. In some cases, for example, technologies with an impact on local planning issues, one approach to identifying criteria has been to involve the stakeholders concerned at the stage of identifying the potential criteria. Additionally, relevant policies and

other secondary information about relevant stakeholders are examined in order to derive criteria for technology prioritization that reflect stakeholder concerns.

GCF Investment Framework Component 6. Efficiency and Effectiveness: the economic and, if appropriate, financial soundness of the programme/project.
Cost–benefit analyses of technologies in TNAs are often limited in their scope to include monetary benefits such as the additional income to be earned from implementing a particular technology. As discussed in the section on TNAs, this may be due to the limited availability of and access to data, as well as to the ability of countries to attribute specific benefits to the technology, such as climate damage averted. In the case of the economic assessments of the technologies provided in TNAs, there is a need for further elaboration of what is currently available to make progress to a stage where the analyses provide adequate information on the economic efficiency, effectiveness and financial soundness of a proposed programme or project.

As evident from the sections above, there seems to be a way forward in using TNAs to pave the way for accessing GCF funding. Nevertheless, TNA methodology could be further modified in accordance with developments in financial institutions' requirements in order to ease the path for countries to use their TNAs to prepare project proposals.

5. Concluding Remarks and Way Forward

Above all, TNAs identify, assess and prioritize technologies for adaptation and mitigation in line with national priorities and sustainable development objectives. Secondly, they identify the barriers to technology transfer, diffusion and uptake, as well as measures to overcome these barriers, along with enabling framework requirements. Hence, the primary purpose of a TNA is not to provide the basis for a solid GCF proposal, but to set out technology action plans as a means for countries to progress towards a low-carbon, climate-resilient development path. Nevertheless, information generated by TNAs should be used as building blocks for, among other objectives, preparing funding proposals for projects and programmes. Given the objective of improving on the ability to measure and document the impacts of the transfer, diffusion and uptake of technologies for adaptation, there is a need to be more systematic in how we identify the impacts of such technologies and how we track their actual benefits once they have been implemented.

By comparing TNA benefit measurements with the GCF's requirements, it becomes quite evident that TNAs do have the potential to provide information on many of the aspects required in preparing the Investment Framework, though it is also clear that a TNA cannot act as the sole source of information as such. The benefit indicators identified by countries in assessing and prioritizing technologies for adaptation may cover some of the requirements for the GCF's performance indicators. However, one recommendation for the further development of TNA prioritization methodology is to integrate aspects that are in line with the requirements of proposals to funding institutions into countries' own assessments of technologies for adaptation. This would ease the process for countries when developing project and programme proposals based on their TNAs in future.

For the purposes of further developing the TNA methodology to make it easier for countries to translate their technology action plans from their TNAs into funding proposals, it is essential to enhance how we understand, identify and measure not only direct benefits, but also auxiliary benefits. If we are able to identify and show wider arrays of benefits from technologies for adaptation and to link these benefits to socioeconomic indicators, instead of only reflecting benefits in terms of monetary flows, it will potentially increase the ability of countries to access the available funding for adaptation.

As part of efforts to overcome data challenges, capacity-building of both national and sub-national government agencies and institutions is recommended to increase not only the availability and quality of data, but also their ability to manage the technical aspects of improved data-collection programmes. As part of improved data provision, capacity in countries regarding how to set up comprehensive monitoring programmes of progress in reaching targets is also recommended as a way forward. In addition, it is recommended that local capacity be built up to monitor and evaluate those managing the technical aspects of improved data-collection programmes. All these efforts need to be integrated into sectoral and cross-sectoral programmes and projects so that data collection and management become comprehensive enough to cover a range of impacts, from introducing technologies for adaptation to measuring adaptation as such.

Lastly, strengthening the transfer, diffusion and uptake of technologies for adaptation is not only the key to being able measure the impacts, but also key to communicating and showcasing these impacts in order to unleash the power of the private sector and markets. This can be done through further sharing of good examples for potential replication and upscaling.

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Assessing results of climate change adaptation projects in practice: learning from German Technical Development Cooperation

Abstract

Implementation of climate change adaptation is increasing globally, and many climate funds, implementing agencies, international and civil-society organisations are now managing a sizable portfolio of adaptation projects. So far only a few accounts exist of how these organisations are assessing the results of their adaptation work at the project and portfolio levels. This article describes how Germany's technical development cooperation agency (GIZ GmbH) has integrated adaptation into its Monitoring & Evaluation (M&E) system and piloted innovative ways of assessing adaptation outcomes, including the monitoring of climate vulnerability or risk over time, measuring avoided negative impacts on the economy and human health, impact evaluation techniques and standard indicators at the portfolio level. Each M&E approach is outlined in detail, and experiences from their implementation in the field are shared. The article concludes with lessons learned to provide helpful insights for other organisations seeking to assess the results of their adaptation actions systematically.

Acknowledgement: The author is grateful for helpful comments from Till Below, Anna Hennecke, Christoph Klinnert, Jörg Linke, Karin Neck, Susanne Schwan, Marc Zebisch and in particular for the detailed comments of the two anonymous reviewers.

* This article is partly based on a presentation the author gave at the Adaptation Knowledge Day, a side event of the UN climate change negotiations in May 2016 in Bonn, Germany.
The views expressed in this article are those of the author and do not necessarily reflect the views of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH or its commissioning Parties, in particular the Federal Ministry for Economic Cooperation and Development (BMZ) and the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

1. Introduction

Adaptation to climate change has become a key priority for many developing countries. Accordingly, development cooperation has been mainstreaming adaptation into its portfolios and is providing technical and financial support to adjust to and prepare for the impacts of climate change. Since 2010, the volume of bilateral official development assistance (ODA) focusing on climate adaptation has more than doubled, reaching USD 14 billion in the two-year average for 2015-2016 (OECD, 2016a, 2017).[1] At the same time, the efforts made by many governments to raise the profile of adaptation have culminated in the Paris Agreement establishing a 'global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development' (UNFCCC, 2015, Article 7).

Many donors, climate funds, implementing agencies and international organizations now manage a sizable portfolio of adaptation projects, raising the question of how their adaptation results can be measured at the project and portfolio levels. As Leiter and Pringle (2018) explain, there is no single, globally applicable metric for assessing adaptation. Instead, the success of adaptation can only be determined in a specific context and might even depend on different perspectives (Adger, Arnell & Tompkins, 2005). Nevertheless, governments, donors, implementers, academia and civil-society organizations are all seeking to understand whether adaptation investments make a difference.

This article describes how the monitoring and evaluation (M&E) of climate adaptation has been addressed by one of Germany's main implementing agencies for development cooperation, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. It begins by outlining the relevance of adaptation M&E for GIZ and explains how the issue was taken up within the organization and aligned with its existing M&E systems. Each of the approaches employed for adaptation M&E is then described in detail:

- Project-specific adaptation indicators as part of results-based monitoring
- Monitoring and comparing climate vulnerability or risk over time
- Adaptation metrics 'saved health' and 'saved wealth'
- Impact evaluation
- Standard indicators at the portfolio level

A summary of these approaches is provided in Table 1. The article concludes with a discussion of GIZ's experiences and lessons learned that may be valuable for other organizations embarking on systematic assessments of their climate adaptation interventions and portfolios.

2. Assessing adaptation projects at GIZ

GIZ is a global service provider for sustainable development with a total workforce of more than 18,000 people in over 120 countries and a business volume of 2.4 billion euros in 2016.[2] In line with the funding priorities of its main commissioning parties, the German Federal Ministries for Economic Cooperation and Development (BMZ) and for Environment, Nature Conservation, Building and Nuclear Safety (BMUB), GIZ's climate change portfolio has grown substantially over the years.[3] In 2014, more than 40% of GIZ's projects were directly or significantly related to climate change.[4] In the same year, GIZ implemented almost eighty projects with the principal objective of adaptation as defined by the OECD.[5]

As GIZ's adaptation portfolio started to grow, project managers and developers expressed the need to explain the characteristics of an adaptation project compared to a traditional development project.[6] At the same time, the need arose to demonstrate adaptation-specific results of projects that had been labelled adaptation under the OECD Rio Marker system, which first introduced a climate adaptation marker in 2010 (the updated climate markers are described in OECD (2016b)). In response, in collaboration with the M&E unit, GIZ's climate change unit, where the author has been working, analysed how climate adaptation could best be assessed by GIZ's existing M&E instruments and which gaps remained. These efforts gained political importance amidst reports that donors' labelling of adaptation projects under the Rio marker was partly inaccurate and inflated (Junghans

[1] In addition, for the two year average 2014-2015 USD 5 billion were spent on multilateral ODA focusing on adaptation and USD 6.3 billion on bilateral ODA activities that were jointly focusing on adaptation and mitigation (OECD, 2017).

[2] Further details are provided at https://www.giz.de/en/html/about_giz.html

[3] GIZ has also attracted co-financing for climate projects from the governments of Australia, the Czech Republic, Denmark, the UK, the US, the European Commission and other donors.

[4] All GIZ projects can be viewed by country at https://www.giz.de/en/html/worldwide.html

[5] The OECD Rio Marker distinguishes between projects with either principal or significant adaptation objectives (OECD, 2016b).

[6] The guidebook 'Adaptation made to measure' proposes minimum requirements for projects with an explicit and partial focus on adaptation (Table 1 in Olivier, Leiter and Linke (2013)).

Table 1. **Approaches used to monitor and evaluate GIZ's adaptation projects.**

	Project-level						Portfolio-level
Approach	**Results-based monitoring**		**Monitoring climate vulnerability or risk over time**	**Metrics 'Saved health' and 'Saved wealth'**	**Independent evaluations**		**Standard indicators at portfolio level**
	Theory of change with indicators	**Qualitative**			**Theory-based evaluations**	**Empirically based impact evaluations**	
Type of infor-mation generated	Quantitative information about the level of achievement of adaptation-specific project goals and indicators.	Views and perspectives of stakeholders regarding project design and progress.	Extent to which quantitative vulnerability or risk indicators have been changing over time.	Avoided economic damage and avoided negative health impacts due to adaptation.	Insights into project performance, what did or did not go well, suggestions for improvement.	Sound evidence of the causality of changes (intended or unintended) based on empirical data.	Quantitative information about selected aspects of the adaptation portfolio.
Timing	During a project's lifespan.		At the beginning and in multi-year intervals during and possibly after the end of a project.	At or towards the end or sometime after completion.	At the termination of a project (or the end of a phase of a longer programme).	At or towards the end or sometime after completion (design and baseline to be established earlier).	Portfolio-wide every two years.
Require-ment?	Mandatory for all projects commissioned by BMZ; other commissioning parties have similar M&E requirements.	Mandatory for all projects commissioned by BMZ (volume of > €1 Mil.).	Voluntary.	Voluntary.	Mandatory since mid-2017; will be applied to a sample of GIZ projects covering at least 40% of the portfolio.	Voluntary.	Technically voluntary, but participation strongly encouraged.
Adaptation-specific guidance by GIZ?	Yes, Olivier et al. (2013).	No.	Yes, Fritzsche et al. (2014) and GIZ and EURAC (2017).	Yes, Köhler and Michaelowa (2013a).	No.	Yes, Silvestrini, Bellino and Väth (2015).	Yes, explanation provided during online survey.

& Harmeling, 2012).[7] GIZ therefore needed to ensure that its adaptation projects actually delivered adaptation and were able to demonstrate results accordingly. One aspect of this was to identify suitable methods and indicators[8] for adaptation, but equally important was aligning them with GIZ's existing M&E procedures. Due to the diversity of adaptation projects implemented by GIZ, ranging from global knowledge exchange over national policy advice to sector-specific measures in very different political and geographical contexts, it was determined that a one-size-fits-all set of indicators would not be suitable. Instead it was decided to provide guidance on how to design adaptation projects and measure their contribution to adaptation through project-specific indicators. An internal participatory process[9] involving project developers and country offices led to the guidebook 'Adaptation made to measure' (Olivier et al., 2013) which provides guidance on how to account for adaptation through results-based monitoring (RBM), building on GIZ's results model (see section 3 for details).

The assessment of adaptation *outcomes* (as opposed to *outputs*) presents methodological and conceptual challenges (Dinshaw, Fisher, McGray, Rai & Schaar, 2014; Bours, McGinn & Pringle, 2014a; Ford & Berrang-Ford, 2016). The OECD

7 The climate adaptation marker was subsequently reviewed in 2013 and updated (OECD, 2016b).

8 The terms 'metrics' and 'indicators' are not used consistently in the literature (IPCC, 2014, p. 853), furthermore they are often used synonymously in climate policy and practice. Both terms are therefore used interchangeably here.

9 Arnott, Moser and Goodrich (2016) incorrectly state that there had been 'low levels of interaction' in the development of the guidebook, although it is stated in the imprint that it was developed in collaboration with various GIZ divisions and projects.

defines outputs as 'The products, capital goods and services which result from a development intervention' and outcomes as 'The likely or achieved short-term and medium-term effects of an intervention's outputs' (OECD, 2008). Examples of outputs include conducted trainings, the adoption of new technologies and the mainstreaming of adaptation into development planning. Outcomes then describe whether these outputs have led to actual adaptation, i.e. whether they have helped to reduce climate vulnerability or risk and safeguarded development despite climate change. Assessing adaptation outcomes is more difficult than measuring outputs because there is no universal metric for the success of adaptation due to its context-specific nature (Leiter & Pringle, 2018). GIZ has therefore piloted several approaches, namely monitoring and comparing climate vulnerability or risk over time, assessing economic and health benefits of adaptation and employing empirical impact evaluations (see sections 4-6 for details). In addition, to showcase the overall performance of all its adaptation activities in a way that can be easily communicated, GIZ introduced aggregate indicators for a range of topics, including climate change (see section 7). All approaches used to monitor and evaluate adaptation projects by GIZ are summarized in Table 1 and described in more detail in the following sections. Table 1 outlines the differences between the approaches with regard to the type of information they generate, the timing of their application, whether their application is mandatory and whether adaptation-specific guidance exists. For the sake of completeness, Table 1 also includes two approaches that will not be discussed further in this article, namely qualitative results monitoring and theory-based evaluations, because no adaptation-specific guidelines are currently available for them at GIZ. Complementarities between GIZ's adaptation M&E instruments are explored further in section 8.

In contrast to other organisations, GIZ has deliberately made the decision not to establish corporate portfolio targets based on aggregate indicators (GIZ, 2017a). One of the reasons lies in the operational setting of GIZ. GIZ is not a donor, but a government-owned service provider. The priorities of development cooperation, and hence the projects GIZ is implementing, are mainly determined by negotiations between the host government and the German government. The timing of the negotiations differs from country to country, as do the start dates of projects and programmes. It would therefore neither be feasible nor useful to determine target values for aggregate indicators. Furthermore, GIZ decided not to make aggregate indicators a mandatory part of GIZ project results frameworks (ibid.). The latter could create false incentives to focus on more easily achievable and short-term results since aggregate indicators typically focus on the output-level in order to be widely applicable across the portfolio. However, for communication purposes, in contrast to other M&E purposes such as management or learning, GIZ and the International Climate Initiative of BMUB employ a small number of standard indicators that are separate from project performance measurement (see section 7).

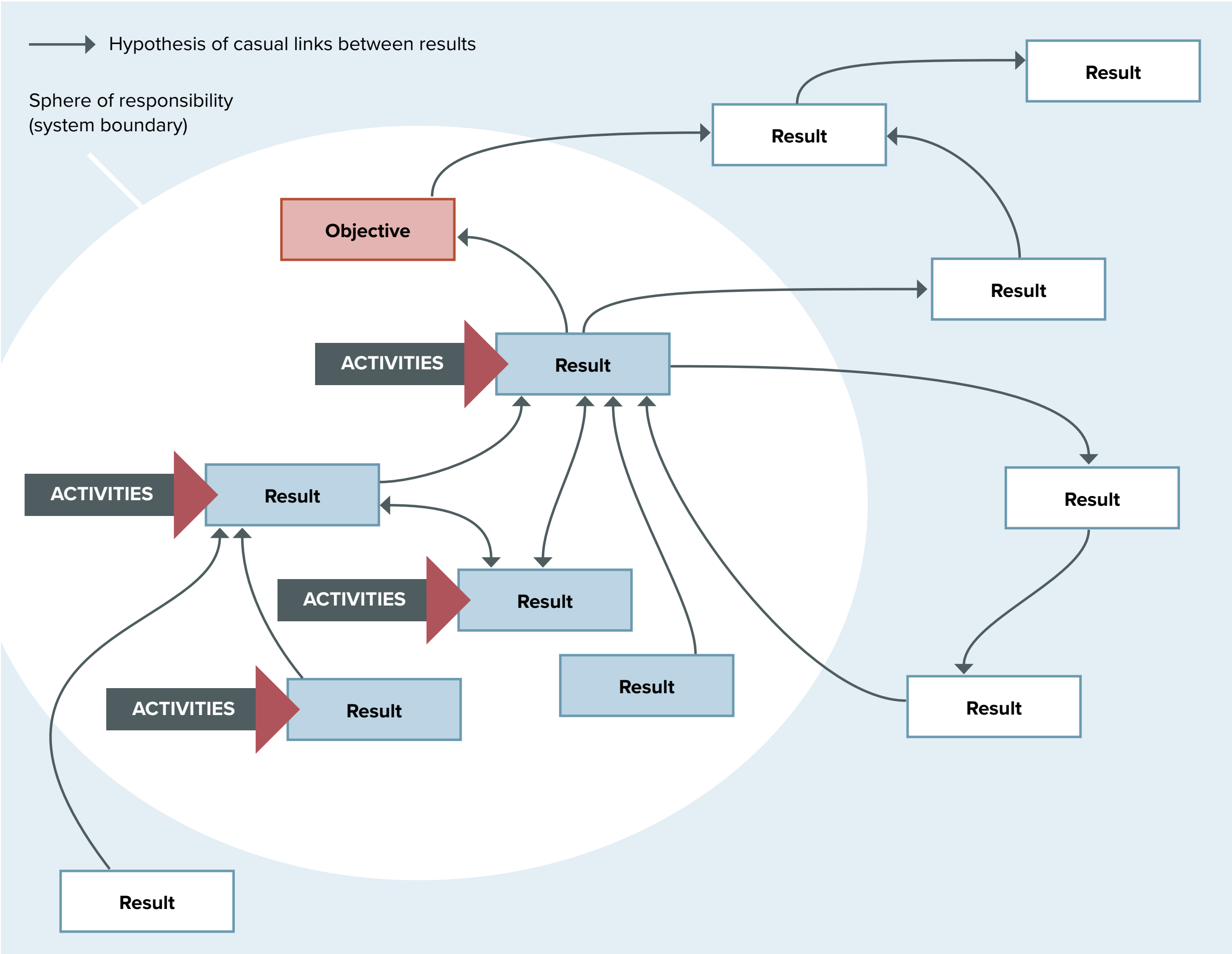
Apart from advancing the assessment of adaptation at its own operations, GIZ has actively contributed to the international debate on adaptation M&E and transparency (GIZ, 2017b). On behalf of BMZ and BMUB, several GIZ projects have provided technical advice and capacity-building to national and sub-national governments for the development of adaptation M&E systems, including Bolivia, Brazil, Cambodia, the Mekong River Commission, Mexico, Morocco, Mozambique, the Philippines, South Africa and Thailand (examples are provided in Hammill, Dekens, Olivier, Leiter & Klockemann, 2014; Leiter & Olivier, 2016; Leiter, 2015, 2017a). The guidebooks, tools and training materials for M&E of adaptation developed by GIZ are compiled in the Adaptation M&E Toolbox (GIZ, 2016). Knowledge exchange and cross-country learning is being facilitated by, for instance, the NAP Global Network and the Partnership on Transparency in the Paris Agreement.

3. Project-specific adaptation indicators as part of results-based monitoring

An adequate starting point for addressing M&E of adaptation within an organization is to look at its existing M&E system. GIZ uses results-based monitoring (RBM)[10] to systematically observe and steer the change process triggered by a development project (GIZ, 2014a). The RBM system is developed during a project's design phase or at the start of implementation and is applied throughout the course of a project. It addresses several aims: supporting project management and learning, reporting to the commissioning party, and providing the basis for evaluations (GIZ, 2013b). GIZ's RBM uses two complementary approaches to achieve this: a quantitative approach based on project-specific indicators embedded in a results framework; and

[10] The OECD uses the abbreviation 'RBM' in a slightly different meaning, namely for 'results-based management', which it defines as 'A management strategy focusing on performance and achievement of outputs, outcomes and impacts' (OECD, 2008).

Figure 1. GIZ's results model



Source: Modified from Olivier et al. (2013).

Description of Figure 1:

- Results indicate intended positive changes caused by a development project, or the changes/results required of actors outside of the sphere of responsibility in order to achieve the objective.
- Arrows represent assumptions about the causal links between results.
- Activities describe how the results are intended to be achieved.
- The circle indicates the sphere of responsibility of a project. Changes outside the circle are those that are beyond the project's control but may influence its ability to accomplish its objective.

a qualitative one to gather the perspectives and opinions of partners, target groups and stakeholders about project performance, unintended results and risks. A main entry point for adaptation M&E at GIZ has therefore been to utilize the RBM system to improve capture of adaptation-specific results. To do so, GIZ conducted an in-house, participatory process that resulted in the guidebook 'Adaptation made to measure', first published in 2012 (a second edition appeared in 2013). It outlines the minimum requirements for projects to be classified as adaptation and recommends five steps to designing and monitoring them (Olivier et al., 2013). The guidebook contains an example of an adaptation project in India that illustrates how to apply the steps in practice.[11] To facilitate implementation further, an accompanying Excel

[11] In their review of adaptation M&E tools, Bours et al. (2014b) conclude that Adaptation made to measure 'is one of very few field-ready guides'. It has been downloaded more than a thousand times at the portal www.AdaptationCommunity.net and is also available in French and Spanish.

Table 2. Examples of indicators of GIZ adaptation projects as part of RBM*

Project	OECD adaptation marker	Adaptation-specific indicators (selection)
Climate Change Adaptation in Rural Areas of India (2007-2014, BMZ-funded)	2	At least three public development programs have been assessed with a climate-proofing instrument and adjusted to reduce their sensitivity to climate change. The population in rural pilot regions confirms the positive results of at least ten measures or insurance products for adaptation to climate change with regard to income security and risk reduction.
Public Investment and Climate Change Adaptation in Latin America (2015-2019, BMUB-funded)	2	By June 2019, climate risks will have been analysed and reduced through appropriate adaptation measures for x% of the total number of public infrastructure projects of two selected sectors in Peru.
Integrated Coastal Management Programme in Viet Nam (2011-2018, BMZ funded and co-financed by Australia)	2	Allocated financial resources for climate adaptation and mitigation in the period 2015-2018 amount to an average of 20% of the total budget in five provinces.
Climate Services for Infrastructure Investments, global project in four countries (2017-2020, BMUB-funded).	2	The use of national climate services in the planning and climate risk assessment of infrastructure investments have increased by x% compared to the baseline.
'Support for the development of the water sector in Tanzania', including climate-sensitive water resources management (BMZ-funded; 2016-2019)	1	In two water basins, an average of 50% of the climate-related activities proposed in the water resources management and development plans (e.g. climate-adjusted data management, improved flood and drought management) have been implemented.
OECD adaptation markers: **2** = a project's principle objective is adaptation; **1** = a project's objectives are significantly adaptation-related; **0** = a project's objectives are not adaptation-related (OECD, 2016b).		

*The wording is taken directly from the project documents and has been translated from German into English.

tool acts as monitoring device in which data for up to thirty indicators can be entered and progress visualized through automated charts (GIZ, 2014/2016).

The guidebook *Adaptation made to measure* promotes a theory of change approach to model the intended change process because a theory of change is better equipped to deal with complex systems than traditional, linear results chains or logical frameworks (Gajo, 2014; Bours, McGinn & Pringle, 2014c). In essence, a theory of change 'helps to present a shared understanding of the path that leads to the desired objective' (GIZ, 2015a). To do so, GIZ adopted a results model that no longer distinguishes between different categories such as inputs, outputs and outcomes, but instead depicts all changes as 'results' (see Figure 1).[12] A non-linear map of intended changes and their relationships can then be developed among the project partners to illustrate how a project's actions are assumed to lead to the intended objective (an example is presented in Olivier et al., 2013, p.23). Once the theory of change is agreed upon, indicators can be defined for the overall objective and the underlying intended results. Hence, indicator formulation is not the starting point in the development of an M&E system.[13] In fact, it forms step 4 out of 5 in *Adaptation made to measure* and step 7 out of 10 in the adaptation M&E guide of the UK Climate Impacts Programme (Pringle, 2011). The foundation for assessing adaptation results therefore lies in a project design that clearly articulates how the project contributes to adaptation, sometimes referred to as 'adaptation hypotheses', and it translates this into a theory of change into which indicators can be embedded (Olivier et al., 2013; Spearman & McGray, 2011).

Adaptation indicators employed for the purposes of project management and learning are best defined for a specific project context. Accordingly, GIZ has never intended

[12] Results are defined as 'intended or unintended, positive or negative changes in a situation or in behaviour that occur as the direct or indirect consequence of an intervention' (GIZ, 2013a).

[13] Leiter (2016) proposes four key considerations for the development of an adaptation M&E system.

to develop a set of standard adaptation indicators for project management, as their usefulness would be very limited. It is only for the separate purpose of facilitating the communication of collective achievements at portfolio level that a few aggregatable adaptation indicators have been developed at GIZ (see section 7).[14] However, these indicators are not being used for project-based M&E and are not part of the assessment of project performance. Instead, each project typically has a small number of indicators agreed with the commissioning party to measure a project's overall performance, as well as a number of additional output indicators and/or milestones to track implementation. Each of these indicators relates to the project's theory of change based on the results model shown in Figure 1. Recent examples of project-specific adaptation indicators from projects implemented by GIZ on behalf of BMZ and BMUB are illustrated in Table 2. Most examples already include a target value.[15] Indicators without a time reference refer to the end of the project's duration. The examples show a mix of output and outcome indicators. For demonstration purposes, only indicators whose wording is explicit about adaptation have been included. Hence, the indicators in Table 2 are not necessarily representative of all the indicators used by GIZ's more than eighty adaptation(-related) projects, but they present an accurate reflection of adaptation-specific indicators currently in use. Projects report annually on their progress to the commissioning party by means of a written report.

Using project-specific adaptation indicators as part of RBM is currently the backbone of assessing adaptation results at GIZ. Building on GIZ's corporate results model and hence not requiring any additional effort other than what is required anyway under GIZ's M&E system has proved successful. It was also important to develop guidance materials and familiarize GIZ's specialized project developers with the characteristics of climate adaptation in order to develop projects and their results-based monitoring appropriately. Nevertheless, variation in the quality of indicators and challenges in measuring outcome-level rather than process-level results still remains. This may be the case in circumstances like short project lifetimes or purely capacity-building activities, for which it can be very difficult, if not impossible, to measure ultimate adaptation outcomes directly such as avoided economic impacts. For circumstances which do permit the assessment of adaptation outcomes, GIZ has piloted additional M&E approaches to be used to complement project-specific RBM indicators. These approaches are described in the following sections.

4. Monitoring and comparing climate vulnerability and risk over time

Based on the conceptual frameworks used in the Third, Fourth and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), a central outcome of climate adaptation is the reduction of climate vulnerability and risk.[16] Accordingly, many adaptation projects express the objective of reducing vulnerability or risk and/or increasing resilience. To understand whether an adaptation project has been successful, it is therefore logical to assess whether the project has contributed to a vulnerability or risk reduction of targeted systems or populations over time. This can be done by repeating vulnerability or risk assessments (VA/RA) after a certain period of time. However, there are various challenges involved in measuring climate vulnerability and risk. Both concepts can be operationalized differently, as shown by the changed frameworks between the Fourth and Fifth Assessment Reports of the IPCC, and a different composition of factors considered or just different weightings of the same factors can lead to substantially different results (Brooks, Adger & Kelly, 2005; Leiter, Kranefeld, Olivier, Brossmann & Helms, 2017; GIZ, 2014b). Moreover, the social and ecological systems in which adaptation takes place are complex. Many factors and their interlinkages can influence the resulting development, which makes it difficult to attribute any changes to an intervention. Practical challenges include the availability of data, especially local climate data, the reliability and representativeness of data in respect of, for example, the views of selected beneficiaries, and timing and cost considerations. Hence, there are conceptual and practical limits to monitoring and comparing climate vulnerability and risk over time. To achieve reliable results, the following requirements need to be fulfilled:

- The method used for the initial VA/RA needs to be exactly replicated using the same method, types of data and procedures. Any deviations would reduce comparability and validity. Since this requirement can

[14] The International Climate Initiative of the German Federal Ministry for the Environment (BMUB) also uses standard indicators for reporting purposes (International Climate Initiative, 2016).

[15] Technically speaking, the 'pure' indicators would not include the target value. For example, the underlying indicator of the Integrated Coastal Management Programme in Vietnam would be 'Percentage of provincial budget allocated for climate adaptation and mitigation in the period 2015-2018'.

[16] The differences between the conceptual frameworks used in the Fourth and Fifth Assessment Reports and their implications for vulnerability and risk assessments are explained in GIZ and EURAC 2017.

be difficult to realize in practice, it is important to document the methods and data used carefully and to keep the assessment rules constant (see Fritzsche et al., 2014, p.162ff.).

- There needs to be a sufficiently long time span between the initial and follow-up VA/RA in order to detect any changes that might have been influenced by project activities. At project level, the interval might be between three and five years, and for more complex programmes or national strategies between five and ten years (ibid.).
- The factors considered in the VA need to be capable of capturing the effect of planned adaptation interventions, otherwise the VA will not be suitable as a basis for assessing a project's achievements.[17]
- The causal link or plausible contribution of adaptation activities to any improvements in vulnerability has to be demonstrated, for example, through theories of change or climate impact chains.

Operationalizing the measurement of adaptation outcomes through repeated vulnerability assessments is one of the aims of the Vulnerability Sourcebook which GIZ developed together with Adelphi and EURAC Research (Fritzsche et al., 2014). The Sourcebook guides users through a standardized approach to designing, carrying out and repeating a VA. A supplement for risk assessments based on the terminology of the Fifth Assessment Report of the IPCC was published in 2017 (GIZ and EURAC, 2017).

Mindful of the challenges noted above, GIZ set out to explore the feasibility of repeated VA/RAs for M&E of adaptation projects in the context of development cooperation. The approach enshrined in the Vulnerability Sourcebook was piloted at the 'Sustainable Agricultural Development Program' (PROAGRO) in Bolivia being implemented by GIZ on behalf of BMZ and co-financed by the Swedish International Development Agency.[18] Among other things, the programme introduced rain-harvesting and modern irrigation technologies for the more efficient collection and use of water for agriculture in an area where the community had identified reduced and erratic precipitation as the climate hazard with the most significant impact. The purpose of the repeated VA in Bolivia was consequently to assess whether the applied technologies had been effective in decreasing this particular climate impact. Since water availability proved challenging to measure, the proxy outcome indicator 'area of land under optimal irrigation (soil moisture)' was chosen. Maximizing the area suitable for farming allows the community to increase its income by planting cash crops. Thus optimizing irrigation not only reduces impacts from climate change but also provides economic development.

Vulnerability was conceptualized based on the IPCC's Fourth Assessment Report as consisting of exposure, sensitivity and adaptive capacity. Following the steps of the Vulnerability Sourcebook, a climate impact chain was developed that identified the key factors of these vulnerability components and their relationship (the impact chain is presented in Cordero and Gutiérrez (2014, p. 68)). Exposure and sensitivity were determined quantitatively using software to model the efficiency of irrigation based on climate information from local meteorological stations and regional climate models. Modelling was undertaken to project vulnerability into the future under different climate scenarios. Adaptive capacity was assessed semi-quantitatively based on proxy indicators and expert interviews. The experts also determined the weighting of the indicators. Details of the VA are described by Cordero and Gutiérrez (2014).

In order to generate a vulnerability score, the various indicator values had to be transformed into a common scale. A scale from 0 to 100 was chosen, 100 representing the highest potential impacts, the highest adaptive capacity and the highest vulnerability respectively. Since the Vulnerability Sourcebook did not exist at the start of the second phase of the programme in Bolivia in 2011, the baseline of the VA had to be assessed retrospectively. According to Cordero (2014), among the main challenges have been defining the impact chain, in particular the component of adaptive capacity, and finding a balance between data requirements and data availability. For example, the geographically closest meteorological station only had records for a ten-year period. The results of the baseline and the repeated VA therefore need to be interpreted with care.

The results of the calculation based on the available data are shown in Table 3 (the calculation is explained in detail by Cordero and Gutiérrez (2014)). The authors state that, while exposure (i.e. temperature, precipitation and evapotranspiration) had not changed much during the project's lifetime, the interventions (i.e. modernized

[17] Additional operational requirements are outlined in the Vulnerability Sourcebook (Fritzsche et al., 2014, p.162ff.).
[18] Its second phase, during which the repeated VA was conducted, ran from 2011 to 2014. Its current phase runs until December 2017. Further information is available on the project's website: http://www.proagro-bolivia.org/ and at https://www.giz.de/en/worldwide/12356.html

Table 3. Results of the repeated VA of an adaptation project in Bolivia (Source: Cordero and Gutiérrez, 2014, p. 77)

Time	Potential climate impact index	Adaptive capacity index	Combined vulnerability index
Before irrigation modernization	92	38	77
After several years of application of the new irrigation scheme	17	66	26
Each component was calculated as an index on a scale from 0-100, 100 being the highest possible.			

Table 4. Project-specific indicators as part of the RBM of the adaptation programme 'PROAGRO II' in Bolivia (2011-2014)

Objective and indicators	Adaptation-specific indicators* as part of RBM
Programme objective	Smallholders in dry rural areas have increased their climate resilience, enhanced the management of water basins with regard to availability and fair distribution of water resources, and sustainably increased the yields of their agricultural production.
Indicator 1	**Increased resilience:** 9,000 smallholders independently apply proven management models to improve their resilience.
Indicator 2	**Reliable availability and fair access to water resources:** integrated water management plans that include adaptation measures are being implemented and (mainly) publicly funded in ten water basins.
Indicator 3	**Profitability of agricultural production:** 30,000 smallholders in the targeted area increase their agricultural incomes by 20% on average

*The original wording is in German. The indicators have been translated by the author.

irrigation) had decreased sensitivity and resulted in a strong reduction of the potential climate impact as measured by the proxy of area under optimal irrigation. It was estimated that, with the adopted technologies, 56 ha of the maximum available 61 ha could be sufficiently irrigated compared to just 5 ha without these technologies. This translated into a strong reduction of the climate impact score from 92 (before intervention) to 17 (with intervention). At the same time, the project strengthened farmers' cooperation in managing the irrigation system and promoting better crop management, including adjustments to the agricultural calendar. This led to an increase in adaptive capacity from a score of 38 before the intervention to 66 with intervention. Taken together, this reduced the normalized score of the vulnerability of smallholders to decreased agricultural land under irrigation from 77 to 26 on a scale from 0 to 100. Thus, the repeated VA shows a reduction of the vulnerability score by 66%. Since no external factors are reported to have influenced the change in vulnerability, the project interventions seem to have been the main driver of vulnerability reduction, which indicates that the interventions have been highly successful. When interpreting this finding, the assumptions and limitations of the assessment methodology should be kept in mind.

The application in Bolivia demonstrates that a VA can be repeated at reasonable cost and effort for M&E purposes. The approach is particularly suitable for longer term programmes, like PROAGRO, which ran over three phases from 2005 to 2017. Its main value is not merely the overall score of vulnerability reduction, but insights into which components of vulnerability have been reduced and how the programmes' interventions contributed to this. Such information can inform project management and the design of future activities, as well as fulfilling accountability purposes. In this regard, the approach of repeated VAs provides significant added value over the sole use of RBM. This is illustrated by a comparison with the indicators that are used to measure the achievement of the programme's objective, as shown in Table 4. These indicators are part of the mandatory project-specific M&E system at GIZ (see section 3) and are not connected to the repeated VA, possibly because the opportunity for this additional assessment was not known at the time the indicators were defined. The first two indicators assume a reduction in vulnerability through the implementation of management models and plans, but do not directly measure it. The third indicator is at an outcome level (agricultural income increased), but the contribution of adaptation interventions to any rise in incomes is not specified. The repeated VA goes a step further by analysing the actual changes in vulnerability over time and thus helps to assess the achievement of the first part of the programme's objective (smallholders having increased their resilience) in a more in-depth and specific way than the defined RBM indicators do. The pilot application in Bolivia therefore demonstrates the potential of repeated VAs to provide useful additional information for project planning and M&E purposes that would otherwise not be provided by the RBM system.

5. Adaptation metrics 'Saved health' and 'Saved wealth'

Adaptation to climate change aims to reduce damage caused by the impacts of a changing climate. Therefore, avoided economic damage and avoided negative health effects[19] mark essential outcomes of successful adaptation. Measuring them would directly respond to the quest for a better understanding of adaptation effectiveness. On behalf of the Swiss Agency for Development and Cooperation (SDC), Stadelmann, Michaelowa, Butzengeiger-Geyer and Köhler (2014) proposed a way to calculate these adaptation benefits using two 'universal' metrics they termed '**saved health**' and '**saved wealth**' (SHSW). Health is addressed separately, since putting a monetary value on a human life is highly contentious. Initially the metrics were primarily intended to estimate the potential adaptation benefits before implementation (Stadelmann et al., 2014) and thus essentially acted as selection criteria, rather than as indicators for monitoring and evaluation (see Figure 1 in Leiter and Pringle (2018)). To fill this gap, in 2013 GIZ commissioned the authors to apply the concepts of saved health and saved wealth to calculate the achieved and future expected benefits of an adaptation project in Vietnam.[20]

The pilot application in the GIZ programme in Vietnam shows the potential of the SHSW methodology for quantifying achieved adaptation benefits and demonstrating both the effectiveness and the efficiency of adaptation programmes (Köhler & Michaelowa, 2013a,b). Similar to the approach of comparing vulnerability over time (section 4), applying SHSW provides added value due to its quantification of actual adaptation outcomes. SHSW can therefore complement or enrich regular results-based monitoring (section 3). The limitations of the approach are that it cannot be applied merely to the capacity-building or planning measures that constitute a sizable part of GIZ's adaptation portfolio. It is likewise not suitable for relatively short-term projects since it takes time for outcomes to materialize. Several challenges also exist for scaling up the approach. First, the methodology needs to be adjusted to the type of intervention and its context. In the GIZ project example in Vietnam, it was comparatively easy to construct damage curves because the intervention was concentrated geographically on a small area, and its protective mechanism (maintaining a mangrove belt) was relatively simple. In more complex settings, significantly more effort is needed and more assumptions are required to establish the detailed calculations for SHSW. This may be the largest barrier to scaling up this approach. Second, the calculation is data-intensive and may necessitate primary data collection. Proxy data from national statistics or international databases may be used, but this can reduce the accuracy of the calculation. Third, expertise outside the project team is likely to be required to develop the methodology, gather data and run the calculations. Utilizing the SHSW approach can therefore be costly and may exceed the available resources. Fourth, project managers and developers or partner governments may not see the value of investing effort and money in additional M&E techniques, since all the costs would usually need to be covered by the project budget. These limitations and challenges partly explain why the SHSW methodology has not been applied much further at GIZ, despite its high level of relevance. Nonetheless the potential for further use remains and may benefit from the increasing focus on adaptation results and transparency under the Paris Agreement.

6. Impact evaluations

Impact evaluations seek to understand the causal change an intervention has made. In contrast to results-based monitoring systems, which operate during a project's lifetime, impact evaluations are typically carried out after an intervention has been completed. Impact evaluations do not just look at the theory of change and its indicators, but focus on any 'impact' which the OECD (2008) defines as 'positive

[19] An overview of climate change and health is provided by Costello et al. (2009).
[20] For a full description of the approach and its pilot application, see Köhler and Michaelowa (2013a,b) and the article by Michaelowa and Stadelmann (2018) elsewhere in this volume.

and negative effects produced by a development intervention, directly or indirectly, intended or unintended'. In particular, impact evaluations examine the causality of changes and the extent to which the actions and results of an intervention have led to the desired objectives in the face of a broad range of potentially impacting factors and developments. While there are many types of evaluations, differing for instance in scope, level of detail, degree of independence and methods used, the term 'impact evaluation' is used here to refer to 'sophisticated evaluation designs that comply with scientific standards and are based on valid empirical data' (Silvestrini et al., 2015). For example, in order to understand causality, impact evaluations compare the effects of an intervention with similar situations without such an intervention and use empirical data to assess whether the difference is statistically significant. Putting empirical data at the core of the analysis distinguishes this type of impact evaluation, which is also referred to as rigorous or robust evaluation, from theory-based evaluations. The latter focus on the theory-of-change model or other logical models of an intervention, but do not employ any of the statistical evaluation designs mentioned below.[21] To ensure objectivity, impact evaluations are typically carried out by third parties that were not involved in the implementation.

Building on experiences with impact evaluations (IE) in other areas of development cooperation, enhanced use of IEs for adaptation interventions could in principle support the need to assess adaptation progress and learn from practice. In collaboration with UNDP, GIZ therefore commissioned the development of a guidebook to provide methodological guidance on the applicability of different IE designs for adaptation projects. Six types of IE designs are discussed in detail:

- Experimental and quasi-experimental designs
- Matching techniques
- Pipeline approach
- Regression discontinuity design
- Time-series designs
- Structural equation modelling.

The guidebook (Silvestrini et al., 2015) discusses their specific application to adaptation projects and assists in identifying suitable evaluation designs.

[21] For an overview of theory-based evaluation, see Weiss (1997).

In 2015, GIZ commissioned its first impact evaluation for an adaptation project in collaboration with the International Initiative for Impact Evaluation (3ie). The BMZ-funded project 'Adaptation to climate change / Implementation of the Nagoya Protocol', implemented in Morocco from 2013 to 2016, focused on the sustainable use of ecosystem services with consideration for climate risks, expanding a monitoring and advisory system for adaptation and biodiversity management, and the development of a legal and institutional framework for the access and benefit sharing mechanism under the Nagoya Protocol.[22] The IE started with a two-week scoping mission, including a stakeholder consultation workshop, to jointly define the purpose of the evaluation with government partners and arrive at a common understanding of the project's theory of change. Such a participatory approach is key to ensuring the relevance, ownership and usefulness of an IE. The scoping mission also explored the feasibility of an experimental or quasi-experimental approach. Further details were presented in a webinar in October 2016 (Bensch, 2016). Results of the IE are expected in 2018.

Impact evaluations offer the potential for conclusive evidence of adaptation outcomes, including what worked well and what did not. If designed well and involving project partners, IEs can produce relevant insights to improve future interventions in line with the Accra Agenda for Action on Aid Effectiveness. However, a main barrier for the wider application of IEs is the high cost required for an external team of experts over an extended period of time. Furthermore, the practical realities of development cooperation are not always suitable for all types of IE designs. For example, the use of control groups can face ethical concerns (e.g. how to select who does not receive treatment), while randomized sampling requires a sufficiently large number of entities that may not exist, as in the case of policy advice to specialized national agencies such as the National Bureau of Meteorology (GIZ, 2012). IEs are therefore more suited to some types of interventions than others, and their application needs to make sense in terms of content, strategy and funding (ibid.). Accordingly, empirically based IEs for adaptation projects at GIZ have so far remained the exception rather than the rule.[23] However, GIZ reformed its project evaluation system in mid-2017 and in the medium term aims to conduct

[22] A summary of the project is available at https://www.giz.de/en/worldwide/20237.html
[23] GIZ has routinely carried out evaluations in other areas of its portfolio. An overview of the more than 200 evaluations conducted between 2014 and 2016 is presented in GIZ (2015b).

theory-based evaluations for about 50% of its portfolio (GIZ, 2018). These mandatory evaluations will be independent, but for reasons of time and money have no requirements to apply empirical IE designs as described in the guidebook by Silvestrini et al. (2015). Nevertheless, the reform provides a strong momentum for the increased use of evaluations at GIZ, and some projects may choose to invest in adaptation-specific impact evaluations.

7. Standard indicators at the portfolio level

Results-based monitoring with project-specific indicators is important for management, learning and accountability purposes, but it does not directly enable statements to be made about corporate results across all projects at regional and global levels. Therefore, in 2014 GIZ started to employ standard indicators[24] that can be aggregated across the portfolio.[25] The introduction of this approach was not motivated by the growing climate portfolio, but rather reflected a broader need for development cooperation to demonstrate and communicate its results better to the development community and the public at large (GIZ, 2015c). Eleven sectors and 22 themes, including climate change, were identified, and a small number of indicators were developed for each. Data are gathered through a corporate-wide survey to all project heads, who are asked to enter the respective data into an online portal. More than 850 projects were involved in the first round in 2014, and the survey is being repeated every two years, with the second round having been completed in 2016. GIZ employees are encouraged to use the results for public communication and a summary is made available online (GIZ 2017a,c).

The first round in 2014 included five climate-specific indicators focusing on climate policy advice, climate finance, reductions in greenhouse gas emissions, people supported in adaptation and mitigation through forest protection. It turned out that, despite the indicators being widely applicable, determining a meaningful value was not always possible owing to the sometimes indirect causality. For example, it is difficult to estimate how many people will eventually benefit from support that leads to better mainstreaming of adaptation into planning or how many emission savings can be attributed to technical advice for the development of a climate strategy (this is known as the 'attribution gap'). In the end it was not possible to arrive at a conclusive figure for all five climate-specific indicators. In light of the experiences from the 2014 survey, including those of the feedback on other topic areas, the procedures for the survey were modified to ensure a high response rate and the number of indicators was reduced across all sectors and themes. As a consequence, climate change was left with just one indicator for mitigation and one for adaptation. The latter was 'How many people were better protected against the impacts of climate change with support from your measure or project between 2010 and 2015?'. While this indicator is widely applicable, it is difficult to define what exactly to count as 'better protected', and it does not allow for a distinction between the direct and indirect beneficiaries. As a result, the numbers obtained were not comparable and eventually proved unusable as single figure at the corporate level (GIZ, 2017a, p.11). The topic of climate change was also not chosen for the supplementary qualitative evaluation of the survey results (GIZ, 2017c). A new methodology for both mitigation and adaptation is currently being developed for the third round of the survey in 2018.

The challenges encountered when trying to express adaptation in a single number or a small set of indicators are similar to those reported by other organizations like the Global Environment Facility (Chen & Uitto, 2014). In fact, the characteristics of climate adaptation defy the use of a simple, universal indicator at the outcome level (Leiter & Pringle, 2018). A compromise must therefore be found between meaningfulness, wide applicability and the effort needed to generate the data. Clear guidance is essential in order to arrive at reliable and comparable figures. Since the purpose of the standard indicators at GIZ is to produce simple to understand statements about development aid, output-level data may be sufficient, provided that outcome-based information is gathered through project-specific M&E approaches. In this way, standardized indicators for communication purposes can usefully complement project-specific M&E systems, as both address different M&E purposes (Leiter, 2017b). In fact, standard indicators are not being used by GIZ to compare projects or assess their performance, but merely to capture results globally, including contributions to the Sustainable Development Goals (GIZ, 2015c, 2017a). Experience at GIZ illustrate the difficulties of applying seemingly simple indicators to a portfolio of diverse adaptation projects in a meaningful way. They also demonstrate the limitations of restricting

[24] GIZ defines aggregate indicators as indicators "on which data can be collected from different projects and programmes - operating in different contexts and under different conditions - using the same methods (including the unit of measurement), and covering the same period" (GIZ, 2017a).

[25] The International Climate Initiative of Germany's Federal Ministry for the Environment (BMUB) has also introduced standard indicators alongside project-specific indicators (International Climate Initiative, 2016).

the assessment of adaptation portfolios to only one single indicator.

8. Lessons learned from assessing adaptation results at German Technical Cooperation (GIZ)

Since 2011, GIZ has undertaken efforts to systematically assess the results of its adaptation projects and its portfolio by integrating adaptation into its existing M&E systems while also piloting innovative M&E approaches that complement traditional RBM. A number of lessons can be drawn from the experiences that were described in the previous sections. Each lesson learned is presented in the following through a concise statement and a detailed explanation.

Integrating adaptation into project development processes and M&E frameworks is an effective way of scaling up the assessment of adaptation results

Programmes and projects at GIZ are typically developed by a team from the respective country office or global department together with planning officers from headquarters and in collaboration with government partners. This team also develops the results framework, including the indicators to be used and their target values. Planning officers at GIZ are specialized in a certain topic area, and those dealing with climate adaptation are instrumental in ensuring robust adaptation projects with well-designed RBM. In order to enhance the measurement of adaptation results, it was therefore vital to equip planning officers with relevant guidance, and this was one of the core tasks of the guidebook 'Adaptation made to measure' (Olivier et al., 2013). In fact, the effectiveness of adaptation projects is determined not by solid M&E systems alone, but by the very design of a project, including clearly specified hypotheses of how it will contribute to adaptation in its specific context (ibid.; Spearman & McGray, 2011; GIZ, 2017d).[26]

The integration of adaptation into the M&E frameworks, planning and reporting standards of an organization has the advantage that adaptation can be monitored without additional costs or separate procedures.[27] This also makes M&E of adaptation compatible with projects where adaptation is only a secondary objective or a co-benefit. Realizing this potential requires an explicit provision to account for the adaptation results of any relevant project. Organizations seeking to assess their adaptation results systematically should therefore explore whether their existing M&E, planning and reporting standards and processes can be modified to cater for adaptation. Any remaining gaps after such integration should also be identified, since existing systems may not offer sufficient flexibility to allow in-depth assessments of adaptation outcomes (see next lesson learned).

Traditional results-based monitoring may require complementary M&E approaches to better account for adaptation outcomes

M&E of adaptation is carried out for multiple purposes (e.g. to guide project management or to gain information about portfolio-wide impacts), and each of them requires tailored M&E methods (Leiter, 2017b). The M&E approaches piloted at GIZ to assess adaptation respond to the following four M&E purposes:

- Supporting ongoing project management and reporting
- Understanding adaptation outcomes (beyond short-term outputs) to support learning and accountability
- Gaining evidence of cause–effect relationships, adaptation and development impacts to inform future projects
- Quantifying portfolio-wide adaptation results for communication purposes

These M&E purposes cannot be sufficiently and simultaneously addressed by the common form of results-based monitoring systems with a handful of project-specific indicators, because each purpose requires targeted M&E methods with different types of indicators. For example, the quantification of portfolio-wide results requires widely applicable standard indicators, whereas project management relies on indicators directly related to the project. Given the difficulties in measuring adaptation outcomes (rather than outputs), additional M&E approaches may be needed to complement traditional RBM. The monitoring of climate vulnerability or risk over time and the measurement of saved health and saved wealth constitute two types of in-depth assessments that can provide added value through detailed insights about actual adaptation outcomes (compare sections 4 & 5). Yet, they also require additional data and resources and are not suitable for short-term or purely capacity-building projects. The key to the effective assessment of adaptation

[26] The importance of the planning stage in ensuring the effectiveness of adaptation interventions was also highlighted at the Side Event 'Aid for Adaptation: Assessing Effectiveness' held by OECD and Japan at COP23 on 8 November 2017, with contributions from Samoa, JICA, GIZ and DEVAL.
[27] Co-funded projects may report additionally under the monitoring and reporting systems of the respective donors.

results in organizations with a large adaptation portfolio is therefore to achieve a certain level of adaptation monitoring through mandatory and established M&E systems and to complement them with specialized approaches whenever this is deemed useful. These additional approaches can build on those presented in sections 4 to 7 or be specific to a particular organization, such as the methods to measure the resilience-building of World Bank operations (World Bank, 2017) or those of the BRACED programme (BRACED, 2015).

Adaptation M&E approaches need to consider the practical realities of development cooperation

Beyond the conceptual challenges inherent in measuring vulnerability, risk and resilience, the pilot applications at GIZ also point to the limitations stemming from the procedures and operational context of development cooperation. They refer in particular to timing and budgeting. With regard to timing, comprehensive data-gathering for VA/RAs or impact evaluations may only be possible once a project is fully operational, i.e. once the budget can be accessed and staff are in place. For newly established projects, the time it takes to get started and procure a service provider for detailed studies may lead to the results only being available at the end of the first year. This could be a structural barrier for some M&E approaches in short-term projects, since the time between initial and final data-gathering could be too short. Similarly, M&E activities beyond a project's lifetime generally depend on continuing support from related projects or from GIZ's respective country office or global department. A good example is the impact evaluation of GIZ's adaptation and biodiversity project in Morocco (see section 6), where GIZ's ongoing thematic cluster on environment and climate change in the country has been supporting the evaluation since the project closed. In more unfavorable conditions, an evaluation after a project's lifetime may not be possible. The institutional arrangements, combined with the time lag between interventions and the occurrence of results, may therefore prevent a full accounting of the adaptation benefits. It should also be noted that more complex M&E approaches require significant resources, including staff time. Significant expenses, such as those for empirical impact evaluations, typically need to be earmarked at the beginning of a project or even in its design phase. Therefore, a clear mandate on behalf of the project partners and the commissioning party are required to devote resources to M&E. These practical constraints need to be considered in the development of adaptation M&E approaches in order to increase their feasibility in the field. This might mean accepting that certain ideal conditions may not be achievable, for example, those for randomized controlled trials (GIZ, 2012). Overall, the requirements for and costs of adaptation M&E beyond those for regular RBM need to be balanced with the value of the generated information and its take-up within the organization and beyond.

Adaptation outcomes are difficult to put into a single figure, and doing so may not be meaningful

Adaptation is a context-specific endeavour that can be expressed through multiple concepts like risk, vulnerability or resilience, each of which can be operationalized differently. The plurality of concepts, contexts and cognitive aspects that determine adaptation 'success' points to the fallacy of searching for a single global metric. In fact, measuring adaptation outcomes differs substantially from measuring mitigation, because mitigation can be described in physical units like tons of avoided CO_2-equivalent emissions, whilst adaptation occurs largely as combination of social and physical factors in a particular situation (Leiter &Pringle, 2018). The experience of GIZ in piloting outcome-focused M&E approaches likewise showcases the limitations of generating a single figure for adaptation. Monitoring climate vulnerability or risks over time can yield an overall index score, but its aggregation masks the actual causes underlying its change, including external factors that may not have been accounted for in the VA/RA. Accordingly, the authors of the Vulnerability Sourcebook caution against interpreting the effect of an adaptation measure at the aggregate level, and instead advise analysing individual indicators or components, rather than the overall score (Fritzsche et al., 2014,p. 158ff.). This aligns with studies examining the use of vulnerability indices which found that underlying indicators offer more useful information for decision-making than the index score itself (Preston, Yuen & Westaway, 2011; Brooks et al., 2005). Organizations should therefore balance demands for easily quantifiable numbers against their meaningfulness. If aggregation is being carried out, proper guidance on data gathering and interpretation should be provided. It should also be remembered that different M&E purposes require different types of information with different degrees of detail. Aggregate indicators or indices condense a lot of information into one figure, which may respond to communication or accountability purposes, but does not assist adaptive management or learning due to a lack of detail.

Clear guidance is needed to apply indicators in a coherent way

GIZ's experience with aggregate indicators at the portfolio level (section 7) further illustrates the pitfalls of aiming for a single indicator to express adaptation results. Identifying an indicator that is applicable to a broad portfolio ranging from global knowledge exchange to local support for climate-sensitive water management necessitates a lowest common denominator approach. If at the same time the effort required for data gathering is meant to be kept to a minimum, then this leads almost automatically to output-based indicators like 'number of beneficiaries' or 'number of policies/tools/trainings'. Interestingly, the experience of GIZ's two corporate-wide surveys shows that even such seemingly straightforward indicators can pose challenges. As part of the online survey, the heads of all adaptation-related projects were asked to estimate their contributions to the indicator 'How many people were better protected against the impacts of climate change with support from your measure or project between 2010 and 2015?' If the interpretation of what to classify as 'better protected' is left to the survey participants, then the results may not be comparable and might eventually turn out to be unusable. Despite the indicators not being directly linked to performance measurement, the desire to report good results can still distort the data. The lesson learned is twofold. First, adaptation M&E is not just about identifying indicators, it also involves facilitating their application from data-gathering to interpretation. Second, if data is gathered in a decentralized way, such as self-reporting by projects, accurate measures need to be taken to ensure the reliability and validity of the results.

9. Conclusion

Based on the need to clearly assess and communicate the results of its adaptation projects and portfolio, GIZ has integrated adaptation into its existing M&E systems whilst also piloting innovative approaches to quantify the outcomes of adaptation. The experience of GIZ offers valuable lessons for other organizations with adaptation portfolios, in particular:

1. Measuring adaptation results is not just about formulating indicators, but about how to embed adaptation into project design processes and M&E systems.
2. Instead of aiming for an all-purpose set of adaptation indicators, M&E methods and indicators need to be targeted to specific information needs.
3. Comprehensively assessing adaptation outcomes presents a challenge to traditional RBM approaches and may require them to be supplemented by specialized M&E approaches.
4. Established procedures for planning and M&E in large organizations and the practical context of development cooperation need to be taken into account in order to pursue adaptation M&E effectively.
5. The requirements for and costs of M&E need to be balanced against the value of the information generated.

Assessing the results of adaptation interventions and demonstrating that adaptation successfully safeguards sustainable development is an important task. The innovative approaches piloted by GIZ mark a step in this direction, but greater efforts are needed by governments, donors, implementers, civil-society organizations and academia at all levels to comply with the demands for M&E and transparency under the Paris Agreement (Möhner, Leiter & Kato, 2017). Organizations should identify suitable ways of conducting adaptation M&E that fit their operational contexts and respond to their information needs. The experiences GIZ has gained since 2011 may inform other organizations embarking on this path.

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Indicators for monitoring and evaluation adaptation within health systems

Abstract

Assessing the ability of communities and nations to prepare for and effectively respond to the health risks of a changing climate over time requires identifying a set of indicators for monitoring, evaluation and learning (traditionally called M&E). M&E also can facilitate identifying good practices for replication and scaling up. There is a long history of monitoring health-outcome specific morbidity and mortality (e.g. the burden of climate-sensitive health outcomes) and of identifying individuals, communities and regions that are particularly vulnerable to climate-related hazards. In addition to traditional indicators that measure health outcomes (e.g. morbidity and mortality), indicators are needed for factors that affect individual and societal vulnerability to the hazards associated with a changing climate, and for the process of increasing resilience to the health risks of climate change. These process indicators can be categorized into 1) indicators for health-system preparedness, including the effectiveness of the process of adaptation and the extent of human and financial resources, and 2) indicators of coordination and collaboration across scales and sectors. Health-system indicators should be embedded within a set of national indicators of the overall risks of and effectiveness in managing the challenges presented by a changing climate.

Acknowledgement. The author would like to thank Dr. Kathryn Bowen for her very helpful review and comments.

1. Introduction

Monitoring and evaluation, and their associated indicators, are a standard approach whereby health systems (1) measure trends in the burden of health outcomes at national and local scales; (2) provide results-oriented evidence of the extent to which a program or project achieved its objectives within the allotted timeframe and with the allotted budgetary and other resources; and (3) measure progress against goals and targets, such as the Sustainable Development Goals.

Policy- and decision-makers in local and national health systems, and in climate change teams, are implementing health-adaptation policies and measures to address current and projected risks. Further information is needed on a range of issues to facilitate identifying and implementing effective and efficient policies, including:

- The magnitude and pattern of current health impacts.
- Projections of how risks could shift over the coming decades under a range of climate and development scenarios at geographical and temporal scales of relevance for the decision under consideration.
- Methods and tools to evaluate the success of health-adaptation programs and projects, including identifying best practices for interventions to reduce current impacts and manage future risks.
- Estimates of the extent to which additional interventions are needed to manage the residual risks that will arise.

Climate change entails unique challenges, including: (a) inherent uncertainties about the magnitude, pattern and rate of climate change; (b) the consequences of a changing climate for multiple drivers of health outcomes, such as food security; (c) weather patterns continuing to change until mid-century, no matter to what extent greenhouse gas emissions are reduced in the short term; and (d) the magnitude and pattern of health risks past mid-century being determined largely by the extent to which emissions are reduced over the coming decades and to which health systems are strengthened to manage current risks and prepare for projected ones (IPCC, 2014).

Health indicators can be used to evaluate progress in reducing the burden of climate-sensitive health outcomes and increase the resilience of individuals, communities and nations to manage likely future risks. A set of minimum indicators, similar to those defined for measuring meteorological and climatological variables, along with the means of verification, are needed to establish baselines against which to measure success. Health adaptation programs and projects use indicators to track the achievement of specific outcomes, to facilitate changes that increase resilience beyond the project timeline in the populations and regions under study. That is, adaptation programs and projects should not just produce an output (e.g. an early warning system), but also facilitate the process of adaptation to ensure longer-term resilience (e.g. ensure that institutional agreements are in place to support data-sharing and analysis, and that there are commitments to maintain sufficient human and financial resources).

2. Developing indicators of the health risks of and adaptation to climate change

With more than 150 years of experience in identifying and responding to health threats locally and internationally, health systems are well placed to monitor the burden of climate-sensitive health outcomes and certain aspects of individual and community vulnerability to those risks. The monitoring and surveillance of health outcomes are key public health activities, as is measuring the effectiveness of interventions to reduce current health threats. However, until recently, these monitoring programs and their associated indicators were developed without considering the risks associated with a changing climate. As monitoring programs and indicators were typically based on assumptions that health-system interventions would reduce risks over time, monitoring and evaluation have been more focused on documenting the successes of interventions than on understanding and supporting the process of iterative risk management for complex issues such as climate change. Because climate change cannot be reduced over the next few decades, health risks will increase if no additional policies and measures are implemented to reduce the burdens of climate-sensitive health outcomes. Iterative risk management is explicitly designed to incorporate the changing hazards associated with climate change into a process of preparing for and managing health risks over time (Ebi, 2011; Hess, McDowell, & Luber, 2012; Kennel,Briggs, & Victor, 2016). Key elements of an iterative risk management cycle include identifying risks, vulnerabilities and objectives, decision-making criteria, implementation (including the monitoring of decisions) and analysis (IPCC, 2014). Indicators should track progress in each component.

3. Categories of indicators of the health risks of and adaptation to climate change

Four general categories of indicators for health systems are proposed: (1) the burden of climate-sensitive health outcomes; (2) health vulnerability to climate variability and change; (3) health adaptation and resilience; and (4) coordination and collaboration across scales and with other sectors.

3.1 Indicators of the burden of climate-sensitive health outcomes (e.g. health outcomes and impacts)

3.1.1 Review of indicators of the burden of climate-sensitive health outcomes

Developing indicators of the burden of climate-sensitive health outcomes began relatively recently (cf. English et al., 2009; Cheng & Berry, 2013). A systematic review by Cheng and Berry (2013) evaluated 77 climate-change and health-outcome indicators based on their specificity, availability, feasibility, quality, comparability over time and place, and relevance to planning in Canada. Eight indicators scored high enough to be included in the final basket of indicators. These focus on the burden of climate-sensitive health outcomes: excess daily all-cause mortality due to heat (modelled); premature deaths due to ozone and particulate matter (PM 2.5) (modelled); preventable deaths from climate change (modelled); disability-adjusted life years lost from climate change (modelled); daily all-cause mortality (trends associated with heat and air pollution); daily non-accidental mortality (trends associated with heat and air pollution); West Nile disease incidence in humans; and Lyme borreliosis incidence in humans.

The United States developed a similar list of indicators, including heat-related deaths, heat-related illnesses, heating and cooling degree days, Lyme disease, West Nile virus and ragweed pollen season (US EPA, 2016). These indicators were based on surveillance data and programs. Although just a fraction of the wide range of climate-sensitive health outcomes of concern, they represented a sensible start based on the available data.

Recently, the Lancet Planetary Health Commission developed indicators to track progress on health and climate change (Watts et al., 2016). The outcome of this process will be indicators whereby routine surveillance would capture data on relatively fine spatial and temporal scales. Countries will likely need to supplement these basic indicators with other indicators relevant to the health outcomes of concern and to their capacity with respect to monitoring and surveillance. Seven indicators were proposed that focus primarily on exposure to changing weather patterns as opposed to changes in the prevalence and incidence of climate-sensitive health outcomes. These include exposure to temperature change, exposure to heatwaves, changes in labor productivity, exposure to floods, exposure to drought, changes in the incidence and geographical range of climate-sensitive infectious diseases, and food security and undernutrition.

3.1.2 Indicators of the burden of climate-sensitive health outcomes

A preliminary set of proposed baseline indicators of the burden of climate-sensitive health outcomes for which information is likely to be available for many countries include:

- Excess mortality associated with exposure to periods of high ambient temperature
- Number of people and communities exposed to extreme weather and climate events (floods and drought)
- Changes in the incidence and geographical range of climate-sensitive infectious diseases, with specific diseases chosen depending on which are important or expected to be important in a country or region
- Undernutrition (generally measured as stunting)
- Years of life lost (or a comparable metric) from climate variability and change (modelled).

Most of these indicators are specific to a health outcome, while the years of life lost from climate change is an aggregate measure of the overall burden of disease that could be attributed to a changing climate. Other indicators can be added, depending on climate-related exposures in a region that can cause adverse health outcomes, such as injuries, illnesses and deaths attributed to wildfires, or the numbers of asthmatic episodes associated with high pollen events.

The goal is to use routinely collected data to analyze the changing burdens of disease over time. Analyses could focus on overall reductions in the numbers of cases of these climate-sensitive health outcomes (or the numbers of people exposed to extreme events) and/or on changes in the slope of the association between a hazard and its health outcomes over time. For example, the number of people exposed to heatwaves may stay the same or increase over time, but effective adaptation would decrease the rate of adverse health outcomes.

There are multiple sources of surveillance data. The World Health Organization,[1] the World Bank[2] and the University of Washington Institute for Health Metrics and Evaluation (IHME),[3] among others, provide country-level data on deaths, disability-adjusted life years lost (DALYs) and life expectancy. Through IHME, for example, data are available at the national level from 1990 onwards for 249 causes of death. These data could be used to quantify changes in the burden of disease over time.

3.2 Indicators of health vulnerability to climate variability and change

Vulnerability indicators are designed to assist health officials and others to identify populations that are particularly at risk of adverse health outcomes because of climate change. Indicators of vulnerability to the health risks of climate change are, in many instances, already being collected, such the numbers of those living in poverty and the numbers of children and pregnant women. In addition, countries collect data on access to health-care services, the status of the public health infrastructure, access to and quality of education, the availability of resources and other factors that determine vulnerability (WHO, 2013). Indicators of relative wealth or poverty provide information on socioeconomic factors that can interact with climate-related hazards in determining vulnerability and sensitivity. Geographical indicators of increased risks for specific climate-sensitive health outcomes due to, for example, the baseline climate or location provide additional information on vulnerability. Instead of developing new indicators, it would be helpful to determine which factors are being monitored by local and national governments.

3.3 Indicators of health adaptation and resilience

There is limited consensus on the criteria for determining whether an adaptation program or project is a success, with evaluations taking different approaches depending on the intended goals (Lamhauge, Lanzi, & Agrawala, 2013). For projects that focus on short-term activities, indicators of success are typically observable, concrete measures (e.g. early warning system implemented; number of people trained). However, these indicators provide limited insights into the extent to which the program or project increases longer-term resilience. Indicators need to measure adaptation as an outcome (e.g. adapted to a risk) and a process. Process indicators also are needed to monitor the extent to which sufficient human and financial resources are available to support adaptation programs and projects.

Local and national indicators (and means of verification) are needed to measure the extent to which public health and health-care policies and programs:

- Assess and manage climate-related risks from a systems perspective, taking into consideration the multiple environmental and social drivers of the geographical range, seasonality and incidence of health outcomes
- Design, implement, monitor and evaluate interventions using projections of health impacts under different climate and socioeconomic futures
- Explicitly incorporate learning (informed by monitoring and evaluation) into iterative management cycles, building capacity for further adaptation as the climate continues to change.

The requirements of selected indicators are likely to change over time, so there should be a process for reviewing and modifying indicators as needs change. Indicators are also needed to monitor the process of adaptation, including the commitment (human and financial resources) of health systems to managing the health risks of climate change, coordination and collaboration with other sectors and with the national / regional climate change team, the extent to which environmental information is used proactively to reduce the burden of climate-sensitive health outcomes and other metrics to evaluate the success of iterative risk management. Indicators could track progress in integrating health into National Adaptation Plans through the Paris Agreement and Nationally Determined Contributions, as well the extent to which they are being implemented.

3.3.1 Health system preparedness, including indicators of the effectiveness of the process of adaptation

Adaptation indicators are needed to describe the capacity of health systems to prepare for and manage the risks of climate change (e.g. adaptive capacity). Examples include:

- Monitoring the frequency with which vulnerability and adaptation assessments are updated

[1] http://www.who.int/healthinfo/statistics/en/
[2] http://datatopics.worldbank.org/hnp/
[3] http://www.healthdata.org/

- Incorporation of health into national adaptation plans, including monitoring the frequency with which these are updated
- Extent and effectiveness of plans incorporating climate resilience measures in water safety plans, infectious disease control programs, etc.
- Effectiveness of measures implemented to manage climate-sensitive health outcomes, including the success or otherwise of approaches to adaptive management; the extent to which adaptive capacity is being built based on the number of people trained following a project; and related issues
- Extent of participation of health professionals in local and national climate change teams
- Awareness of the health risks of climate change, as measured by the number of general practitioners and other health personnel trained on climate change; and the extent of public awareness of and actions to address the health risks of climate variability and change
- Availability of human and financial resources for adaptation locally and nationally. Plans without budgetary allocations are often not implemented or not sustainable.

Linking these indicators across local and national scales can provide a more comprehensive and nuanced understanding of where a community and nation stand in relation to the process of adaptation, progress that has been achieved and additional efforts that could be helpful.

3.4 Indicators of coordination and collaboration across scales and with other sectors

Effective health adaptation requires the active engagement of health systems with other ministries and organizations, recognizing that vulnerabilities and capacities change over time. Examples of possible indicators include: (1) the existence and effectiveness of collaborative mechanisms (e.g. memoranda of understanding) with other departments and ministries, such as meteorological services, to measure the extent to which these organizations are sharing data and coordinating efforts to manage risks that span sectors; and (2) the extent of local and national governments' commitments to climate change adaptation, for example, by incorporating adaptation strategies into development plans and budgets. Social network analysis (Bowen, Alexander, Miller, & Dany, 2014) can be used to measure the extent of coordination and collaboration across organizations and institutions.

Whilst most climate change impacts, such as the spread of disease, are indeed experienced locally, these localized impacts can have national and international ramifications requiring action beyond the local level. Indicators should monitor the extent to which local actions are embedded within national adaptation and development plans.

4. Constraints on indicator development and deployment

The complexities of climate change and the risks it presents to health and health systems result in multiple constraints on indicator development, including:

- The availability of long-term data sets to develop robust baselines against which to measure changes in the burden of climate-sensitive health outcomes and of the effectiveness of adaptation. Such data are limited in many low- and middle-income countries, and in low resource settings in high-income countries.
- Often limited data availability at finer temporal scales than at the scale of national or large sub-national regions, including the distribution of vulnerable groups within regions. Data on the number of cases of reportable health outcomes are available at national and large sub-regions within countries, but may not be available for smaller geographical regions.
- Limited data availability to develop indicators of some health risks of climate change, such as mental wellness, means that these risks may be under-represented.
- Data need to be collected using uniform definitions and methods to develop comparable indicators. However, outside the International Health Regulations,[4] definitions and methods in collecting health data vary.
- One inherent uncertainty is what indicators will be needed as the climate continues to change and health risks emerge (Smith et al., 2014).
- Better understanding is needed of the multiple drivers of adverse climate-sensitive health outcomes and how they could interact with climate change and development scenarios in ways that could alter risks over time. Understanding is needed of how the multiple upstream drivers of adverse health outcomes could interact in ways that could alter health burdens. For example, the top five upstream drivers of infectious disease threats in Europe are (in order) travel and tourism, food and water quality, natural environment, global trade, and climate

[4] http://www.who.int/topics/international_health_regulations/en/

(Semenza et al., 2016). This suggests that indicators in health systems need to be linked with indicators in other sectors to ensure that information is collected to support efforts to prevent possible future outbreaks of disease.
- Developing, monitoring and evaluating indicators of risks and of the effectiveness of adaptation options requires human and financial resources. Although there is widespread agreement of the importance of M&E within health systems, the extent to which expertise and financial resources are available is highly variable. Adaptation funding under the United Nations Framework Convention on Climate Change carry requirements for M&E that can be supportive during projects.

Developing and maintaining the requisite datasets requires investments in surveillance and monitoring programs, and in capacity-building in resource-constrained situations to implement and maintain these programs and associated analyses (Dowell, Blazes, & Desmond-Hellmann, 2016). It would be useful to prioritize projects that address urgent and immediate needs or that provide multiple benefits (e.g. win-win).

Indicator development should consider more than just the data needed for M&E of the health risks of and adaptation to climate variability and change. National policies and institutions can affect local vulnerabilities and the capacity to respond to climate change-related threats. National priorities, constrained national human and financial resources, and other factors influence the extent to which a nation focuses on addressing the poor and underserved regions that are most likely to be affected by climate variability and change. Historically, for example, choices regarding the locations of critical infrastructure have been made without considering the potential consequences of increases in the intensity of extreme weather and climate events. Further, international donors can influence national development priorities, which can have consequences for local vulnerabilities. Therefore, indicator development should consider the broader forces that could affect future burdens of climate-sensitive health outcomes and the effectiveness of adaptation.

5. Research needs

Investigations are being conducted into which indicators of the health risks of and adaptation to climate change are most sensitive (e.g. the extent to which the indicator accurately measures the proportion of affected individuals), specific (e.g. the extent to which the indicator measures what is intended) and useful. Research also is needed with respect to some of the constraints noted above.

Areas where research could provide insights into developing local and national indicators that measure the extent to which public health and health-care policies and programs are effective in increasing resilience to climate change, and to increase understanding and communication of the indicators, include:

(1) Designing and facilitating prioritization of the health risks of climate change over spatial and temporal scales. Health systems traditionally prioritize surveillance and monitoring based on either the current burdens of disease or the potential for infectious diseases to cause epidemics. Climate change will likely affect both, with changes in the magnitude and pattern of climate-sensitive health outcomes as the climate continues to change. Proactive prioritization using environmental information (e.g. projected changes in temperature and precipitation) could prevent morbidity and mortality.

(2) Assessing and managing risk from a systems perspective, taking into consideration the multiple environmental and social drivers of the geographical range, seasonality and incidence of health outcomes. For example, indicators are needed to monitor the robustness of health surveillance systems as climate change-related health threats emerge and intensify in some regions, including indicators of emergency preparedness to better protect population health. Research is also needed to identify key environmental variables to include in surveillance systems linked to health outcome data or to establish proxy data (e.g. pollen, harmful algal blooms).

(3) Designing and implementing interventions using projections of health impacts under different climate and socioeconomic futures to inform the implementation of new forms of surveillance or modify current forms, create early warning systems and develop other programs to avoid, prepare for and cope with the changes and new threats that are expected to arise. This includes determining how indicators can be used to identify disease thresholds in different geographical regions. This may be most effectively achieved through the co-design of indicators with stakeholders (Kenney, Janetos, & Lough, 2016).

(4) Explicitly incorporate learning (informed by M&E) into iterative management cycles, building the capacity for further adaptation as the climate continues to change.

(5) Effectively communicating indicators to health-system professionals, the public and other stakeholders.

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ISBN: 978-87-93458-27-7