Universal metrics to compare the effectiveness of climate change adaptation projects

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Abstract

Adaptation to climate change is increasingly supported through international financing. In contrast to mitigation, where the effectiveness of policy action can be measured through the metric "tonnes of CO_2 equivalent reduced", no universally accepted metric for assessment of adaptation effectiveness exists. Without such a metric, adaptation finance vehicles such as the Adaptation Fund under the Kyoto Protocol encounter challenges when trying to compare the adaptive effect of ongoing or proposed projects in order to achieve an efficient allocation of their funds. The first experiences with adaptation funding show a tendency to use intermediate outcome indicators but no final impact metrics, similar to the state-of-art in development funding. This might lead to a backlash against adaptation funding by electorates in the North if the funding cannot show clear results. We assess two possible candidates for generic adaptation effectiveness metrics: 1) wealth saved from destruction through climate change impacts, and 2) disability-adjusted life years saved (DALYs), which are widely used in public health policy analysis. Apart from those two metrics we propose to use no-harm assessments in the environmental and cultural field. We discuss uncertainties encountered in applying these metrics, including the uncertain link between commonly reported outcome indicators and our metrics for saved wealth and health. The two metrics are tested by assessing five adaptation project proposals. Finally, we line out some ideas to handle these uncertainties, e.g. the use of regularly updated sectoral methodologies and agreed climate and economic models.

Keywords: Climate change, adaptation, efficiency, parameters, project evaluation, health, wealth

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1. Climate change and the emergence of adaptation policies

Burning of fossil fuels and other human activities have led to an increase of atmospheric CO_2 concentrations from around 280 parts per million (ppm) in the preindustrial era to over 379 ppm by 2005. Global temperature increase from preindustrial levels has already reached more than 0.7°C, and temperatures are expected to further raise 1.1-6.4 °C until 2100 leading to sea-level rise, melting of ice and changes in wind and precipitation patterns (Solomon et al., 2007).

Due to these alarming trends, anthropogenic climate change has been on the agenda of the international community for the last two decades and led to a series of multilateral treaties to address the problem. The United Nations Framework Convention on Climate Change (UNFCCC, 1992) has the ultimate objective to achieve a "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (Art. 2 UNFCCC). The Kyoto Protocol to the UNFCCC agreed in 1997 has introduced legally binding emissions targets for industrialized countries and an array of market mechanisms to reduce the costs of reaching those targets. These market mechanisms include the Clean Development Mechanism (CDM), which allows the generation of greenhouse gas emissions credits through emission reduction projects in developing countries.

While adaptation to the adverse effects of climate change has generally taken a back seat to mitigation in international climate policy, Parties to the UNFCCC and the Kyoto Protocol have increasingly realized that adaptation is vital in order to reduce the impacts of climate change that has already taken place or to which we they are committed. Therefore, in 2001 the UNFCCC has set up two funds for adaptation financed by voluntary contributions of industrialized countries – the Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF), which are managed by the Global Environment Facility (GEF). In 2007, parties of the Kyoto Protocol established the Adaptation Fund (AF) with a creative system of financing. The AF receives 2% of all emission credits (CERs) issued under the CDM, i.e. an in-kind tax on emissions credit transactions. The CERs are then sold by the Trustee of the AF (i.e. the World Bank) in tranches. However, attempts to extend this tax to other market mechanisms have failed due to the resistance of Russia and other countries in transition.

The unexpected success of the CDM has led to a substantial inflow of finance to the AF. By late February 2011, 550 million CERs had been issued and the AF thus received 11 million CERs, which currently have a market value of about 170 million USD, which is a large sum raised in only 5 years compared to the 270 million USD the LDCF and the SCCF have raised together in the last 10 years (HBS/ODI, 2011).

Besides these existing funds, the negotiations about a post-2012 climate policy regime have led to the commitment of industrialized countries to provide 30 billion $ of "fast start" financing to developing countries within the period 2010-2012. Around one third of these funds are allocated towards adaptation (own analysis using data from HBS/ODI, 2010; WRI, 2010).

Currently, projects financed with international adaptation funding are not assessed according to comparable metrics. .The guidelines used by the AF's Project and Programme Review Committee (PPRC) entail many criteria for the assessment of projects, such as economic, social, and environmental benefits, meeting national standards, cost-effectiveness, arrangements for management and monitoring etc. (AFB, 2010b). These multiple criteria are very general and do not allow to compare the concrete adaptation effect of project proposals. As another example, the GEF is missing efficiency indicators and global targets for adaptation projects (GEF, 2008).

From an economic point of view, it would be desirable to maximize the adaptive benefit achieved with the available financial resources for adaptation, especially given the limited level of these resources compared with the adaptation needs calculated by Parry et al. (2009), which are three orders of magnitude higher. This implies that funds need to be allocated to those projects/programmes that bring most benefits to economies, people and the environment, which requires first of all clear metrics of the "adaptive benefit" and secondly an evaluation of proposals with regards to these metrics.

In this paper, we try to identify universal metrics for adaptation benefits and test them by assessing existing adaptation projects. First, the lack of universal metrics, as well as its opportunities and challenges are specified. Second, we discuss how the AF and GEF evaluate their adaptation interventions and assess the currently used indicators. Third, we analyze first attempts in the literature to use universal indicators and propose two universal metrics: Saved Wealth and Saved Health. As these metrics depend on long-term results of the projects, we discuss how (measurable) outcome indicators can be linked with them. To illustrate and test our approach, we apply it to specific examples and conclude.

2. Lack of universally accepted metrics: opportunities and challenges

For projects mitigating GHG emissions a universal consensus has emerged that their effectiveness is to be measured in terms of tCO_2 equivalent reduced. This metric is used for all project-based mechanisms and allows calculating the efficiency of projects in terms of currency units spent to achieve one t CO_2 equivalent reduced.

Regarding adaptation, the situation is much more diffuse as adaptation policies just start to emerge and even basic concepts of adaptation are still contested. The 4th IPCC assessment report (Adger et al., 2007) is lamenting the lack of globally accepted and agreed indicators for vulnerability and adaptive capacity, while also noting that there is no consensus on the usefulness of such generic indicators. A 2008 workshop on adaptation metrics has not managed to identify universal metrics but only stated that good adaptation metrics should be comparable but also context-specific and developed in participatory processes (IGES and WorldBank, 2008). The lack of universal metrics has continued until today (UNFCCC, 2010a).

The skepticism against global indicators and the call for bottom-up approaches may be linked to the disciplinary background of many adaptation researchers and stakeholder: they are mainly coming from qualitative, case-study based social science. In this vein, e.g. Klein (2009) argues that vulnerability cannot just be defined by technical experts as any definitions involve value judgments. In his view, a definition rather has to evolve through a "consultative, stakeholder-driven process".

Economists have not managed to clearly specify adaptation metrics either. While there have been several highly publicized studies on the economics of adaptation (Agrawala and Fankhauser, 2008; WorldBank, 2010), they have concentrated on highly aggregated adaptation costs and did not assess how effectiveness of projects could be measured.

A recent review of approaches for assessing costs and benefits of adaptation options (UNFCCC, 2010b: 68) clearly shows that most approaches focus on either on adaptation costs or vulnerability / risk management. Only two options clearly compare costs and impacts: cost-benefit analysis (see e.g. ECAWG, 2009; Moench et al., 2009) and cost-effectiveness analysis. This situation can be compared to the early days of assessing effectiveness of emission reduction, where the metrics to compare the effect of different greenhouse gases were contested.

What may be the reasons for the lack of global indicators, apart from disciplinary backgrounds? Table 1 shows that universal metrics have both opportunities and challenges. On the political side, agreed adaptation metrics may help to improve the shared vision in the climate change regime. However, political agreement may be difficult as some metrics leave some nations better off than others.. Ethically, universal indicators may bring some transparency in assessing adaptation projects but some scholars argue that defining universal adaptation metrics will include value judgements, which raises the question which stakeholders are involved in defining the metrics (Hinkel, 2008; Klein, 2009).

The largest advantages of universal indicator are on the economic side. Promising projects and programmes may be identified ex-ante and monitoring may allow for ex-post adjustments of projects (Noble, 2008; Hallegatte et al., 2011). The main challenge here is that the prediction and measurement of indicators for adaptation is highly uncertain (Hinkel, 2008; Hallegatte et al., 2011) given the missing knowledge on climate change and its impacts, as well as the development and influence of other socio-economic variables. Hinkel (2008) argues that this makes outcome indicators for adaptation non-promising and calls for using process indicators. Hallegatte et al. (2011) are more optimistic by saying that cost-benefit analysis is a useful tool as long as uncertainty is satisfactorily addressed.

Table 1: Opportunities and challenges of universal metrics for adaptation

	Opportunities	**Challenges**
Political view	Shared vision of adaptation goals	Choosing indicators will make some nations better off than others; agreement is therefore difficult (Hinkel 2008)
Ethical view	Transparent criteria for projects	Value judgments are needed (Hinkel, 2008; Klein, 2009);
Economic view	Ex-ante identification of promising projects (Noble, 2008); ex-post monitoring (Noble, 2008), ex-post corrections / adjustment (Hallegatte et al., 2011), and potentially for allocation of funds (Butzengeiger et al., 2011)	Measurement of indicators is uncertain (Hinkel, 2008; Hallegatte et al., 2011), important metrics are qualitative (IGES and WorldBank, 2008).

Concluding, the several opportunities of universal adaptation metrics justify a closer look at possible metrics. However, the challenges should not be forgotten: while the political and ethical issues are not part of this paper, we explore how uncertainty could be addressed.

3. Synthesizing three approaches for effectiveness of adaptation projects

When searching for a universal metric for the effectiveness of adaptation projects, three existing approaches are particularly relevant: vulnerability assessment, cost-benefit and cost-effectiveness assessment.

Reducing vulnerability is the shared goal of many adaptation programs and is anchored in several UNFCCC documents. However, vulnerability is not universally defined and many different vulnerability indicators and assessment exist: the Disaster Risk Index, the impact vulnerability index, the Disaster Deficit Index , UNDP's Vulnerability Reduction Assessment (VRA) scorecard and further vulnerability indicators (GEF, 2008). Politically, it has never been possible to agree on a specific indicator. Therefore, vulnerability has to be incorporated in any adaptation metric system but developing a new vulnerability (benefit) index will not solve the problem.

Another starting point for universal effectiveness metrics is cost-benefit analysis simply looking at economic benefits of adaptation projects. For example, Moench et al. (2009) discuss the appropriateness of cost-benefit analysis coupled with intense stakeholder participation and apply cost-benefit analysis for a series of case studies in India and Pakistan. In a bold study, the Economics of Climate Adaptation Working Group (ECAWG, 2009: 23) criticized the lack of a systematic way of estimating climate risks and the absence of an overarching methodology to facilitate comparisons between the risks posed by different hazards and in different geographies.. It developed a methodology that gave rise to adaptation benefit-cost curves and applied it to China, Guyana, India, Mali, Samoa, Tanzania, the UK, and the US. Such cost-benefit analysis can be criticized for often neglecting non-monetary benefits such as health, which is recognized by Moench et al. (2009: 4).

Cost-effectiveness analysis, as the third approach, includes non-monetary or difficult-to-monetize benefits as well: it identifies the least-cost method of reaching a prescribed target or risk reduction level. For instant, it is widely used in the literature on public health (see e.g. Detsky and Naglie, 1990). On the down side, cost-effectiveness analysis for adaptation was only applied in a sectoral context until now. Universal metrics are missing, which hinders to compare effects between different areas.

With the indicators to be proposed, we aim at synthesizing the three approaches: while we want to avoid the monetary-only approach of cost-benefit analysis, we also want to guarantee global comparability, currently missing in cost-effectiveness studies focusing on. Furthermore, vulnerability should be captured by the metrics as well.

As starting point, we analyze the current evaluation system of GEF and the AF, in order to identify existing metrics already used.

4. Current evaluation of adaptation projects in multilateral institutions

This chapter looks at the current evaluation system within GEF and the AFB in order to analyze currently used indicators. First, the idea of the results-chain is explained in order to illustrate how uncertainty is addressed by current evaluation systems. Second, the concrete evaluation frameworks are assessed and adaptation metrics identified.

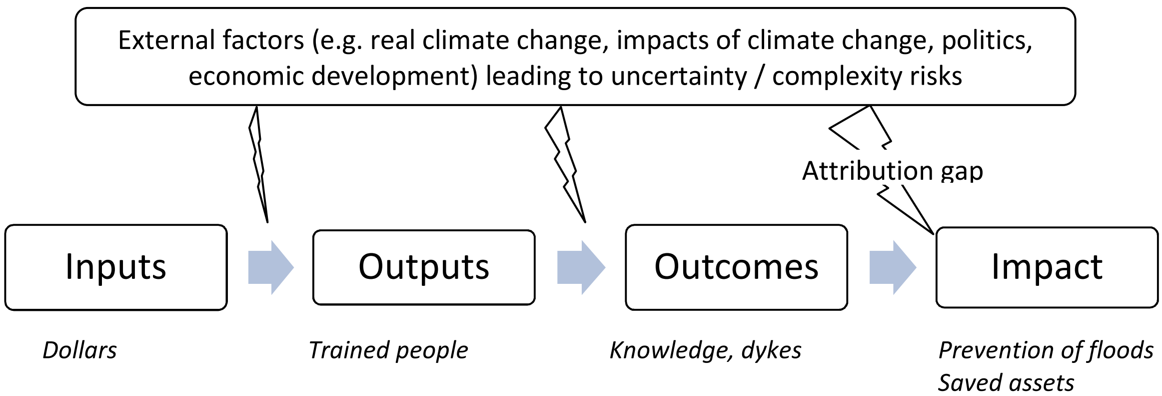
The results chain and how it addresses uncertainty

Effectiveness indicators for the evaluation of projects in multilateral institutions can be found in their Results-Based Management (RBM) frameworks. Following the introduction of performance-based management in the public sector reforms of industrialized countries in the 1990s, RBM has become popular in multilateral and bilateral development organizations (Hulme; UNDP, 2007). Both the GEF managed adaptation funds and the AF have established a RBM framework (GEF, 2009; AFB, 2010c).

A RBM framework is according to the OECD a 'strategy aimed at achieving important changes in the way government agencies operate with improving performance (achieving better results) (Binnendijk, 2001)." Therefore, the RBM does not only consist of measuring the performance of projects and programmes but also to learn and modify programme design. In the following, we will just discuss the measuring of performance or results.

Both the GEF and the AFB use the RBM terminology of a "results chain" starting with inputs, outputs, outcome, impact and finally ending with the goal, as defined by the OECD (2002), see Figure 1. *Inputs* are the financial, human, and material resources used for the adaptation intervention. They should result in *outputs*, the "products and services which result from the completion of activities (OECD, 2002)." After that, the *outcomes* follow, which are the "intended or achieved short-term and medium-term effects of an intervention's output". In the longer term, the adaptation interventions result in *impacts*, which can be positive or negative. Forces beyond the control of the project may influence impacts considerably and, therefore, an "attribution gap" arises (see Douthwaite et al., 2003).

Figure 1: Chain of results-based monitoring & evaluation in development assistance



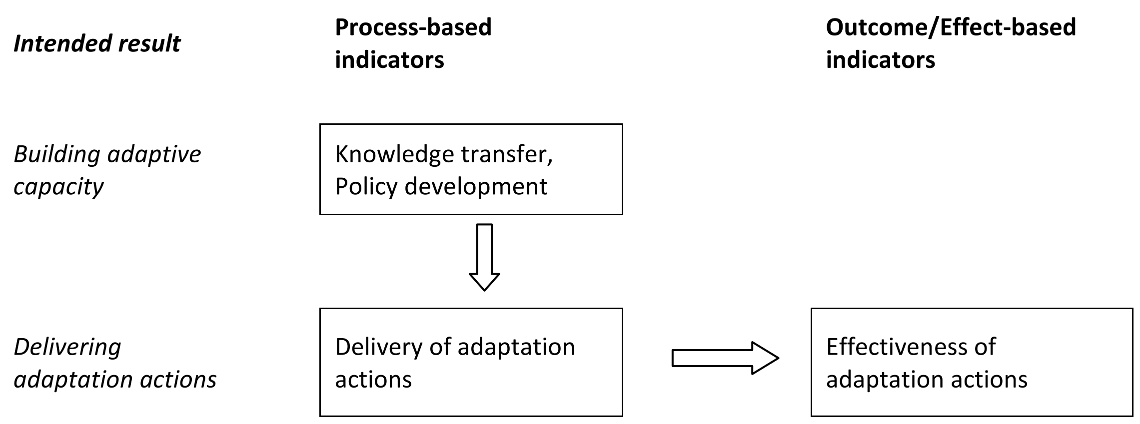
Source: Own figure (after Binnendijk, 2001; UNFCCC, 2010a), example of coastal adaptation project in italics

To illustrate the different concepts along the result-chain, we may take the example of a coastal adaptation project. The input would consist of the money and human resources invested in the adaptation project, while the output could comprise the amount of trained or informed people. The short-term or mid-term outcome could be soft skills such as enhanced knowledge on climate change induced sea-level rise or hard technology intervention such as the building of dams. In the long-term this should contribute to the protection from flooding and, thereby, saving of assets and lives, which would be the impact.

Clearly, the inputs and outputs are best under control of the project and programme managers, while outcomes and even more impacts and goals are difficult to influence and measure. The risks and "noise" of external factors (see UNFCCC, 2010a) are increasing when moving to long-term results such as impacts (Binnendijk, 2001). While multilateral institutions can measure outputs and some of their outcomes they have to make strong assumptions about external factors and risks to estimate the long-term impacts. This fact is also reflected in the proposed AFB project evaluation framework (AFB, 2011a), according to which project proponents have to discuss the risks that outcomes are not sustainable

The achievement of results (e.g. outputs, outcomes, impacts) is measured with both process and outcome/effect indicators (see Figure 2): on the one hand, so-called "process-based indicators" measure the progress in building adaptive capacity as well as developing and implementing adaptation actions, so-called "outcome-based indicators" measure the effect of concrete adaptation actions based on an actual technology intervention (UNFCCC, 2010a).

Figure 2: Process vs. Outcome/Effect-based indicators, depending on the goal of the adaptation projects



Source: Harley et al. (2008), Harley & van Minnen (2009)

When searching for universal adaptation metrics, we will focus on outcome-/effect-based indicators measuring the effectiveness and we will call them "effect-based" indicators in order to avoid confusion with "outcome" as part of the result chain, which may also include process-based indicators. In the following, we will assess, which indicators GEF and the AF use for the different steps in the result chain, and if those indicators are more process- or effect-based.

Indicators of the GEF managed funds

The GEF (2009) uses the same RBM Framework and indicators for adaptation projects for both the LDCF and the SCCF. Under this framework, eight outcome results are aimed at: climate change information, institutional capacity, mainstreaming of adaptation awareness and ownership, sectoral adaptive capacity, diversified and strengthened livelihoods, and transfer and adaption of technologies[1]. Most of the 19 indicators for outcomes are clearly process-based such as the provision of information or integration of adaptation into sectoral or development strategies.

However, on the impact-level, the only indicator - the reduction of economic losses - is clearly outcome and not process-based. Therefore, the GEF framework has a global indicator for effectiveness of adaptation projects. However, it is not clear how the economic loss savings and non-monetary benefits are assessed. Furthermore, an internal review of the RBM (GEF, 2008) criticized that the GEF has not set targets for its indicators and does not prioritize projects with a higher contribution to reaching the target.

The higher order goal is to provide support for developing countries to become climate resilient. This higher order goal of “support for resiliency” is logically not clearly a result of the impact (the reduction of economic losses), as it should be according to the theory; “support for resiliency” is rather a pre-condition of “reducing economic losses”.

Indicators of the Adaptation Fund

The Adaptation Fund strives for almost the same results and uses similar outcome indicators as the GEF in its Strategic Results Framework (AFB, 2010a)[2]. Similarly to the GEF, the overwhelming majority of the indicators are process and not outcome based.

One of the major differences to the GEF framework is the absence of any impact indicator. While “Increased resiliency to climate variability and change” is the description of the impact, it is neither clearly defined what such resiliency could mean nor is an impact indicator given. As well, the links

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[1] The outcomes contribute to three objectives: reducing vulnerability, building adaptive capacity and transferring as well as adopting technologies. The distinctions between the three objectives are sometimes unclear: e.g. some capacity building is grouped under “reducing vulnerability” rather than “building adaptive capacity”

[2] It excludes, however, the transfer and adoption of technologies with its two outcomes and five indicators, while “ecosystem services” are seen as a main outcome, which are only a subsidiary indicator for the outcome “Adaptive capacity within relevant development sectors and natural resources” in case of the GEF.

between the outcomes and the impact remains unclear[3]. Therefore, the indicator system of the Adaptation Fund covers the initial parts of the results chain and would require substantial elaboration when aiming for universal indicators.

Comparison of GEF and AFB approaches and related challenges

When comparing the two frameworks under the idea of global adaptation indicators at least three critical issues arise (marked with flash in Table 2). First, the global impact indicators are missing either altogether as in case of the AF or there is only one economic indicator which is unable to capture all benefits including health and environment as in case of the GEF. Second, even if we had global impact indicators, there are no elaborated causal links between outcome and impact concepts. Implicitly, the two frameworks assume that outcomes lead to a proportional impact beyond the "attribution gap" (Douthwaite et al., 2003). This strongly depends on the "dilution" by the multiple forces active in that gap. Third, and related to the second concern, is the focus on process- rather than outcome-based indicators in the two frameworks. The output indicators are 75-90% process-based, which is understandable as outputs are just a first step towards a longer goal. However, it is more critical that on the outcome level, still 65-70% are clearly process-based, and only 10-15% clearly results-based indicators. When measuring or estimating those process-based outcome indicators in a final evaluation, there is still a really high uncertainty regarding achieving long-term adaptation impacts.

Table 2: Comparison of GEF & Adaptation Fund Results Framework (lightning strokes mark problems)

	GEF LDCF / SCCF Results-Based Management Framework	**Adaptation Fund Strategic Results Framework**
Impact	Economic loss trend as indicator for impact, outcome-based indicator but ⚡only economic ⚡Link to outcomes unclear	Increased resiliency as impact ⚡ No indicator determined ⚡ Link to outcomes unclear
Outcome	8 different results and 19 indicators, ⚡65% are clearly process-based indicators, Link to outputs mostly clear	7 different results and 11 indicators, ⚡ 70% are clearly process-based indicators Link to outputs mostly clear
Output	8 different results and 20 indicators, 75% are clearly process-based indicators	8 different results and 16 indicators. 90% are clearly process-based indicators

Source: own table, after GEF (2009) and AFB (2010a: 6),

Reflecting these three problematic areas – lack of impact indicators, focus on process indicators and missing outcome-impact link, we will now explore universal impact metrics that meet the following

[3] Similar as the GEF, the AFB has assistance for climate resilience in developing countries as goal. Again, the goal to assist developing countries is rather a precondition for the impact (increased resiliency) rather than the result.

criteria: they should be effect- and not process-based, and they should causally be link to existing more process-based outcome indicators.

5. Two possible impact metrics

Theoretically, the effects of adaptation projects could be measured in monetary terms. This theoretical approach underlies the cost-benefit analysis approach of ECAWG (2009) which leads to a "benefit cost curve" for adaptation projects. However, a substantial share of the benefits of adaptation projects is the avoidance of direct impacts on human life and health. Then the challenge arises how to value human life and human health. Fankhauser and Tol (1998) argue that "values of a statistical life" embodying people's attitude to mortality risks should be used for that valuation. These values strongly depend on the income of the person and thus are substantially lower for a poor person than that of a rich person, varying by a factor of 15 between China and OECD countries (Fankhauser and Tol, 1998: 70)[4]. This approach thus became heavily contested in the elaboration of the 2nd Assessment Report of the IPCC, when developing country authors and policymakers strongly attacked what was seen as "Northern arrogance" (described condescendingly by Tol, 1997). As a response to the controversy, Fearnside (1998) suggested to separate human lives and property values. In our view, Fearnside's approach should be followed to avoid endless political debates about an equitable valuation of human life and health. This is also in line with UNFCCC (2010b) which stresses that pure cost-benefit analysis "fails to account for those costs and benefits that cannot be reflected in monetary terms, such as ecological impacts and impacts on health". We thus differentiate between monetary and human life/health-related benefits, in the form of two indicators.

Saved Wealth (SW)

Accumulated income not spent for consumption gives rise to wealth; this can include productive assets and other forms of property (e.g. real estate and precious metals). The indicator specifies wealth protected by an adaptation project against destruction by climate change impacts. For cross-country comparisons, Purchasing Power Parity should be used.

When assessing the wealth benefit of an adaptation project/programme one can use two different concepts: absolute wealth and relative wealth (assessed on an aggregate or individual level):.

- **Absolute wealth saved**: This approach, similar to the approach in cost-benefit analysis, measures the absolute wealth saved The concept is straightforward but does not take into

[4] Other studies even have value of a statistical life based on surveys and studies is ranging from below to over 20 Million 2000 USD (Viscusi and Aldy, 2003; Viscusi and Gayer, 2003) and he valuation is country, income, and age-dependent (Viscusi and Aldy, 2003; Aldy and Viscusi, 2008)

account differences of wealth, which might be crucial for overall resilience: Regions with a higher wealth level would be favoured. The indicator would be currency units.

- **Relative wealth saved (aggregated assessment)**: Here, the absolute wealth saved by the project/programme is divided by the total wealth of the region, city or community. This allows to cater for differences in average wealth, but does not yet cover the distribution of wealth within the project region. The indicator would be % wealth saved times population.
- **Relative wealth saved (individual level assessment):** This concept relates to the affected number of people and their individual wealth shares protected by the adaptation project. In contrast to the aggregate assessment of relative wealth, here the relative wealth is assessed on an individual level and then summed up. Data challenges are massive as every person has to be accounted individually. It might only be possible in countries with a highly efficient tax administration and no data confidentiality restrictions regarding personal fortunes. Given data constraints, the concept is more realistic, when using a city or community as individual unit: in this case, the total relative wealth saved consists of the sum of the relative wealth saved in each city or community, rather the sum of the relative wealth saved per individual.

Advantages and disadvantages of the different approaches are described in Table 3:

Table 3: Approaches to measure Saved Wealth

Concept	**Description**	**Advantages**	**Disadvantages**
Absolute wealth saved	Wealth benefit in absolute terms	Relatively easy to measure	Benefits richer countries, does not reflect vulnerability
Relative wealth saved (assessed on an aggregate level)	Wealth benefit relative to overall assets of a nation (or region, city, community), multiplied with population	Allocates (adaptation) funds to poorest countries (or regions, cities, communities)	Benefits not necessarily poorest or most vulnerable persons within a country (or region, city, community)
Relative wealth saved (assessed on an individual level)	Wealth % saved per person (or city; multiplied with population of city); individual percentages are summed up	Close to vulnerability	Data access difficult in case of individualized approach

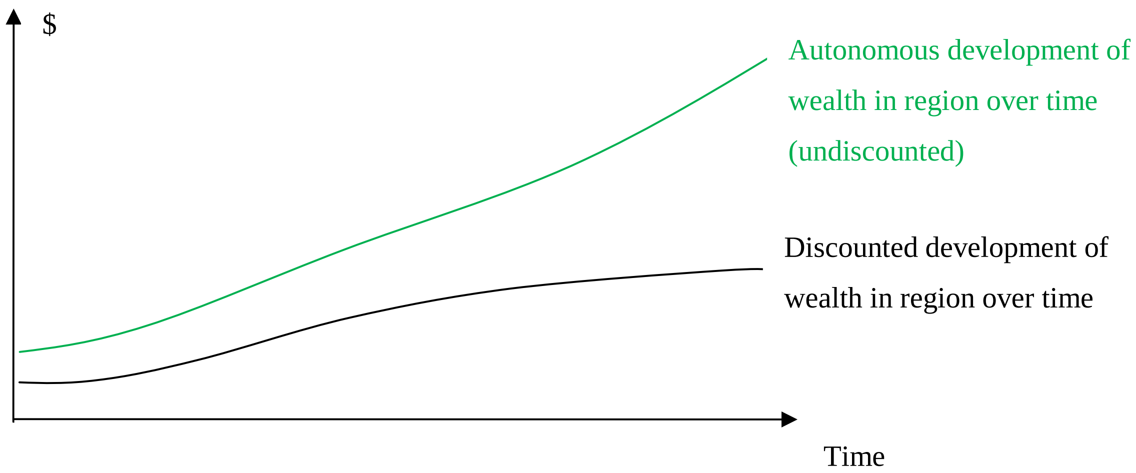
The relative wealth concept (on an aggregated basis), seems to be most adequate from a vulnerability perspective taking data availability into account. The more local the geographical scale of this relative wealth concept is, the better the concept addresses vulnerability. However, from an economic perspective, the absolute wealth concept is most appropriate as it measures the overall wealth savings (which may still be distributed). We thus propose to both include relative and absolute wealth savings in the Saved Wealth indicator in order to balance vulnerability and economics benefits.

For determining the potential of an adaptation activity to save wealth, one needs to consider autonomous developments of the wealth of the relevant region during the project duration. Demographic and/or economic developments over time will lead to changes of property, and therefore wealth under a baseline scenario.

A time-related discounting of wealth in the region impacted by an adaptation activity should take place in order to reflect inflation as well as autonomous decrease of the economic value of infrastructure and hardware over time (capital consumption, standard accruals). Discounting is also important to achieve comparability of adaptation projects with different lifetimes.

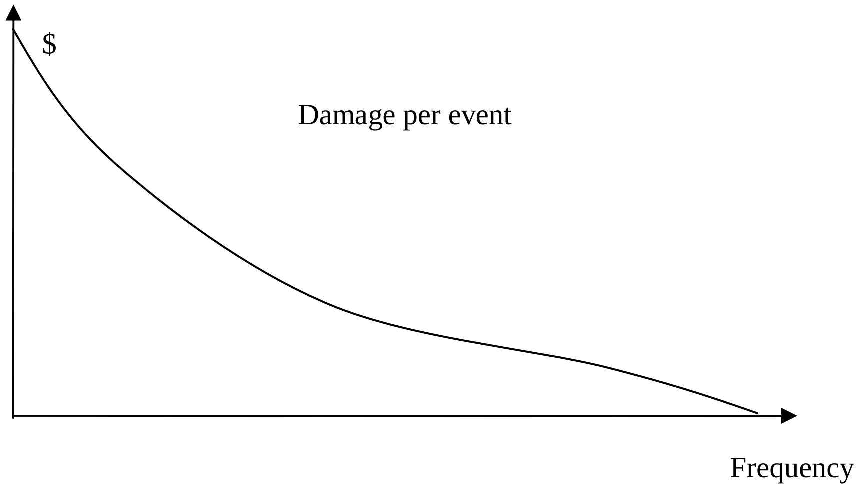
Figure 3 below visualizes the effects of autonomous development of wealth in the region over time and of discounting on Saved Wealth.

Figure 3: Change of wealth over time and discounting



The total wealth that can theoretically be saved by an adaptation activity is the discounted wealth that would be lost by climate-change induced events during the technical lifetime of the adaptation project/programme. To calculate this, one needs a frequency distribution function of climate change impacts for the duration of the project (see Moench et al. 2009 for the first conceptualization of such frequency functions, here shown in Figure 4).

Figure 4: Frequency distribution function of expected damage



Using the approach of the frequency distribution function, Saved Wealth (SW_p)[5], for a disaster risk reduction adaptation project can then be calculated as:

$$SW_p = \sum_{1}^{i} MDP_i \cdot (1 - \mathrm{r})^{\mathrm{i}} \cdot DS_i \cdot p_{occ,n,i}$$

Where:

1…i: Years of duration of adaptation project

MDP_i: Maximum Damage Potential from climate change in year i.

DS_i: Share of discounted MDP damaged by event forecast in year i

$p_{Occ,\, n,i}$: Probability of occurrence of a certain damage event n (increase of risk due to climate change) in year i.

r = Discount rate to be applied to the project

From a purely economic perspective, total damage should be assessed differentiated by whether it is due to baseline climatic variability or due to events that can be linked to climate change. For projects financed by third parties, only the differential damage due to climate change should be covered. However, differentiation of impacts from baseline climate variability, climate change and autonomous adaptation is likely to be extremely difficult.

[5] Here, for simplicity just the absolute and not the relative wealth savings are calculated.

Saved Health (SH)

As discussed above, valuation of human life is fraught with ethical challenges and thus should be avoided, especially if comparing industrialized and developing countries. In this section, we look at the concept of Disability Adjusted Life Years Saved (DALYs), which was introduced 1993 by the World Bank (WorldBank, 1993), and has since then been systematically utilized – inter alia by the World Health Organization (WHO) in the "Global Burden of Disease Concept" (GBD), which provides a comprehensive and comparable assessment of mortality and loss of health due to diseases, injuries and risk factors for all regions of the world (WHO, 2010a). It is a concept to quantify the burden of disability and death, expressed as the number of years lost due to disability and early death.

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

Where:

N: Numbers of deaths

L: standard life expectancy at age of death (in years). Here, an ethical issue is the choice of the region. From an equity viewpoint, the average global life expectancy should be chosen, whereas from a comparative economic view, the locally applicable life expectancy would be preferred.

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 reflects the severity of the disease or injury on a scale from 0 (perfect health) to 1 (dead) and have been estimated by WHO (2010b) for a wide range of diseases.

Taking the frequency distribution function approach described above (see Figure 2), for assessing the saved health for a particular adaptation activity, one needs to define a health damage frequency distribution function that quantifies the typical health damages of a given event and its frequency.

Environmental and cultural benefits

The valuation of non-monetary environmental and cultural benefits is fraught with conceptual difficulties (see e.g. Bockstael and Freeman, 2005). Fankhauser et al. (1998) describe the differences in willingness-to-pay and willingness-to-accept valuation approaches. In our view, the challenges of this approach are so high that a simple "no harm" rule should be followed for the evaluation of adaptation projects. For projects of certain minimum sizes, a qualitative evaluation system comparable e.g. to standard Environmental Impact Assessments (EIA) could be applied to check whether an adaptation project has negative impacts regarding biodiversity, soil, air and water pollution. Likewise, projects should check whether cultural heritage, be it material or immaterial would be jeopardized. Generally, an approach could be imagined where the host country of foreign-funded adaptation projects approves the ecologic and cultural sustainability; in a procedure akin to today's approval of CDM projects.

Conclusions on the proposed metrics

Obviously, introduction of the impact indicators requires highly challenging data collection exercises. Given the uncertainties of future climate change and economic development, coordinated approaches are required to prevent ad hoc choices of data that are favourable for the project developer. At first, a political agreement on the downscaled climate models used for derivation of the frequency curves of climate impacts is required. In a similar vein, forecasts for economic development need to be made consistent to allow a comparable wealth forecast. While the use of such indicators is certainly a non-perfect solution given data constraint, it is preferable to a situation where projects are evaluated according to a heterogeneous set of (often project-specific) process indicators.

Furthermore, the proposed set of impact metrics fulfils three criteria for impact metrics set out before;

1. The metrics go beyond a pure economic analysis by using a health metric (and the environmental/cultural no-harm rule)
2. Vulnerability is addressed by both including a health and a relative wealth metric
3. DALYs and the different wealth indicators are clearly effect- and not process-based indicators.

The only criterion not clearly fulfilled, is the one of outcome-impact links or in other words, how to address the attribution gap. We will address this in the following.

6. Linking of outcome indicators with proposed impact metrics

As we have argued above, the current outcome and impact indicators are not clearly linked. In this section, we will both try to link outcome indicators and impact metrics on basis of the literature, as well as setting out a proposal for dealing with these links in the future.

Links according to existing literature

The outcome indicators used here are mainly taken from the GEF RBM framework (GEF, 2008), adding the outcome indicator of "ecosystem services" from the AF strategic framework (AFB, 2010b). As impact indicators we use the two indicators proposed above.

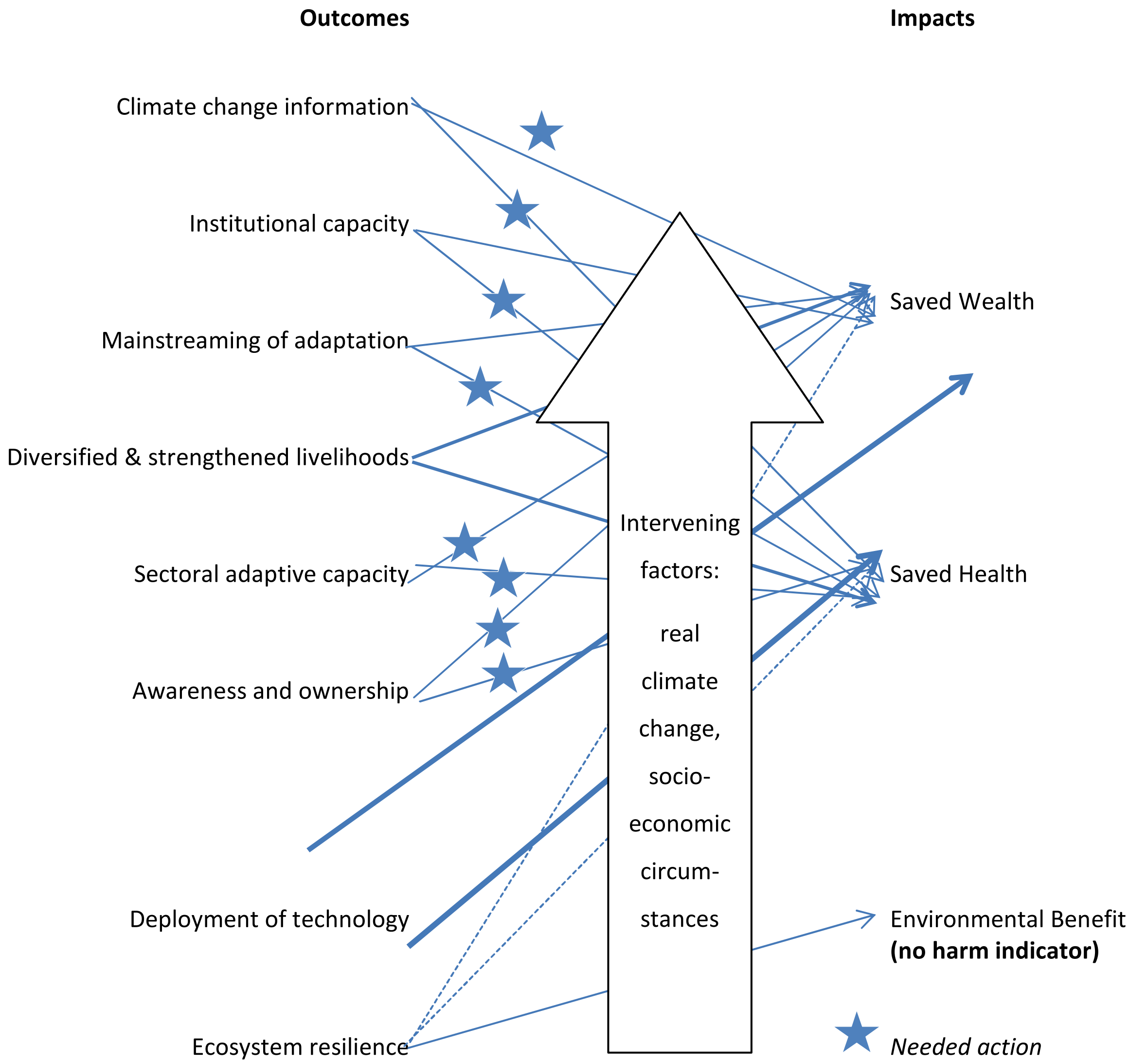
Generally, following the existing theoretical literature, we may assume that all outcome indicators have a positive impact on reducing vulnerability, which we measure here in Saved Wealth and Health. The last IPCC report (Adger et al., 2007) emphasized the relevance of all outcomes shown in Figure 5 for adaptation and reducing vulnerability.

The only one not explicitly mentioned as factor contributing to adaptation is ecosystem resilience. However, Adger et al. (2007) see ecosystem resilience as one of the goals of adaptation measures and it may be seen as directly environmental benefit. Generally, the literature is not very explicit about the size of the effects, while it becomes clear that only few effects are direct such as the use of new dam technology on saving wealth. Most links are rather indirect and require an intermediate action (e.g. the climate change information provided by an early warning system has to be put into use via disaster response actions). Furthermore, several intervening factors may reduce the strength of the theoretical link.

A key issue for outcome-impact links is the time horizon. The longer an adaptation intervention lasts, the higher is the risk that an adaptation, appropriate in the short and maybe medium term, turns into maladaptation – "changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli" (McCarthy et al., 2001). For example, an adaptation project may change the design level of water supply for an irrigation system based on the estimate of the increased river flow due to glacial melting in the catchment area. As long as the glacial melting continues, the project contributes nicely to adaptation, but once the glaciers have vanished, the irrigation system will be oversized and a water supply crisis will erupt. So in the long term, the link between outcome and impact indicators will be weakened.

A response to the risk of maladaptation could be to introduce an indicator that defines the risk of long term maladaptation and to check this indicator periodically, triggering an adjustment in the adaptation project design. In the context of the irrigation project case, the indicator would be glacier volume in the catchment area and the probable date of glacier disappearance. If for example, the glacier disappearance would be less than a decade in the future, a downsizing of the irrigation system would be started combined with an economic diversification strategy.

Figure 5: Linking adaptation project outcomes with impacts (own graph)



Dealing with causal links in the future

The assessment of the existing knowledge and the use in practice has shown that outcome-impact links are highly uncertain and prone to risks. Furthermore, new scientific evidence may change the intensity or even direction of the expected effects. Therefore, any approach to estimate effectiveness of adaptation projects with global indicators has to apply an encompassing but flexibility and permanent adaptability, as also called for by Hallegatte et al. (2011).

We propose a four-pronged approach to guarantee the flexibility. First, as start, the intermediate steps between outcome and impact indicators have to be elaborated more in detail. This idea is similar to the concept of secondary outcomes as proposed by the AFB (2010b). Secondly, the intervening variables enabling or hindering an effect to take place have to be identified and potentially measured or estimated. Third, all links and assumptions are to be seen as best assumption for-the-time-being. As soon as new scientific evidence is available, the assumptions have to be changed. Fourth, the outcome (and output) indicators as set out here are to be complemented or replaced by other indicators, if scientific studies show the importance of further indicators. In the end, various approaches and ways may lead to the desired results. Certainly, the current eight or nine indicators are too broad if applied to specific sectors. An example of refined indicators per sector is given by Schönthaler et al. (2010).

How can this encompassing and flexible approach be achieved institutionally? One idea is to elaborate specific causal-chain methodologies for each sector or even better for each project type, similar to the methodologies in the CDM (see Michaelowa, 2005). Methodologies could be elaborated by the Adaptation Fund itself, country programme managers, international organizations or academic experts. Each methodology would have to be approved by the AFB and revisions can be proposed by stakeholders or the AFB itself at any time, as long as they are based on the newest scientific findings.

7. Application of framework to specific examples

In order to illustrate and test the applicability of the proposed impact metrics and their relation to the outcome, we assessed five adaptation projects. For the assessment we use information in the official project proposals downloaded from the Adaptation Fund website at the end of February (AFB, 2011b). No external sources were used to verify the information, which means that the following results are more indicative than precise.

Table 4 shows the predicted benefits of the 5 projects when assessed against our metrics.

Relating to *absolute saved wealth* (measured in annual $ saved per $ of requested grant), project A has the highest score, followed by D and C. The other two projects did not give any information on absolute saved wealth. Where absolute wealth benefits were given, justification was mostly scarce and the assumptions were not fully specified. Projects report saved wealth not over the total project lifetime but only per year, which raises the question how long a project will last.

Relative wealth saved is measured here in number of persons, which's personal income is saved per Million $ of requested grant[6]. Here, project E scored highest before projects C, E and D. For project B the factor could not be calculated as numbers of beneficiaries and absolute saved wealth are missing. Interestingly, project C is performing better on this relative wealth indicator than project D, where as it is the other way round in case of absolute wealth saved. The reason is both higher number of beneficiaries and lower income in case of project C.

Finally, when assessing *health saved*, measured in DALYs saved per Million $ of requested grant, we find no data in the project documents. For project E we know the number of beneficiaries with

[6] This relative wealth number was calculated as share of average income saved multiplied with the number of beneficiaries. Therefore, aggregate wealth numbers were used, as individual wealth numbers are not available. Average income was assumed to equal the national GDP per capita using data from the World Bank (2011).

malnutrition, and assuming a disability weight of malnutrition of 0.3 we can estimate the number of DALYs saved.

Table 4: Assessment of 5 real-world adaptation projects against proposed metrics

Metric	Unit	Project A	Project B	Project C	Project D	Project E
Beneficiary intensity	Persons with improved livelihoods / million $	22,600	Not reported	950	50	26,850
Wealth saved -absolute	$ saved p.a. / $	6	Not reported	0.3	0.7	Not reported
Wealth saved – relative (aggregate level)	# of personal wealth saved/ million $	5,000	Not reported	700	75	[530]
Health saved	DALYs / million $	Not reported	Not reported	Not reported	Not reported	120,000
Environmental benefits	[qualitative scale]	Positive	Positive	Positive	Slightly positive	Positive

Source: own assessment, using project documents from AFB (2011b). As numbers given here are based on low-quality data and rather illustrative, neither the country nor the requested funding is given here to guarantee anonymity

The numbers given here would indicate that projects A & E perform highest on the adaptive benefit, before projects C and D. Deciding on the exact rating for the adaptive benefit will depend on the political weighting of different indicators. Environmental no-harm is never a critical issue, as all projects show significant positive environmental benefits. Interestingly, the low rating of project B is consistent with a general review of the projects (not indicator-related).

Table 5 shows the assessment of predicted outcomes for these five projects. Two major challenges arrived: First, the projects do not report the standard AFB outcome indicators but project-specific ones. Secondly, information on the projected achievements is of low quality due to non-transparency on assumptions. Due to these challenges and the small sample, it is not possible to thoroughly analyse the interrelation between the outcome and our proposed impact indicators. Nevertheless, we make some observations: the project A, performing well with our impact indicators, has also most high ratings on outcome indicators, while project B has also most low ratings.

Table 5: Assessment of 5 real-world adaptation projects against standard outcome indicators

Outcome / Indicator	**Project A**	**Project B**	**Project C**	**Project D**	**Project E**
CC information / Relevant threat and hazard information generated and disseminated to stakeholders on a timely basis	Partly fulfilled	Partly fulfilled	Partly fulfilled	Fulfilled	Partly fulfilled
Institutional capacity / No. of targeted institutions with increased capacity to minimize exposure to climate variability risks	Fulfilled	Fulfilled	Partly fulfilled	Fulfilled	Partly fulfilled
Awareness &ownership / Percentage of targeted population aware of predicted adverse impacts of climate change, and of appropriate responses	Partly fulfilled	Hardly fulfilled	Fulfilled	Partly fulfilled	Partly fulfilled
Sectoral adaptive capacity / Physical infrastructure improved to withstand climate change and variability-induced stress	Hardly fulfilled	Partly fulfilled	Fulfilled	Fulfilled	Fulfilled
Ecosystem resilience / Ecosystem services and natural assets maintained or improved under climate change and variability-induced stress	Fulfilled	Fulfilled	Fulfilled	Partly fulfilled	Fulfilled
Diversified & strengthened livelihoods / Percentage of households and communities having more secure (increased) access to livelihood assets	Fulfilled	Hardly fulfilled	Partly fulfilled	Partly fulfilled	Fulfilled
Mainstreaming of adaptation / Climate change priorities are integrated into national development strategy	Fulfilled	Partly fulfilled	Partly fulfilled	Partly fulfilled	Partly fulfilled

Source: own assessment, using project documents from AFB (2011b). As numbers given here are based on low-quality data and rather illustrative, neither the country nor the requested funding is given here to guarantee anonymity. Only own indicator was chosen per outcome; the following ones were omitted: number of people with reduced risk to extreme weather events, modification in targeted population behaviour, development sectors' services responsive to evolving needs from changing and variable climate, percentage of targeted population with sustained climate-resilient livelihoods.

This illustrative analysis of five adaptation projects has revealed three major problems: missing data on impact indicators, missing assumptions and inconsistency between AF/GEF indicators and the one used by projects. For making global metrics feasible, AF projects would have to be obliged to use agreed outcome indicators and to report on promising impact indicators to assess their feasibility before introduction.

8. Conclusion and discussion

In contrast to climate change mitigation, the effectiveness of adaptation projects so far is not evaluated according to universally accepted metrics. As adaptation so far was the “step child” of the climate regime, it was mainly treated as a by-product of development assistance and thus the evaluation procedures of development assistance projects have traditionally been used. These procedures are based on a “results chain”, with a series of indicators from input to project impacts. The key feature of this chain is the “attribution gap” between outcome and impact indicators, which is due to the effect of many non-project related influence on the level of the impact indicators.

Adaptation has now become a full strand of international climate policy with the setup of funds that are to finance adaptation projects, as well as with the “fast start” financing of industrialized countries for climate-change related activities in developing countries. We find that all the funds focus mainly on output and outcome indicators, with very few impact indicators being used.

To avoid a situation where adaptation funding is essentially distributed in a “first come, first serve” mode, it is imperative to agree on one or a set of indicators that allow a choice of adaptation projects according to their effectiveness per unit of money invested. A single, universal indicator is not possible due to the challenges in valuating protection of human lives and health. We therefore propose two main indicators: one assessing economic assets saved from destruction by climate change impacts (Saved Wealth) and one calculating human lives and health protected (Saved Health). The former indicator is a combination of two values, one of which is the absolute value of wealth saved, while the other looks at the relative wealth saved. This is done in order to take into account vulnerability. The latter indicator uses the concept of disability-adjusted life-years saved (DALYs).

The indicators are calculated in a procedure that first estimates the expected wealth existing in the project area over time. Subsequently, the expected climate change damages during the lifetime of the adaptation project are calculated to set the baseline. A frequency distribution of damaging events is used for this purpose. Finally, the remaining damages after implementation or the project are assessed.

To reduce uncertainties that may make the indicator calculation irrelevant, coordinated approaches for the determination of wealth forecasts and damage frequency curves are required. A political agreement on the climate and economic models used would help. Here, the regulatory structure for the evaluation of emissions mitigation projects in the context of the Clean Development Mechanism could serve as example. As an initial step, the indicator systems of adaptation funds should be oriented versus outcome indicators. Moreover, indicators should periodically assess the risk of maladaptation, especially for projects with a very long lifetime. The links between outcome and impact indicators should be studied in more detail.

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Annex

LDCF/SCCF Result-Based Management Framework Adaptation to Climate Change (simplified)

Goal: Support developing countries to become climate resilient by integrating both immediate and longer-term adaptation measures in development policies, plans, programs, projects and actions

Expected results	Indicators
Impact: Reduced absolute economic losses at country level due to climate change, including variability	Economic loss trend over a project period and beyond due to climate change, including variability
Outcomes: 8 different ones: *Increased knowledge, general adaptive capacity*, **awareness and ownership** , *mainstreaming in broader development plans*, **diversified and strengthened livelihoods, sectoral adaptive capacity**, enabling environment for technology transfer; demonstration, deployment, and transfer of technology	19 different ones: **threat and hazard information**, perception index; **no. of targeted institutions**, capacity perception index; Reduced losses per weather events; **% of targeted population aware**; % of population affirming ownership; Adaptation actions implemented according to plans; % of frameworks / strategies that reach adaptation targets; **development sectors responsive to needs**; Physical infrastructure maintained; **Ecosystem services and natural assets maintained; more secure access to livelihood assets; sustained climate-resilient livelihoods**; Policy environment for TT, Strengthened capacity for TT; Uptake rates of technology, % of population adopting transferred technologies, technologies strengthen coping mechanisms.
Output : 8 different ones	20 different ones available

Source: simplified after GEF (2009), full version in Annex. Results and indicators in bold letters are the same as for the AFB, while results and indicators in italics are similar to some AFB results and indicators.

Adaptation Fund Strategic Results Framework (full)

Goal: Assist developing country Parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change in meeting the costs of concrete adaptation projects and programs, in order to implement climate resilient measures.

Expected results	**Indicators**
Impact: Increased resiliency at the community, national, and regional levels to climate variability and change.	MISSING
Outcome 1: Reduced exposure at national level to climate related hazards and threats	1. Relevant threat and hazard information generated and disseminated to stakeholders on a timely basis
Output 1: Risk and vulnerability assessments conducted and updated at a national level	1.1. No. and type of projects that conduct and update risk and vulnerability assessments
	1.2 Quality of relevant risk and vulnerability assessments
	1.3 Early warning systems developed
Outcome 2: Strengthened institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses	2.1 No. of targeted institutions with increased capacity to minimize exposure to climate variability risks
	2.2 Number of people with reduced risk to extreme weather events
Output 2.1: Strengthened capacity of national and regional centers and networks to rapidly respond to extreme weather events	2.1.1No. of staff trained to respond to and mitigate impacts of climate related events
Output 2.2: Targeted population groups covered by adequate risk reduction systems	2.1.2. Capacity increase of staff from targeted institutions trained to respond to and mitigate impacts of climate related events
	2.1.3. Percentage of population covered by adequate risk reduction systems
	2.1.4. No. of people affected by climate variability
Outcome 3: Strengthened awareness and ownership of adaptation and climate risk reduction processes at local level	3.1. Percentage of targeted population aware of predicted adverse impacts of climate change, and of appropriate responses
	3.2. Modification in targeted population behavior
Output 3: Targeted population groups participating in adaptation and risk reduction awareness activities	3.1.1 No. and type of risk reduction actions or strategies introduced at local level
	3.1.2 Degree of understanding of adaptation risk reeducation among the beneficiaries
	3.1.3 No. of news outlets in the local press and media that have covered the topic

Expected results	**Indicators**
Outcome 4: Increased adaptive capacity within relevant development and natural resource sectors	4.1. Development sectors' services responsive to evolving needs from changing and variable climate
	4.2. Physical infrastructure improved to withstand climate change and variability-induced stress
Output 4: Vulnerable physical, natural and social assets strengthened in response to climate change impacts, including variability	4.1.1. No. and type of health or social infrastructure developed or modified to respond to new conditions resulting from climate variability and change (by type)
	4.1.2. No. of physical assets strengthened or constructed to withstand conditions resulting from climate variability and change (by asset types)
Outcome 5: Increased ecosystem resilience in response to climate change and variability-induced stress	5. Ecosystem services and natural assets maintained or improved under climate change and variability-induced stress
Output 5: Vulnerable physical, natural and social assets strengthened in response to climate change impacts, including variability	5.1. No. and type of natural resource assets created, maintained or improved to withstand conditions resulting from climate variability and change (by type of assets)
Outcome 6: Diversified and strengthened livelihoods and sources of income for vulnerable people in targeted areas	6.1 Percentage of households and communities having more secure (increased) access to livelihood assets
	6.2. Percentage of targeted population with sustained climate-resilient livelihoods
Output 6: Targeted individual and community livelihood strategies strengthened in relation to climate change impacts, including variability	6.1.1.No. and type of adaptation assets (physical as well as in terms of knowledge) created in support of individual or community livelihood strategies
	6.1.2. No. of households with more secure access to livelihood assets
Outcome 7: Improved policies and regulations that promote and enforce resilience measures	7. Climate change priorities are integrated into national development strategy
Output 7: Improved integration of climate resilience strategies into country development plans	7.1. No. , type, and sector of policies introduced or adjusted to address climate change risks
	7.2. No. or targeted development strategies with incorporated climate change priorities enforced

Source: AFB (2010a)