United Nations Division for Sustainable Development

Expert Group Meeting on
Climate Change and Sustainable Development – The Role of Indicators
New York, 15-16 October 2008

Measuring Progress towards Sustainable Development and Climate Change – The potential of the CSD Indicators of Sustainable Development *

Background paper

---

* This paper was prepared by the United Nations Division for Sustainable Development.

This paper has been issued without formal editing.

Table of Content

I. Introduction

Climate change has re-emerged in the global debate as one of the major problems for achieving sustainable development. In response, in December 2007 all Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have agreed on the Bali Action Plan to negotiate a comprehensive climate change regime. The negotiations are scheduled to conclude by December 2009, at the 15th Conference of the Parties of the UNFCCC in Copenhagen.

Indicators of sustainable development came to the forefront of the international sustainable development debate in 1992 when Agenda 21 recognized the important role they could play in helping countries make informed decisions concerning sustainable development. The Indicators of Sustainable Development developed under a mandate of the Commission on Sustainable Development (CSD), henceforth CSD indicators, serve as a reference for countries developing new or revising existing national indicator sets. The third edition of the CSD indicators was released at the end of 2007.[1]

The UNFCCC and the ongoing negotiations recognize that climate change is sustainable development issue, rather than just an environmental problem. The impact of climate change could erase much of the progress made in achieving the goals of sustainable development. At the same time, controlling greenhouse gas emissions will depend ultimately on underlying economic and technological development pathways. Moreover, climate change involves at the same time both inter- and intra-generational equity, which are at the core of sustainable development. Due to the long-lasting effects of greenhouse gases in the atmosphere, current emissions impact on the living conditions of future generations, whereas the costs of mitigation actions have to be borne to a large extent by present generations. Moreover, poor and vulnerable countries are expected to face the greatest burden of climate change, while having contributed the least to the problem.

The Bali Action Plan not only confirms the existing principles and commitments, including those referring to sustainable development, but also explicitly calls to consider in the negotiations "nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner".[2] This paragraph also highlights the important role of information for the future climate change regime. In addition, the Bali Action Plan also calls to consider "means to incentivize the implementation of adaptation actions on the basis of sustainable development policies".[3] The need to address climate change while meeting the requirements of sustainable development, including the different responsibilities for

---

1 United Nations, Indicators of Sustainable Development: Guidelines and Methodologies, Third Edition (New York, 2007), available at http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm

2 Decision 1/CP.13 , para 1. (b) (ii); see United Nations, FCCC/CP/2007/6/Add.1.

3 Decision 1/CP.13 , para 1. (b) (iv); see United Nations, FCCC/CP/2007/6/Add.1

Annex 1 and non-Annex 1 countries, had already been noted explicitly by the Conference of the Party to the UNFCCC in 2002.[4]

Despite the general understanding that climate change is a sustainable development issue and the specific formulation of the Bali Action Plan, it often remains unclear how to ensure that climate change adaptation and mitigation are indeed considered in the framework of sustainable development. One approach is to link climate change policies and actions to national sustainable development strategies (NSDS) and plans, as these strategies enable countries to consider the economic, social and environmental needs for and effects of such policies and actions in an integrated manner. Thereby, NSDS provide a framework to harness co-benefits of climate change related actions for other sustainable development objectives. Perhaps more importantly, NSDS also facilitate harnessing co-benefits of actions aimed at other objectives for climate change mitigation and adaptation. An analysis of current country experiences in linking climate change to NSDS has been prepared by the United Nations Department for Economic and Social Affairs.[5]

Monitoring NSDS is one of the critical elements of effective strategies. And indeed, most countries employing indicators of sustainable development use them for the purpose of strategy monitoring. Therefore, using existing indicators of sustainable development as a point of departure for deriving climate change indicators promises to be an effective way to ensure that a broader sustainable development perspective is applied for measuring climate change policy and analysis. Indicators may also play an important role for countries that do not have an NSDS in place, or for those that do not use sustainable development indicators for strategy monitoring purposes. For these countries, climate change related indicators derived from broader sustainable development indicator sets could be used to identify areas for possible policy interventions on climate change that are embedded in the broader national sustainable development agenda. Thus, national-level climate change related indicators can potentially play an important role in both developed and developing countries.

The remainder of this paper is as follows. Section II briefly presents the CSD Indicators of Sustainable Development, including a discussion of their framework. The following section presents a possible framework for organizing climate change related indicators of sustainable development, which is loosely based on current negotiations under the Bali Action Plan and other processes under the UNFCCC. Afterwards, section IV explains how general sustainable development indicator sets such as the CSD indicators can be used to develop issue-specific indicator sets, such as climate change indicators. It will focus on specific steps to be taken and discuss advantages of this approach. Section V then applies the approach of the previous sections and present a preliminary set of climate change indicators of sustainable development. This set should be seen as work-in-progress, but it may be a useful reference for additional work at the

[4] Decision 1.CP.8; see United Nations, FCCC/CP/2002/7/Add.1.

[5] Addressing climate change in national sustainable development strategies – common practices, 16th Session of the Commission on Sustainable Development, Background Paper No 12, available at http://www.un.org/esa/sustdev/documents/docs_csd16.htm

national and international level on linking climate change policy and sustainable development through the use of indicators. Finally, section VI contains the conclusions.

II. CSD Indicators of Sustainable Development

Indicators of sustainable development have generally been recognized as important tools for improved decision-making for sustainable development. Whereas indicators can in principle perform various functions at the local, national, regional and international level, the CSD indicators are specifically designed to assist countries in developing national indicator sets suited to country-specific conditions. Consequently, the CSD indicators are not a blueprint for national indicator sets, but are rather designed to be adapted and modified by countries in line with national conditions and priorities. The publication on the CSD indicators referred to in the introduction contains some guidance material on how to adapt the indicators.[6] Moreover, the detailed methodology sheets for each of the indicators often contain references to alternative indicators that may be more applicable to a particular national context.[7]

The third edition of the CSD indicators contains a core set of 50 indicators. These core indicators are part of a larger set of 96 indicators of sustainable development. The full set of indicators is contained in an annex to this paper. The indicators are the outcome of a collaborative effort by national governments, international organizations, academic institutions, non-governmental organizations and individual experts. The introduction of a core set helps to keep the indicator set manageable, whereas the larger set allows the inclusion of additional indicators that enable countries to do a more comprehensive and differentiated assessment of sustainable development. Core indicators fulfil three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that are either readily available or could be made available within reasonable time and costs.

The CSD indicators are embedded in a thematic/sub-thematic framework, consisting of 14 themes with 44 sub-themes with a broad coverage of all aspects of sustainable development.

Table 1: CSD indicator themes

• Poverty	• Natural hazards	• Economic development
• Governance	• Atmosphere	• Global economic partnership
• Health	• Land	• Consumption and production patterns
• Education	• Oceans, seas and coasts	
• Demographics	• Freshwater	
	• Biodiversity	

[6] See footnote 1.

[7] These methodology sheets are available at http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm

This type of theme or issue-based framework, which had been already used for the second edition of CSD indicators[8], is also the dominant type of framework for national indicator sets, even though thematic coverage is often more limited in accordance with national sustainable development priorities as expressed in relevant NSDS. A main reason for the prominence of thematic frameworks is their ability to link indicators to policy processes and targets. This provides a clear and direct message to decision-makers and facilitates both communicating with and raising awareness among the public. A thematic framework for indicators is also well suited to monitor progress in attaining the objectives and goals stipulated in national sustainable development strategies. These frameworks are also flexible in the sense that they allow indicators to be regrouped according to changed priorities. It should be noted that the assignment of indicators to sub-themes and themes necessarily contains some arbitrariness as due to the integrated nature of sustainable development, an indicator may be simultaneously informative for various themes or sub-themes.

III. Framing climate change indicators

There are many different ways to organize climate change related indicators of sustainable development. In order to facilitate interaction with policy-oriented theme or issue-based frameworks such as those used for the CSD indicators, a two-tier framework may constitute a good choice. Para. 1. b) of the Bali Action Plan can serve as a broad guideline to distinguish three main issues: climate change mitigation, climate change adaptation, climate change financing and technology.[9] The distinction between climate change mitigation and adaptation would probably be made in most feasible indicator frameworks on this topic. With regard to adaptation, it may be useful to follow the IPCC and the UNFCCC to include impacts and vulnerability as aspects of adaptation. Financing and technology could loosely be described as means of implementation of climate change mitigation and adaptation. Hence, they could in principle also be subsumed under mitigation and adaptation, depending on the purpose of the financial means and technologies to be covered by the indicators. However, many possible indicators in that area would likely be very similar (such as official development assistance for climate change mitigation or adaptation purposes, or contribution or access to climate change related funds), so that separating financing and technology as a different issue does not only increase the alignment of an indicator set with the most important international policy process, but could also lead to a more compact and hence more manageable indicator set. At the same time, indicators on climate change financing and on technology would in many cases overlap, because technology transfer requires international financial flows. Hence, combining climate change financing and

[8] United Nations, Indicators of Sustainable Development: Guidelines and Methodologies, Second Edition (New York, 2001), available at http://www.un.org/esa/sustdev/publications/publications.htm#indicators

[9] The Bali Action Plan, in its para. 1. b), separates mitigation, adaptation, technology development and transfer, and provisions of financial resources and investment. Combining technology and financing in the indicator framework does not imply any political stand of the Secretariat with regard to their treatment in the negotiations or any other processes.

technology into a single issue may be more appropriate than separating them. The indicators for these issues may be broken down into mitigation and adaptation if feasible.

With regard to the second tier, or sub-themes, of climate change mitigation, one can take greenhouse gas (GHG) emissions as the first sub-issue, containing indicators that directly relate to the emissions of the various GHGs. Indicators that relate to climate change mitigation in a broader sustainable development context (for example, indicators on renewable energy or on sustainable forest management) could be organized along the lines of the new 2006 IPCC guidelines[10], i.e. energy; industry and product use; agriculture, forestry and other land use; and waste. An alternative is to follow the 1996 IPCC guidelines, separating agriculture from forests and other land use as well as industry from product use. However, it may be difficult to identify relevant sustainable development indicators for product use. Another possibility is to separate forests as a sub-issue, given the high political importance of reduced deforestation for climate change mitigation.

In climate change adaptation, one can take temperature and precipitation changes as a possible sub-theme. Another sub-theme may be natural hazards, as climate change is expected to increase the frequency of weather-related hazards and, in case of limited preparedness to response, disasters. Whereas the sectors that are most vulnerable to climate change and require major adaptation efforts vary across country, the following sectors or sub-themes could be used as a guideline: water, agriculture, health, biodiversity, coastal zones and economic development. Other categorizations, however, could well be justified and some sub-themes such as coastal zones may not be relevant for all countries. In addition, as climate change adaptation not only depends on the policy measures specifically related to climate change vulnerabilities, but also on the overall capacity of a country to adapt to significant external shocks, adaptive capacity could be added as a separate sub-theme for climate change adaptation.

Defining appropriate sub-themes for climate change finance and technology is difficult as they may depend on the outcome of the ongoing negotiations. One sub-theme could be public or publicly guaranteed transfers, containing not only indicators on climate change related official development assistance (ODA), but also contributions to and receipts from internationally agreed funds that may be outside the definition of ODA. Contributions and access to the new Adaptation Fund financed through a levy on clean development mechanism (CDM) projects may be one suitable example. Climate change related foreign investment, both direct and portfolio, could be a second sub-theme, with trade as another sub-theme. Indicators on technology transfer would be part of these three sub-themes, but a separate sub-theme for indicators focusing on technology development may be beneficial.

[10] Simon Eggleston et al (eds.), 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 1-5 (Hayama, 2006)), available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

In total, this section suggests a framework of three themes with 18 sub-themes. It should be noted that the flexibility of theme-based indicator frameworks allows for easy reorganization of sub-themes according to country-specific conditions and data availability.

Table 2: Possible framework for climate change indicators of sustainable development

Theme	Mitigation	Adaptation	Financing and technology
Sub-theme	GHG emissions	Temperature and precipitation changes	Public or publicly guaranteed transfers
	Energy	Natural hazards	Investment
	Industry and product use	Fresh water	Trade
	Agriculture, forestry and other land use	Agriculture	Technology development
	Waste	Health	
		Coastal zones and marine environment	
		Biodiversity and terrestrial ecosystems	
		Economic development	
		Adaptive capacity	

IV. Developing issue-specific sets of indicators of sustainable development

Climate change is but one important sustainable development topic for which countries may want to use indicators to assess progress. Energy[11] and biodiversity[12] are among the topics for which issue-specific sets of indicators of sustainable development have been developed at the international level. Due to the integrated nature of sustainable development, indicators can be informative for different issues as well as for overall progress towards national sustainable development goals. For example, energy efficiency indicators are included in most general sustainable development indicator sets, in energy indicator sets and, as evident from the potential framework discussed in the previous section, can be used for climate change indicator sets as well. Similarly, forest coverage is of interest for general sustainable development indicators, for climate

[11] International Atomic Energy Agency et al., Energy Indicators of Sustainable Development (Vienna, 2005).
[12] See Convention on Biological Diversity, Decision VII/30, UNEP/CBD/COP/7/21 (2004). See also 2010 Biodiversity Indicator Partnership, http://www.twentyten.net/

change and for biodiversity. Therefore, general sets of indicators of sustainable development provide a promising starting point for deriving issue-specific indicator sets.

Such an approach has a number of advantages. First, taking a general sustainable development indicator set as the point of departure facilitates the recognition of important linkages between climate change and other sustainable development issues as the general set will typically cover issues with major linkages. This advantage is more likely to materialize if the general indicator set is comprehensive in its coverage of sustainable development issues. Second, aligning issue-specific indicator sets with general indicator sets increases the coherence of indicator sets used in a country, thereby reducing the risk of sending 'mixed' messages. Third, it helps avoiding a duplication of efforts, as the resources needed to develop, compute and interpret indicators can serve multiple purposes. Fourth, and related to the previous point, it reduces the reporting burden for agencies. This holds especially if the same national entity is responsible for coordinating general and issue-specific indicator sets.

There are several steps needed to develop issue-specific indicator sets on the basis of general indicator sets. To start with, an appropriate framework for issue-specific indicators has to be constructed, such as the one on climate change described in the previous section. The existing indicators of sustainable development can then be assessed with regard to their usefulness for fitting into the issue-specific set. It should be noted that the indicator framework matters. First, the assessment is easier if the frameworks of the general and the issue-specific sets are similar. This is the case of the CSD indicators and the climate change indicator framework listed above, which do not only both use a two-tier theme-based framework, but for which many themes and sub-themes coincide. However, the assessment should not be restricted to indicators in those coinciding themes or sub-themes, as due to the integrated nature of sustainable development issues, indicators assigned to other themes may still be relevant for the issue-specific indicator set. Second, the indicator frameworks should be sufficiently flexible in the sense that the indicators retain their meaning if re-organized in an issue-specific indicators set.

Such assessments can also be done for other general sustainable development indicator sets. Countries will typically start with their national indicator sets, but it maybe worthwhile to also use international reference sets (such as the CSD indicators or the Millennium Development Goal Indicators[13]), relevant regional indicator sets (such as EU Sustainable Development Indicators[14], the Indicators for the Follow-up of the Mediterranean Strategy for Sustainable Development[15] or the Indicators of Sustainable Development of the United Nations Economic Commission for Latin America and the

[13] See http://mdgs.un.org
[14] See http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1998,66119021,1998_66292168&_dad=portal&_schema=PORTAL
[15] See http://www.planbleu.org/methodologie/indicateursSmddUk.html

Caribbean[16]) as well as national indicator sets of countries in similar situations as additional sources of information. Moreover, existing issue-specific indicator sets, such as energy indicators of sustainable development or biodiversity indicators could be assessed. As a next step, further indicators should be identified to fill gaps in the issue-specific indicator framework. For filling the gaps, existing indicator sets could be instructive as well, as climate change indicators may be related to existing indicators. For example, an indicator on climate change related ODA received or given is a subset of an indicator on general ODA. Using such related indicators reduces the additional burden of developing and computing indicators.

V. Preliminary set of indicators of sustainable development for climate change policy and analysis

This section presents a preliminary and indicative set of indicators of sustainable development for climate change policy and analysis. The set is embedded in the policy oriented framework presented in section III. It is based on the CSD indicators and an identification of additional indicators to fill gaps in the framework. It is preliminary as other indicator sets have not been fully assessed, even though it may be noted that the latest revision of the CSD indicators included coherence to other indicator sets as one of its criteria. Further work is also needed to refine the indicators outside the CSD set. Whereas some of these indicators are well established in international indicator processes, others require substantial methodological work before they can be applied. Moreover, some gaps still exist and demand the identification of appropriate indicators. Consequently, the set should be seen both as an illustration of using the CSD indicators for the development of issue-specific indicator sets and as a starting point for a reference set of climate change related indicators of sustainable development.

The following sub-sections will present for each of the three climate change themes or issues defined in section III the sub-themes, relevant CSD indicators, other indicators and, if applicable, CSD indicator to which they relate. If other indicators were taken from established international indicator sets, these sets are mentioned. Brief comments on the indicators are also made but do not aim to provide a complete discussion.

A. Climate change mitigation

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
GHG emissions	Carbon dioxide emissions (total and by sector)		
	Emissions of greenhouse gases (total and by GHG)		
	Consumption of ozone depleting substances		

[16] See http://websie.eclac.cl/sisgen/ConsultaIntegrada.asp?idAplicacion=5

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
		CO2/GHG emissions per capita (MDG indicator)	Carbon dioxide emissions/ Emissions of greenhouse gases
		CO2/GHG intensity of the economy (total and by sector) (MDG indicator)	Carbon dioxide emissions/ Emissions of greenhouse gases
		Consumption-based GHG emissions	Emissions of greenhouse gases

Greenhouse gas emission inventories are part of national reporting to the UNFCCC. Methodologies for emission indicators are therefore well established. The CSD indicators include carbon dioxide emission as a separate indicator, because of its high political prominence, the fact that it is the main GHG in most countries and its better data availability compared to other GHGs in developing countries. As certain ozone depleting substances (ODS) are also GHGs, but are not covered in national emission inventories reported to the UNFCCC, the indicator on consumption of ODS is also relevant for measuring, especially if broken down by substance.

For countries interested in comparing themselves to their peers, per capita emissions constitute a useful additional indicator. Again, for data comparability reasons, it may be advisable to compute the indicator separately for CO2 and total GHG, or separately for each GHG. It should be noted that the MDG indicator covers CO2 only. For countries measuring progress towards a goal of 'de-carbonizing' their economy, carbon intensity of the economy (total CO2 emissions divided by real GDP) could be a useful indicator. Such indicator is also contained in the set of MDG indicators, even though currently data is available only for Annex 1 countries of the UNFCCC. Similarly, one could also use an indicator of GHG intensity of the economy. It should be noted, though, that overall GHG intensity indicators measure changes in the carbon intensity of production processes as well as changes in the overall structure of economic activity. Hence, countries in an industrialization phase on their development trajectory may observe an increase in CO2 intensity even if every production process were to become more carbon efficient, as industrial activities typically require more energy and other (potentially) carbon-dependent inputs than agricultural or service activities. Conversely, countries with more service oriented economies may observe a decrease in CO2 intensity even if production processes and consumption patterns were to become less carbon efficient. Sectoral carbon intensity indicators may be preferable, even though carbon intensity within sectors is also highly variable and emission data would be needed based on standard economic classification rather than sectors used for UNFCCC purposes.

In the current indicators, GHG emissions are attributed to the producer of the emissions. In terms of geographic coverage, the indicators are based on the territorial principle. However, strong interest exists in linking GHG emissions to the consumer of goods whose production (including the production of intermediate goods) led to GHG emissions. Due to differences in production structure and in production technologies

across countries, consumption based GHG emissions can differ substantially from production based emissions. Consumption based emissions are equal to production-based emissions, plus emissions embedded in imports (including emissions caused by international transport), minus emissions embedded in exports. In principle, consumption based emissions could be constructed on the basis of emission inventories and input-output tables for both the domestic economy and all (major) trading partners. Moreover, emission data must be transformed from the territorial to the residence principle used for national accounts. Due to limited availability of inventories and input-output tables, various estimation techniques are under development. Despite these methodological shortcomings, countries may gain important insights by using indicators based on both production and consumption.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Energy	Annual energy consumption, total and by main user category		
	Intensity of energy use, total and by economic activity		
	Share of renewable energy sources in total energy use		
		Carbon intensity of energy use	Carbon dioxide emissions/ Energy consumption
	Energy intensity of transport (fuel use per km)		
	Modal split of passenger transportation		
	Modal split of freight transport		
		Household energy intensity (Energy use per household and/or per floor area) (Energy Indicators of Sustainable Development)	

Energy consumption is a central indicator for measuring progress towards energy savings, which is contained in many NSDSs and which contributes in many cases to various goals such as increasing energy security, promoting the use of sustainable consumption patterns and reducing GHG emissions. Energy intensity is also a key indicator that is frequently applied by countries to measure progress towards the goal of increasing energy efficiency. As discussed above for carbon intensity indicators, sectoral

breakdowns may be more policy relevant, as they are less susceptible to changes in the economic structure. Similarly, promotion of renewable energy sources is a common goal for reducing GHG emissions, increasing energy security and, in some cases, attaining technological leadership. The share of renewable energy sources is, therefore, another central and common indicator relevant for climate change in the context of sustainable development.

Transport, especially road transport, is a major driver of GHG emissions. Consequently, energy intensity of transport is an indicator useful for measuring goals of increasing transport efficiency. As water and rail transport is typically associated with lower environmental impacts and similar economic and social benefits than road transport, the modal split of passenger and freight transport are relevant indicators for measuring progress towards increasing the share of transport modes with low external costs. In many countries, the household sector has been identified as a potential source of sizeable GHG emission reductions that could be achieved with long-term economic benefits. Increasing energy efficiency through applying more efficient household appliances and heating systems as well as through better insulation of buildings are typical policies in this regard whose impact can be measured through household energy efficiency. This indicator is methodologically well developed as it is part of the Energy Indicators of Sustainable Development mentioned in section IV.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Industry and product use	Material intensity of the economy		
	Domestic material consumption		
Waste	Generation of waste		
	Waste treatment and disposal		
	Wastewater treatment		
	Ambient concentration of air pollutants in urban areas		

GHG emissions from industrial processes are often concentrated in certain sectors and products such as iron and steel, aluminium, cement, or fertilizers. However, in terms of indicators it may be noted that the indicators on sectoral GHG emissions and intensities discussed above under the GHG emission sub-theme provide important information on industrial emissions in the context of sustainable development, as do the indicators on sectoral energy use and energy intensity. However, the overall goal of de-materializing the economy or economic growth, which is important for some countries, may be relevant in this regard. Therefore, the CSD indicators on domestic material consumption and material intensity may be of interest from a climate change

perspective, especially as material intensive sectors also tend to be major factors for emissions of pollutants in general.

GHG emissions from waste are mostly in the form of methane emissions from landfills and methane and nitrous oxide emissions from wastewater. The indicator on the generation of waste measures progress towards reduction and re-use of waste, which have obvious climate change co-benefits. The indicator on waste treatment provides information about co-benefits of recycling and waste incineration for climate purposes. However, as methane recovery from landfills constitutes another option for reducing GHG emissions, a high share of waste that is landfilled does not indicate negative climate impact per se. Therefore, for climate change purposes this indicator should be considered in conjunction with an indicator of GHG emissions from the waste sector. Wastewater treatment has a number of environmental and health benefits, with reduced GHG emissions as a relevant co-benefit. Reducing air pollution through the adoption of cleaner technologies also has climate change co-benefits, as pollutants such as particulate matter often complement carbon dioxide emissions from energy combustion and industrial processes. Moreover, pollutants such as nitrogen oxides (NOx), carbon monoxide (CO) and non-methane volatile organic compounds (which are included in the CSD indicator on air pollution) are also indirect GHGs. Whereas air pollutants do not constitute waste in most commonly-used definitions, this sub-theme may be appropriate as it may be infeasible to break this indicator down into pollution caused by energy use and industrial processes.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Agriculture, forests and other land use	Fertilizer use efficiency		
	Area under organic farming		
	Proportion of land area covered by forests		
		Deforestation rate	Land use change
	Area of forest under sustainable forest management		
		Area under payment for ecological services (PES) schemes	
	Land use change		
	Land degradation		

In the agricultural sector, soil carbon sequestration and mitigation of methane and nitrous oxide emissions are regarded as main options to reduce GHG emissions. The indicator on fertilizer use efficiency measures the extent of fertilizers actually used by crops. As the amount of nitrogen not taken up by crops is a major source of nitrous oxide emissions, this indicator is relevant for climate change purposes. Organic farming

is typically associated with enhanced soil conservation and, thus, carbon sequestration. However, indicators on other types of sustainable agricultural management practices would deliver additional insights. Another option in the agricultural sector is the use of land for biofuel production, either as main or as by-product of the production of crops such as sugar-cane. Hence, the development and application of biofuel indicators would be important, taking into account that the sustainable development benefits or costs of biofuels depend on the production methods and other factors such as the prevalence of threats to food security. The contribution of agriculture to GHG through the conversion of forests into agricultural land would be covered by the overall land use change indicator discussed below.

Forests are a key sector for climate change mitigation, due to their potential role as enhanced carbon sinks through afforestation and sustainable forest management as well as due to the potential of reducing emissions through reducing deforestation. The forest coverage indicator provides insights on the overall role of forests for climate change mitigation. Given the prominence of reduced emissions from deforestation in developing countries in the ongoing negotiations, a separate deforestation indicator (i.e., forest land converted into other land divided by all forest land) based on an overall land use change indicator can be useful in this context. Sustainable forest management is one of the mechanisms that generally lead not only to reduced emissions and enhanced sequestration, but has also significant other benefits. In some countries, payment for ecological services is another mechanism used to enhance the role of forests as carbon sinks.

As conversion of forest and of peatland into agricultural land (both grassland and cropland) as well as the increase in built-up area are important factors for GHG emissions, an overall land use change indicator provides important information for climate change purposes. Land degradation (especially in forests and cropland) is a major source of emissions and decreased capacity to sequester carbon, so that the land degradation indicator is very relevant. However, it should be noted that measuring land degradation is hampered by both the lack of well-established methodologies and data availability.

B. Climate change adaptation

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Temperature and precipitation changes		Annual mean and variability of temperature	
		Annual mean and variability of precipitation	
Natural hazards	Percentage of population living in hazard prone areas		

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
	Human and economic loss due to natural disasters		

Changes in temperature and precipitation are main manifestations of climate change and influence vulnerability and adaptation needs. Therefore, specific indicators on these issues would be well placed in any set of climate change related indicators. It should be noted though that vulnerability and adaptation needs are critically determined by future rather than current changes, whereas sustainable development indicators typically contain information on past and present only.

As an increase in climate related natural hazards such as floods, landslides (including avalanches), droughts and cyclones is among the main expected impacts of climate change, the CSD indicators on population living in hazard-prone areas and on losses due to disasters provide important insights into key vulnerabilities. It is suggested that these indicators are broken down by type of hazard. As certain risk mitigation measures (for example, establishing evacuation and response infrastructure) can be applied to various hazards, it may be useful to include also non-climate related hazards (earthquakes, tsunami, and volcanos) in the indicator.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Fresh water	Proportion of total water resources used		
	Water use intensity by economic activity		
Agriculture		Land productivity in agriculture (FAOSTAT)	
		Agriculture diversification index	Arable and permanent cropland area
Health		Morbidity of vector-borne diseases such as malaria and dengue	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis
		Area in which vector-borne diseases such as malaria and dengue are endemic	

A decrease in water availability is one of the major possible impacts of climate change. The proportion of water resources used is a standard indicator for measuring water stress, so that high values of this indicator may show a key vulnerability. It should be noted, though, that spatial disaggregation would provide further and more detailed information, especially for large countries. Decreasing water use intensity is one possible

adaptation measure with broader sustainable development benefits in areas threatened by water stress.

Agriculture is not only a sector contributing to climate change, but also a sector most vulnerable to it. A decrease in agricultural productivity caused by climate change is expected for countries in warmer climate zones. Therefore, measuring the productivity of land, for example as yield per hectare for major crops (as regularly reported to or computed by the Food and Agriculture Organization of the United Nations), would be of key interest. As the main concern is the impact of climate change on food availability, a quantity based indicator may be preferable to those based on the market value of agricultural products. As diversification is one of the key adaptation strategies that may also address vulnerability against external shocks other than climate change, a diversification index based on information on land area harvested per crop may be of interest.

In the area of health, a spread of vector borne diseases such as malaria and dengue is frequently cited as a major threat. Therefore, information on the incidence of these diseases would provide information on climate change impacts as well as on the success of adaptation measures. In addition, mortality rates of these diseases would provide additional information on vulnerability. Moreover, by using geographic information on disease incidence, an indicator measuring the area in which these diseases are endemic could be developed. Another expected climate change related impact is an increase in heat related deaths and a decrease in cold related deaths. However, indicators on temperature-related mortality would have to be estimated on the basis of models, as heat or cold are not separate causes of death in health statistics. It should be noted that other health related indicators are listed above in the natural hazard sub-theme and below in the adaptive capacity sub-theme.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Coastal zones and marine environment	Percentage of total population living in coastal areas		
	Proportion of marine area protected		
	Area of coral reef ecosystems and percentage live cover		
Biodiversity and terrestrial ecosystems	Change in threat status of species		
	Abundance of invasive alien species		

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
	Proportion of terrestrial area protected, total and by ecological region		
	Land degradation		
	Land desertification		

Sea-level rise is one of the key long-term impacts of climate change, threatening the existence of low lying island states and areas. Consequently, the indicator on population living in coastal areas measures a key vulnerability. For the marine environment, coral bleaching is considered as a major impact that could be measured with the indicator on the extent and live cover of coral reef ecosystems. As the establishment of effective protected areas is a well established measure for ecosystem conservation, the indicator on the proportion of marine area protected can be relevant for climate change adaptation.

Similarly, the indicator on terrestrial area protected provides information on adaptation in terrestrial ecosystems. Extinction of species is another potential climate change impact in the area of biodiversity, making the indicator on the change in threat status of species relevant. Climate change may also increase the threat to biodiversity posed by alien species, so that the indicator on abundance of invasive alien species may also function as an effective climate change indicator. Land degradation is not only a contributing factor of climate change but also a consequence of it. Introducing the CSD indicator in both mitigation and adaptation may appear as double-counting. However, it should be noted that the CSD indicator requires additional methodological work, so that different measures of this indicator may be chosen for mitigation and for adaptation. Land desertification is defined as land degradation in semi-arid and arid areas. The methodology for this CSD indicator is currently under revision.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Economic development		Economic diversification indicator	Gross domestic product
		Infrastructure investment in areas vulnerable to climate change	Investment share in GDP
Adaptive capacity	Proportion of population living below national poverty line		
	Proportion of population using an improved water source		

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
	Under-five mortality rate		
	Gross domestic product per capita		

A broad based adaptation strategy may include increasing economic diversification as a main element, as more diversified economies may be better able to cope with any kind of external shocks, whether climate or non-climate related. Therefore, an indicator on economic diversification based on shares in value added or shares in employment of various sub-sectors would be of interest. However, as sectoral vulnerabilities to climate change differ, increased diversification does not necessarily imply reduced vulnerability to climate change. In order to adapt to climate change, additional infrastructure expenditures may be required to protect for damages caused by more intense weather events and sea-level rise. Hence, measuring infrastructure investments in areas vulnerable to climate change provides information on adaptation. It should be noted that the computation of such an indicator requires the availability of appropriate sub-national accounts data.

In addition to the vulnerabilities to climate change specific impacts, a low overall adaptive capacity to cope with external events is another key vulnerability. As sustainable development in general increases adaptive capacity especially in less developed countries, key general indicators of sustainable development may be included in a comprehensive climate change indicator set. It is certainly difficult to select a few common indicators of sustainable development, so the following four indicators would serve largely illustrative purposes. Poverty and low economic development (measured in GDP per capita) are critical social and economic oriented indicators. Access to safe drinking water covers the environmental and social dimensions of sustainable development. Under-five mortality does not only provide information on health, but is often regarded as a robust overall development indicator as data is widely available.

C. Climate change financing and technology

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Public and publicly guaranteed transfers		Climate change related official development assistance	Net Official Development given or received as a percentage of GNI
		Contribution to and receipts from climate change specific funds	
Investment		Climate change related FDI net inflows and net outflows	Foreign direct investment (FDI) net inflows and net outflows as percentage of GDP

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
		Climate change related portfolio investment net inflows and net outflows	

The selection of indicators on climate change financing and technology will to some extent depend on the details of the future international climate change regime that is currently under negotiation. Consequently, many of the indicators proposed in this sub-section lack details that would depend on the progress of these negotiations. A most critical factor in this regard are definitions that would allow to distinguish climate change related financial and technological flows from non-climate change related ones.

Official development assistance (ODA) is expected to provide an important amount of climate change financing. Currently, international ODA data does include information on climate change related ODA through a 'marker' used by ODA donors to identify those ODA that is related to the UNFCCC. As usage of the marker may be heterogeneous across countries and ODA data on non-traditional donors is incomplete, this indicator may warrant further methodological efforts. Contributions to and receipts from special climate change funds could be a source for further indicators falling under this sub-theme. An example would be the new adaptation fund under the UNFCCC, which is financed through a levy on CDM projects. Among other things, methodological work on such an indicator would involve allocating contributions to countries, as CDM projects themselves are of a bilateral nature. Moreover, the current negotiations induce many proposals for the establishment of other financing mechanisms specific to climate change mitigation, adaptation and/or technologies. Such proposals, if agreed upon, would have to be included in appropriate indicators. Transfers related to technology transfer would cover transfers used to acquire technological equipment (or embodied technologies), transfers used to acquire experiences and know-how (disembodied technologies), as well as transfers used to build capacities to apply those technologies (capacity-building).

In addition to ODA, international investment flows can be an important mode of technology transfer. This holds for inward foreign direct investment (FDI), where the investor may transfer technologies to the host country that he would be unwilling or unable to provide without management control. However, outward FDI can also be an important mode of technology transfer, as management control typically includes the control of decisions to transfer technologies. The link between climate change and international investment goes beyond technology transfer. As climate change policies, in addition to the finiteness of fossil fuels, are a major driver for a (possible) transition to low carbon economies, investments in renewable energy or other cleaner energy technologies could be seen as climate change related. These investments involve not only direct, but also portfolio investments. Whereas indicators on climate change related direct and portfolio investment may in general cover a large amount of investments, it could also be feasible to develop more specific indicators with clearer boundaries, such as investments in CDM or joint implementation (JI) projects.

Sub-theme	CSD indicator	Other indicator	Related CSD indicator
Trade		Exports and imports in emission reduction certificates or similar instruments (measured in CO2 equivalents and in currency)	
		Exports and imports of climate change technologies (goods and services) , at commercial and at preferential terms	
Technology development		R&D in climate change technologies, domestic and in international cooperation	Gross domestic expenditure on R&D as a percent of GDP

Trade is another important issue for climate change financing and technology. Emission trading schemes have already been set up on a regional scale in the European Union, and existing or future domestic trading schemes may be linked to regional or international trading schemes. Moreover, the CDM and JI mechanism also create emission reduction certificates that are internationally transferred. Hence, the development of indicators on emission trading in the broad sense seems to be very important. Such indicators should measure trade both in volume (for example, in CO2 equivalents of avoided emissions) and in value. In principle, volume emission trading indicators could also be placed under the climate change mitigation theme, GHG emission sub-theme (see sub-section A above), however, one single indicator covering both volume and value information may increase coherence of an indicator set and better address the linkage between climate change mitigation and development financing.

Trade is also a major mode of technology transfer. Whereas merchandise trade data is in general widely available, it should be noted that this covers trade in embodied technologies only. And whereas the discussion on trade in environmental goods could provide important inputs in the development of indicators, there is still widespread disagreement on which constitute an environmental good. Therefore, defining climate change related goods is also likely to be difficult. Transfer of disembodied technologies is in general covered under trade in services. However, despite methodological progress, data on trade in services is still not widely available. Moreover, trade statistics (both for trade in goods and trade in services) aggregate the different varieties of goods and services by using market prices. Therefore, an increase in technology flows caused by the provision of preferential prices may even appear as a decline if the induced rise in demand for technology goods is not that strong (more specifically if the price elasticity is less than one). Consequently, it may be advisable to measure trade in climate change technologies separately for trade under commercial and trade under preferential terms.

In addition to technology transfer, further efforts for technology development may require the development of targeted indicators such as R&D expenditures for climate change related technologies. Given the international orientation of the theme, R&D through international cooperation could be reported separately. Again, though, the definition of climate change related technologies would constitute the main hurdle in developing such indicators.

VI. Conclusion

Indicators of sustainable development can be an important vehicle to ensure that climate change policy is firmly placed in its broader sustainable development context. This paper outlined how general sets of indicators of sustainable development can be used as a basis to develop climate change related indicators of sustainable development. The paper used the CSD indicators as starting point, as they are broad based in their coverage of sustainable development issues, designed to be adapted to national conditions rather than being used at face value and intended to be informative for countries in different environments and levels of development. The CSD indicators were assessed not only with regard to their possible placement in the climate change framework, but also with regard to their potential to serve as basis for more specialized indicators related to climate change. However, the general approach can be applied to most national or international indicator sets. It can also be used to develop other issue-specific indicator sets, thereby potentially laying a foundation for a coherent system of sustainable development indicator sets.

The paper derived a framework for climate change indicators of sustainable development, broadly oriented along the Bali Action Plan and the ongoing negotiations under the UNFCCC. The framework shares basic feature with the CSD indicator framework: it is policy oriented and has a flexible two-tier structure, consisting of three themes (climate change mitigation, climate change adaptation and climate change financing and technology).

Afterwards, a tentative set of indicators of climate change was constructed. For this, all CSD indicators were checked for their potential role in the climate change oriented framework. Gaps in the framework, then, were filled by identifying further indicators. In total, the set consists of 60 indicators, of which 38 are CSD indicators. Moreover, 12 of the 22 indicators outside the CSD indicators are disaggregated versions of CSD indicators or are otherwise closely related to some CSD indicators. Almost half of the indicators (28) fall in the climate change mitigation theme, followed by adaptation (25 indicators) and financing and technology (7 indicators).

The indicator set in its current form should not be seen as a definitive reference but rather as a potential starting point for future work in this area. First, whereas existing indicator sets were casually used as a basis for identifying indicators outside the CSD indicators, more systematic efforts have to be made in this regard. Moreover, an assessment of national indicator sets would provide additional information. Second, some of the additional indicators identified would require substantial methodological

work before they could be applied. It should be noted that major ongoing processes related to statistical methodologies could facilitate the work on indicators. One process is the work on remote sensing and geographical information systems (GIS), including their integration with other statistical areas such as censuses. This is relevant especially for climate change adaptation as well as for mitigation in the forest and other land-use sector, as indicators in these areas could benefit from more standardized spatial statistical frameworks. Another process is the System of Environmental-Economic Accounting (SEEA), which provides an integrated framework for environmental and economic data, thereby facilitating the development of consistent indicators related to the 'ecological efficiency' of economic activities.

Even though details of many indicators, especially for climate change financing and technology, depend on the outcome of the ongoing negotiations, proactive work on such indicators would be beneficial. This work would require further interaction between experts and decision-makers on climate change and on sustainable development indicators. Such interaction promises to be beneficial for both sides. Whereas existing indicators provide useful information for climate change purposes, work on climate change can help to sharpen and refine existing indicators. And whereas the outcome of climate change negotiations would lead to new indicator demands, the development of new and the refinement of existing indicators could also assist climate change decision-makers to develop measurable policies that place climate change in the broader sustainable development context.

Annex: CSD Indicators of Sustainable Development

Theme	Sub-theme	Core indicator	Other indicator
Poverty	Income poverty	Proportion of population living below national poverty line	Proportion of population below $ 1 a day
	Income inequality	Ratio of share in national income of highest to lowest quintile	
	Sanitation	Proportion of population using an improved sanitation facility	
	Drinking water	Proportion of population using an improved water source	
	Access to energy	Share of households without electricity or other modern energy services	Percentage of population using solid fuels for cooking
	Living conditions	Proportion of urban population living in slums	
Governance	Corruption	Percentage of population having paid bribes	
	Crime	Number of intentional homicides per 100,000 population	
Health	Mortality	Under-five mortality rate	
		Life expectancy at birth	Healthy life expectancy at birth
	Health care delivery	Percent of population with access to primary health care facilities	Contraceptive prevalence rate
		Immunization against infectious childhood diseases	
	Nutritional status	Nutritional status of children	
	Health status and risks	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	Prevalence of tobacco use
			Suicide rate
Education	Education level	Gross intake ratio to last grade of primary education	Life long learning
		Net enrolment rate in primary education	
		Adult secondary (tertiary) schooling attainment level	
	Literacy	Adult literacy rate	
Demographics	Population	Population growth rate	Total fertility rate
		Dependency ratio	

Theme	Sub-theme	Core indicator	Other indicator
Demographics (continued)	Tourism		Ratio of local residents to tourists in major tourist regions and destinations
Natural hazards	Vulnerability to natural hazards	Percentage of population living in hazard prone areas	
	Disaster preparedness and response		Human and economic loss due to natural disasters
Atmosphere	Climate change	Carbon dioxide emissions	Emissions of greenhouse gases
	Ozone layer depletion	Consumption of ozone depleting substances	
	Air quality	Ambient concentration of air pollutants in urban areas	
Land	Land use and status		Land use change
			Land degradation
	Desertification		Land affected by desertification
	Agriculture	Arable and permanent cropland area	Fertilizer use efficiency
			Use of agricultural pesticides
			Area under organic farming
	Forests	Proportion of land area covered by forests	Percent of forest trees damaged by defoliation
			Area of forest under sustainable forest management
Oceans, seas and coasts	Coastal zone	Percentage of total population living in coastal areas	Bathing water quality
	Fisheries	Proportion of fish stocks within safe biological limits	
			Area of coral reef ecosystems and percentage live cover
Freshwater	Water quantity	Proportion of total water resources used	
		Water use intensity by economic activity	
	Water quality	Presence of faecal coliforms in freshwater	Biochemical oxygen demand in water bodies
			Wastewater treatment

Theme	Sub-theme	Core indicator	Other indicator
Biodiversity	Ecosystem	Proportion of terrestrial area protected, total and by ecological region	Management effectiveness of protected areas
			Area of selected key ecosystems
			Fragmentation of habitats
	Species	Change in threat status of species	Abundance of selected key species
			Abundance of invasive alien species
Economic Development	Macroeconomic performance	Gross domestic product (GDP) per capita	Gross saving
		Investment share in GDP	Adjusted net savings as percentage of gross national income (GNI)
			Inflation rate
	Sustainable public finance	Debt to GNI ratio	
	Employment	Employment-population ratio	Vulnerable employment
		Labor productivity and unit labor costs	
		Share of women in wage employment in the non-agricultural sector	
	Information and communication technologies	Internet users per 100 population	Fixed telephone lines per 100 population
			Mobile cellular telephone subscribers per 100 population
	Research and development		Gross domestic expenditure on R&D as a percent of GDP
	Tourism	Tourism contribution to GDP	
Global economic partnership	Trade	Current account deficit as percentage of GDP	Share of imports from developing countries and from LDCs
			Average tariff barriers imposed on exports from developing countries and LDCs

Theme	Sub-theme	Core indicator	Other indicator
Global economic partnership (continued)	External financing	Net Official Development Assistance (ODA) given or received as a percentage of GNI	Foreign direct investment (FDI) net inflows and net outflows as percentage of GDP
			Remittances as percentage of GNI
Consumption and production patterns	Material consumption	Material intensity of the economy	Domestic material consumption
	Energy use	Annual energy consumption, total and by main user category	Share of renewable energy sources in total energy use
		Intensity of energy use, total and by economic activity	
	Waste generation and management	Generation of hazardous waste	Generation of waste
		Waste treatment and disposal	Management of radioactive waste
	Transportation	Modal split of passenger transportation	Modal split of freight transport
			Energy intensity of transport