MILESTONE MS30

Catalog of impact indicators

Abstract

This document provides the listing of all climate change and impact indicators documented in the CLIP project until month 19. Subsequent revisions are planned and will be undertaken until the final inclusion of indicators in the common portal. As the moment of writing a total of 81 climate change and impact indicators are examined using a consistent set of reference criteria. The indicators were grouped in three tiers, with Tier-1 focusing on the climate system, Tier-2 indicators the impacts of climate change in bio-physical systems and Tier-3 indicators on the socio-economic systems affected by climate change.

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Classification of indicators in CLIPC

In the CLIPC project, an impact indicator is described as an observed or projected measure that indicates a 'relevant' environmental/human/economic impact, and whose causes can be linked to the interaction between changes in climate and society. A meta-classification of impact indicators into three Tiers (see Figure 1) is proposed, from indicators mainly concerning natural systems to those reflecting changes in human systems. An additional distinction can be made based on the timeframe. Generally indicators have been developed based on historical observations-based data to infer trends, but climate change scenarios also play an important role. The obvious distinction is that indicators based on historical data are primarily driven by available observations whereas projections are based on model outputs. Validation of model output and bias correction methods provide links between the two types of indicators.

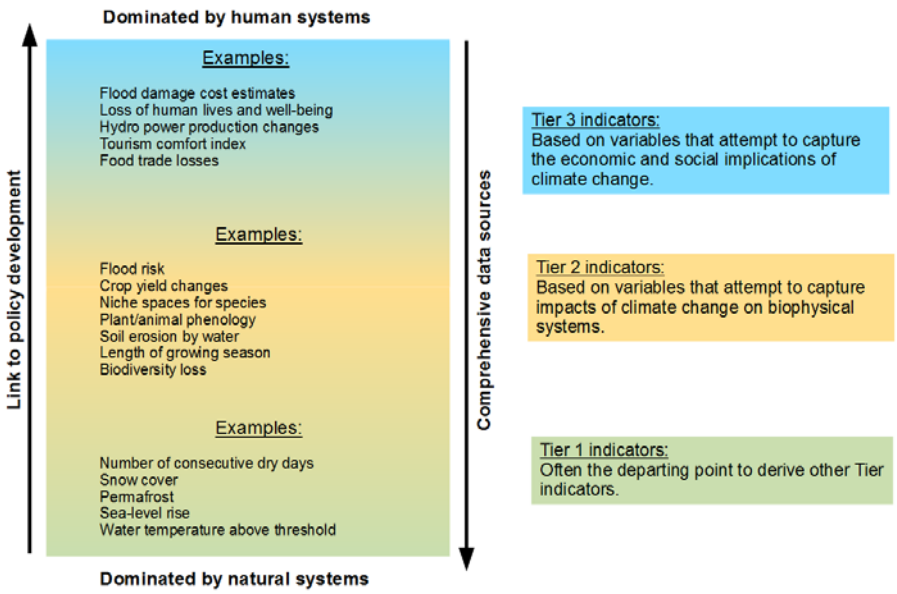

Figure 1 - Framework of climate impact indicator classification as used by CLIPC

In this categorization, Tier-1 indicators are intended to give information on the past and future evolution of the climate system. For example, mean temperature change, ice cover extent or sea-level rise provide indications of the impact on the climate system that are caused by anthropogenic interference with the global energy balance. Tier-2 indicators attempt to quantify the impacts of climate change in bio-physical systems. Flood risks, crop losses, changes in distributional ranges or phenology of organisms or soil erosion are examples of such variables that can be used as indicators. Tier-3 indicators primarily aim at providing information on the socio-economic systems affected by climate change. These indicators usually build on previous ones and make the bridge from a bio-physical change to social or economic loss/gain. For example, indicators based on the economic consequences of extreme weather events or morbidity during heat waves belongs to this group. It comes without saying that the classification is not free of inconsistencies as there are indicators that overlap the classes proposed. Nevertheless, this structuring of indicators is useful for the purposes of the

CLIPC work, since it establishes a common framework of reference for communication with the consortium and wider climate-impact community.

For the sake of clarity, we provide some of the working definitions of indicators and related terms. These do not yet constitute a comprehensive glossary, but are useful as clarification of terms; especially since the use of the wording “climate indicator” or “impact indicator” is often used by scholars of very different disciplines.

- **Climate impact indicator** - an observed or projected measure that indicates a 'relevant' environmental/human/economic impact that can be linked to changes in the climate.

- **Tier-1 climate impact indicator** - A climate impact indicator primarily intended to give information on the past and future evolution of the climate system. Changes in temperature and precipitation extremes, artic ice coverage or sea-level changes are examples of such variables that belong to this indicator category.

- **Tier-2 climate impact indicator** - A climate impact indicator primarily intended to quantify the impacts of climate change in bio-physical systems. Flood risks, crop losses, changes in distributional ranges or phenology of organisms or soil erosion are examples of such variables that belong to this indicator category.

- **Tier-3 climate impact indicator** - A climate impact indicator primarily intended to provide information on the socio-economic consequences entailed by the changes in Tier1 and 2 indicators. Crop-value loss, human casualties and economic losses from floods or storm events are examples of such variables that belong to this indicator category. Several Tier-2 indicators can be converted into Tier-3 indicators provided that reliable estimates can be provided on the economic consequences of physical impacts.

- **Climate indices** - Calculated value that can be used to describe the state and the changes in the climate system. Indices are often used as synonyms for indicators.

- **Essential Climate Variable** - A physical, chemical, or biological variable or a group of linked variables that critically contributes to the characterization of Earth's climate.

I. Catalog of impact indicators as in Month 19

The efforts of CLIPC returned a total of 81 climate change and impacts indicators consistently documented. Figure 2 shows the number of indicators documented according the Tier classification of CLIPC. The bulk of the indicators documented have been documented as Tier-1, that is, those informing mostly on changes of the climatic system. Next on the list are Tier-2 indicators, although already in substantially lower numbers. Tier-3 indicators constitute the least documented types of indicators in CLIPC. In general, the frequency of Tier-1 to 3 indicators resembles that of comparable efforts deriving impact metrics on societal and economic systems from indicators of change in the climate system. This reflects partly the availability of data sets in a form that allows calculation of indicators (easily accessible, standardized methods, long data series and wide spatial coverage).

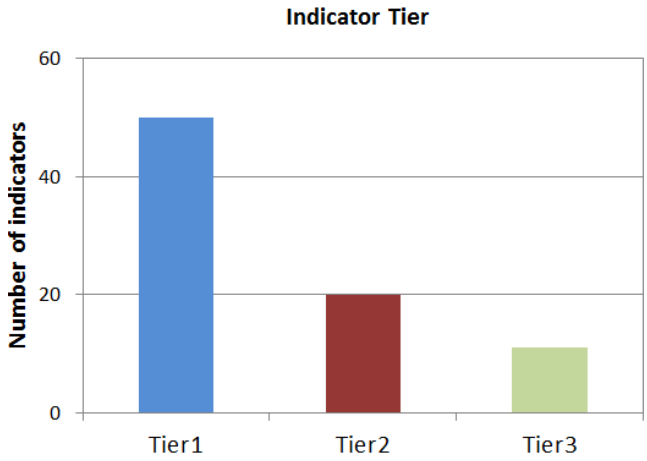

Figure 2 - Number of indicators documented according to CLIPC Tier classification.

Figure 3 shows the number of indicators allocated to each CLIPC theme. Most of the documented indicators were identified for the water theme, followed by the urban and rural themes. About 43 indicators have been documented as exclusive for one theme (mostly Water). 19 indicators have been documented as touching two themes, the same amount of indicators that has been recorded as useful for all the three themes. This shows that cross-thematic indicators emerged from the documentation without the need for having a specific theme dedicated to that purpose. Tier-1 indicators have been documented as belonging to two or more themes but also as unique to a particular theme. In terms of indicators allocated specifically to one theme, the most numerous were found for the water theme followed by the rural theme. The current catalog of indicators explored can be found in Table 1.

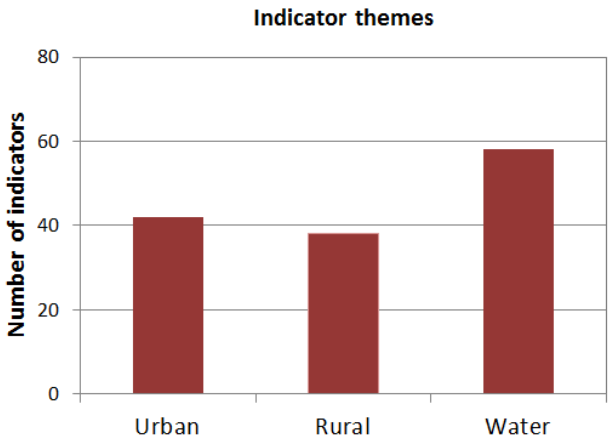

Figure 3 - Number of indicators documented according to CLIPC themes.

Table 1 - Catalog of potential impact and climate change indicators for CLIPC. The color coding reflects the indicator Tier. Blue for Tier-1; Green for Tier-2; Red for Tier-3.

Indicators	
Arctic and Baltic Sea ice extent	River flow change
Bathing water quality	100 years flood return level
Chlorophyll-a concentration	Water-limited crop yield
Cold days	River flood occurrence
Cold nights	River flow
Cold spell duration index	Water scarcity
Consecutive dry days	Water temperature
Consecutive wet days	Water-limited crop productivity
Diurnal temperature range	Intensity of urban heat island with city size
Frost days	Heating degree-days
Mass balance of glaciers	Rainfall Deciles
Sea level change	Reconnaissance Drought Index
Greenland ice sheet mass balance	Growing Degree Days
Grow season length of vegetation	Chilling Units
Hazardous substances in marine organisms	Climatic favorability of tree species
Heavy precipitation days	Distribution of marine species
Ice days	Freshwater biodiversity and water quality
Lake and river ice cover duration	Growing season for agriculture
Lake and river ice phenology	Land-cover extension below projected sea-level
Lake Ice extension	Moth Phenology Index
Max 1 day precipitation	Coastal flood damage and adaptation costs
Max 5 day precipitation	People affected by floods
Maximum of daily minimum temperature	Irrigation water requirement
Maximum of daily maximum temperature	Annual average damage from river floods
Mean precipitation	Average annual heat-related deaths per 100,000 habitats
Minimum of daily minimum temperature	Potential impact of river flooding on major roads
Minimum of daily maximum temperature	Potential impact of river flooding on railways
Number of wet days	Potential impact of river flooding on settlements
Nutrients in transitional, coastal and marine waters	Percentage change in arrivals/departures due to global warming

Ocean heat content	Annual olive-crop yield
Permafrost thickness	Natural disasters
Precipitation extremes	
Ocean acidification	
River flow drought	
Sea surface temperature	
Simple daily precipitation intensity	
Spring snow cover extension	
Snow cover extension	
Standardized SnowPack Index	
Snow Water Equivalent	
Storm surges	
Summer days	
The length of thermal growing season	
Total precipitation	
Tropical nights	
Very heavy precipitation days	
Very wet days	
Warm days	
Warm nights	
Warm spell duration index	