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Towards a Global Adaptation Progress Tracker: first thoughts

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Understanding whether we are on track to climate change adaptation at the global scale is critical to validate the "well below +2°C" mitigation target as a sustainable objective for humankind over the 21st century and beyond. In substance, the 2015 Paris Agreement suggests countries to be in charge of assessing and reporting their own adaptation progress, with then the United Nations Framework Convention on Climate Change (UNFCCC) helping with aggregating such efforts to provide a global-scale picture. Although many works have been developed to identify indicators and metrics for assessing national-level adaptation, no universal, agreed-upon framework has emerged to date that could be implemented in the coming years and allow feeding the UNFCCC Global Stocktake first round in 2023 with a global-scale assessment. An alternative, complementary approach consists of assessing adaptation progress directly at the global level, and avoid being locked in the political and diplomatic barriers inherent to any country-level reporting system. Such a global-lens approach however raises several challenges, including the development of innovative indicators and the identification of an organization responsible for implementation.

SUPPLEMENTARY MATERIAL https://bit.ly/2lMCdrU

KEY MESSAGES

Answering the question 'are we on track to adaptation at the global scale?' is critical to validate that the "well below +2°C" mitigation target is sustainable for humankind over the 21st century.

The usual approach to global adaptation tracking relies on the development of national-level indicators and frameworks to be developed by the Parties to the UNFCCC.

Such an approach however raises political and diplomatic barriers (e.g. reluctance to report on national progress), as well as more technical concerns (e.g., not climate risks-specific indicators).

A complementary, alternative approach consists of directly adopting a global-level perspective, based on the identification of metrics describing adaptation gaps/benefits directly at the global level. To this end, starting from the 8 key risks (i.e. of global importance) identified by the IPCC could help. They refer to key risks to people, land-based food security, ocean-based food security, water security, medium-to-large scale urban systems, functional networks, terrestrial biodiversity, and ocean biodiversity.

This Working Paper describes the theoretical skeleton of a Global Adaptation Progress Tracker (GAP-Track) to inform UNFCCC climate negotiations with a scientifically robust, sound and relatively simple assessment of adaptation progress at the global level. Main steps and challenges ahead are described.

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The need for tracking adaptation progress at the global scale is widely recognised as a "Grand Challenge" (Magnan and Ribera, 2016; AGR, 2017; Berrang-Ford *et al.*, 2019). However, despite the high-level political momentum (APA-SBSTA-SBI, 2018) around the Paris Agreement (PA) incentives to "establish a global goal on adaptation" (Article 7.1) and inform progress through the 5-year revision process, 'no technical work has been mandated to be undertaken by any subsidiary and constituted body in support of reviewing the overall progress made in achieving the global goal on adaptation. Therefore, the details of the global goal on adaptation and how to measure progress against it remain an open question' (UNEP, 2017: 10; see also EU, 2016; Kato and Ellis, 2016; UNFCCC, 2016; UNEP, 2017). To fill in this gap, various initiatives emerged within the UNFCCC Adaptation Committee, UN organisations, NGOs and scientists, to develop relevant frameworks (for overviews, see GIZ and IIED, 2014; Lenikowski *et al.*, 2015, Kato and Ellis, 2016; UNEP, 2017). L Berrang-Ford and colleagues (2019) propose the most advanced approach to assess adaptation progress across governments: instead of trying to identify the most relevant indicators for tracking adaptation efforts (i.e. what governments are doing) and results (i.e. effective changes in climate vulnerability), they propose to frame the issue around "concepts that are translatable and scalable across levels of government, and that can be systematically compared between governments" (2019: 447). Such a framing offers considerable opportunities for developing assessment that are consistent across scales and nations, and therefore for understanding global-scale adaptation progress. However, as any approach, it is not exempt from barriers, especially because it relies on governments assessing their own progress. This *Working Paper* advocates for a complementary way, i.e. non-state-driven, to track adaptation progress globally, in order to enhance confidence in conclusions (i.e. through results comparison) and feed a nuanced debate at the international level. Despite the fact that alternatives are moving beyond the standardized national assessment approach, they have been poorly explored to date by the scientific literature (Craft and Fisher, 2018), this *Working Paper* advances first thoughts on the development of a *Global Adaptation Progress Tracker* (GAP-Track).

1. THE STANDARDISED NATIONAL REPORTING APPROACH

1.1. Overview

The classical approach to track global adaptation progress relates to the development of country-level indicators reflecting the implementation of adaptation, both in terms of results and process (Cristiansen *et al.*, 2016, 2018). Although there is currently no formal obligation for Parties to the UNFCCC to engage in such an assessment, the institutional process would benefit from the inclusion of a component on tracking adaptation progress into Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs) or National communications, as suggested by A. Moehner *et al.* (2017) and T. Kato and J. Ellis (2016). A country-level-driven assessment would also be best suited to fully consider national circumstances by using the context-relevant indicators (Berrang-Ford *et al.*, 2019). However, some limitations must be recognized leading to a call for an alternative, complementary approach.

1.2. Political and diplomatic barriers

Diplomatic reluctances – Despite a persistent official call for broadening the way adaptation is addressed within the UNFCCC arena (APA-SBSTA-SBI, 2018), some Parties, especially developing countries, are reluctant to distract climate negotiations from the historic funding-focused lens, which they consider as the top priority. In that view, efforts are focused on assessing countries' adaptation needs, and translating these needs into international funding requests. In the same line, 'some developing countries could be reluctant to report their adaptation efforts, depending on the way the international community will take them (e.g., encourage further efforts with more funding or prioritise countries showing less progress)' (Magnan and Ribera, 2016: 1282). Developed countries could also be reluctant to report on their progress on adaptation, being afraid, for example, of growing internal pressure from their own authorities, populations and stakeholders judging nationwide efforts insufficient.

Outdated North/South divide – There are still difficulties to move beyond the traditional Annex 1/Non-Annex 1 divide. Within the UNFCCC context, adaptation issues are usually discussed only for developing countries, when tracking progress globally requires to also include a developed-country perspective in order to get a comprehensive, global picture (see Table SM1 in Supplementary Material 1; SM1).

Extra burden – There is a serious risk that institutionalising a country-level tracking process will put an extra burden on Parties' negotiation teams and national institutions, especially in developing countries (but not only). As a result, some parties could show reluctant to engage in a tracking progress process, all the more that the associated workload remains unclear.

Latency in the negotiation process – A last barrier refers to the timing of tracking global adaptation progress. Such an assessment must fit into the PA-inherent 5-year revision cycle of progress made to address climate change causes and impacts, which means a first round of assessment by 2023. Yet, the history of negotiations shows relative difficulty for the UNFCCC arena to decide quickly on emerging issues. While the issue of adaptation progress indicators could be clarified relatively quickly based on the huge amount of work already done on the intertwined issues of adaptation to climate change (AC, 2015), Sustainable Development Goals (SDGs) and Disaster Risk Reduction (Berrang-Ford *et al.*, 2019), other dimensions remain contentious among Parties, and therefore require time for reaching an agreement. This is the case, for example, of the aggregation of country-level information and the way results will feed negotiations: e.g., who should aggregate, and how will country-level results be utilised?

1.3. More technical concerns

The monitoring, reporting and evaluation of adaptation 'at the national level is challenging due to many factors, including long-time scales, uncertainty, shifting baselines and contexts, unclear and multiple policy goals and objectives, a lack of causal link between policies and indicators, the diversity of key concepts and definitions, a lack of appropriate data, and resource constraints' (EU, 2016: 319; see also UNEP, 2017; Vallejo, 2017; Dilling *et al.*, 2019).

Not suited for a global perspective – Most of the existing frameworks for assessing adaptation 'are not designed—and have negligible potential—to be used for systematic global aggregation or synthesis of nationally-reported data' (Berrang-Ford, 2017: 39). While several frameworks have been identified to provide potentially suitable information for a global assessment exercise (Berrang-Ford, 2017, see also Supplementary Material 1, SM1), all face serious limitations such as heavy and time-consuming methods to inform indicators, use of indicators that are not adaptation-specific but rather reflect the availability of already-established global datasets, low transparency in the methodological backgrounds for scoring indicators, and lack of time series in data (thus hampering trends analyses). Importantly, recent advances from Berrang-Ford *et al.* (2019) offer new opportunities for aggregation, in that they focus on how to make context-specific indicators systems compatible across scales and across nations.

Missing future climate-related risks – Analysing pre-COP21 Intended Nationally Determined Contributions (INDC), the UNFCCC shows that despite most Parties' long-term goals or visions are climate-oriented, they 'are closely intertwined with development objectives such as poverty eradication, economic development or improvement of living standards, environmental sustainability, security and human rights.' (UNFCCC, 2016: 61). As a result, 'many countries do not yet have clear adaptation-related goals (i.e. specific outcomes, timelines, actions at the national or sub-national level)' (Kato and Ellis, 2016: 22), these latter remaining rather aspirational (UNFCCC, 2016). Accordingly, indicators and databases tend to focus on current vulnerability and use development-oriented descriptors that are expected to limit or enhance adaptation in the future (UNFCCC, 2016). The GIZ and IIED repository of adaptation indicators (2014) provides some examples of associated metrics, e.g. the percentage of farmers and fisher folk with access to financial services. While these development-related dimensions are obviously relevant to adaptation, they rather describe the background or enabling conditions for enhancing adaptation at the national level and in the long run, and highlight the (lack of) adaptive capacity of a given society. Such a knowledge is critical to feed discussions on groups of population or priority areas, and on the related funding needs and flows, but we argue is not enough climate change-oriented, and therefore is not suitable to describe progress made specifically against future climate-related risks reduction. To our view, a more forward-looking approach is needed that should be focussed on clear goals in terms of future risk reduction levels. Clarifying such goals is scientifically, politically and socially challenging, but at least proxies would help. Examples inspired from the GIZ-IIED repository (2014) could be: the awareness level of populations about the contrasting futures to be expected from a +1.5/+2°C and a +4°C end-century worlds; soils conservation measures in relation to future risk reduction targets (IPCC 2019); the geographical extent of marine protected areas in relation to future climate-related risk to ecosystems and their services; the percentage of transport infrastructure standards revised according to future climate change impacts; the percentage of areas at risk from future sea-level rise (e.g., based on exposure mapping) and that are already implementing responses (protection, relocation, etc.); the number of businesses with risk management plans considering climate change aspects/or adaptation benefits; etc.

2. FIRST THOUGHTS ON AN ALTERNATIVE WAY TO TRACK GLOBAL ADAPTATION PROGRESS

2.1. Overview

The above technical concerns are not specific to the design of standardised national-level indicators and also apply to the alternative approach proposed in this *Working Paper*, making the two approaches complementary rather than competitive. However, as the latter consists of directly adopting a global-level perspective and therefore not relying on any country-level reporting, it could help moving away from the fear of comparisons between the Parties, and thus from some of the above-mentioned diplomatic and political barriers. Especially, as it does not require systematic national-level assessments for each indicator, it limits the risk of stigmatising countries with the lowest progress. On the other hand, the alternative global-lens approach will necessarily remain at a generic level (i.e. global), *de facto* limiting the possibility for in-depth analyses of where the main gaps and priorities are, and poorly reflecting the diversity of national and local circumstances. We however do not consider this as a major problem as the primarily goal of a global assessment is not to go in-depth into the results' causes and geographical disparities. Its function is foremost to provide a global-scale snapshot of where we stand in terms of adaptation to climate change. Such a specific scope and related limitations must be acknowledged from the beginning, and by all, in order to avoid misinterpretation and false expectations about the final results.

2.2. The basics of global scale, climate change-focussed adaptation indicators

Four critical dimensions are considered in the design phase of the indicators.

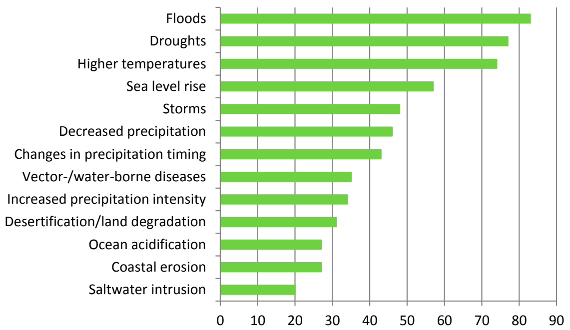
Target climate change-specific risks – The assessment must reflect a clear priority on addressing the specific risks induced by climate change rather than some background conditions for vulnerability reduction (e.g., access to electricity, political stability, etc.). Although these background conditions play a critical role in explaining the root causes of vulnerability, they rather refer to tracking development progress, e.g. in the frame of the SDGs, which carries the risk of distracting analyses from the specific threats posed by climate change impacts. The potential success of a tracking climate change adaptation progress framework will indeed crucially rely on the level of specificity of its scope, i.e. progress made on implementing means/options/strategies to *directly* address climate change impacts and future risks. This refers to answering the following question: "how far are we from a low level of impacts in the future?", which in turn supposes to assess the risks, quantitatively and/or qualitatively, either for a series of impact indicators (as done for Europe; EU, 2016) or for more generic risks as done with the IPCC Reasons for Concern framework (Oppenheimer *et al.,* 2014; O'Neill *et al.,* 2018). Whatever the option, the results can be used as benchmarks to assess current progress towards future risk reduction.

Contribution to adaptation rather than undisputed attribution to future risk reduction – Another (related) starting point is that 'even imperfect references to capture adaptation are needed to guide and delimit international discussions' (Magnan and Ribera, 2016: 1282). A key challenge consists of defining indicators that reflect as much as possible adaptation progress (process and results). Indicators must be aligned with as clear as possible adaptation targets, advocating for 'proxy indicators that are coherent with our understanding of what constitutes meaningful adaptation, and are underpinned by empirically validated or methodologically sound assumptions' (Berrang-Ford, 2017: 37; see also Ford *et al.,* 2013, 2015). In such a perspective, 'a focus on the contribution made to a result rather than strict attribution is emerging as a more useful concept to link national efforts with results' (Berrang-Ford, 2017: 46). The attribution issue theoretically refers to the evaluation of the specific contribution of a given or a set of adaptation action(s) to future risk reduction. While potentially critical to assess adaptation progress, this topic remains understudied (Ford *et al.*, 2013) and highly challenging (Berrang-Ford, 2017; Dilling *et al.*, 2019)).

Reflect worldwide concerns in terms of risks from climate change – Because of the overall context of the global adaptation progress tracking, the indicators must reflect worldwide societal and policy concerns about climate change. To this end, the assessment must cover the critical hazards/risks across the world and that make sense also from a policy perspective. A potentially relevant basis is provided by the UNFCCC analysis of INDCs (Fig. 1), which shows that 'the main sources of concern identified by most Parties are flooding, sea-level rise and drought or desertification' (UNFCCC, 2016: 16-17). It must also cover the sectors identified by Parties to the UNFCCC as critical (Fig. 2), especially 'water, agriculture, biodiversity and health [as well as] forestry, energy, tourism, infrastructure and human settlements' (UNFCCC, 2016: 64).

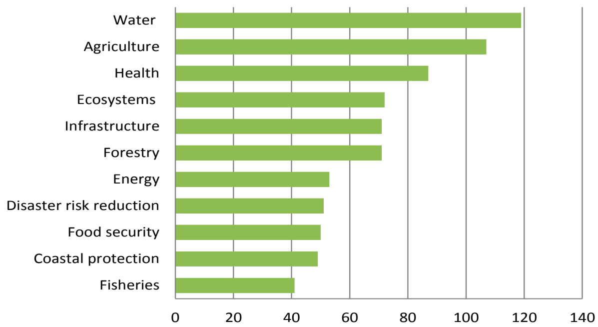
Consider developing and developed countries together, not separately – It is often assumed in climate negotiations that critical geographies have to be prioritised, which is reflected in the INDCs: 'in terms of vulnerable geographical zones, arid or semi-arid lands, coastal areas, river deltas, watersheds, atolls and other low-lying territories, isolated territories and mountain ranges were identified in the adaptation components, and some Parties identified specific regions of their countries that are most vulnerable' (UNFCCC, 2016: 64). The question remains open whether the progress indicators should distinguish more vulnerable geographies/environments, or rather cover all the types of geographies at the Earth surface, no matter which types of country they describe (e.g. temperate continental areas, tropical forests, low-lying coastal areas, etc.). This second option would help going beyond the above-mentioned Annex 1/Non-Annex 1 divide and reflect the more worldwide dimension

FIGURE 1. Key climate hazards identified in INDCs' adaptation components



(source: UNFCCC, 2016)

FIGURE 2. Priority areas and sectors for adaptation actions identified in INDCs' adaptation components



(source: UNFCCC, 2016)

of climate-induced risks and related threats to ecosystems and societies.

2.3. Towards an application: first thoughts

A way to address the above dimensions consists of starting from identified worldwide key risks, as done in the IPCC Reasons for Concern framework (Oppenheimer *et al.,* 2014; O'Neill *et al.,* 2018), and then associate global-scale indicators to each of them. To this end, we propose a 4-phase approach that describes the skeleton of a *Global Adaptation Progress Tracker (GAP-Track)* to inform UNFCCC negotiations with a scientifically robust and sound assessment of adaptation progress at the global level.

Phase 1: Identify key risks of worldwide concern – The IPCC Working Group 2 contribution to the 5th Assessment Report (AR5) identified 8 key risks (KRs) as representative of the range of critical risks to the global society. These KRs have been used in the AR5 (Oppenheimer *et al.,* 2014) and in subsequent publications to structure a reflection on the worldwide Reasons for Concern (RFCs) about climate change, and in the aim of communicating 'scientific understanding about risks in relation to varying levels of climate change' (O'Neill *et al.,* 2018: 28). Table 1 simplifies the IPCC KRs to highlight 8 KRs providing relevant benchmarks to assess progress on global adaptation.

Phase 2: Assess key risks-related benchmarks in the future – Phase 2 aims at defining the KRs-associated benchmarks to be considered when assessing progress made on adaptation globally (i.e. adaptation goals). To make sense, such benchmarks must consider future risks in the absence of substantial additional adaptation efforts, in a business-as-usual adaptation scenario made of only incremental measures lacking an anticipative dimension. Adopting a forward-looking approach allows to assess current levels of risk in light of these future benchmarks, and thus inform gaps in current adaptation. To define these forward-looking risk benchmarks, we propose to consider risks by the end-century, at the global scale, and according to

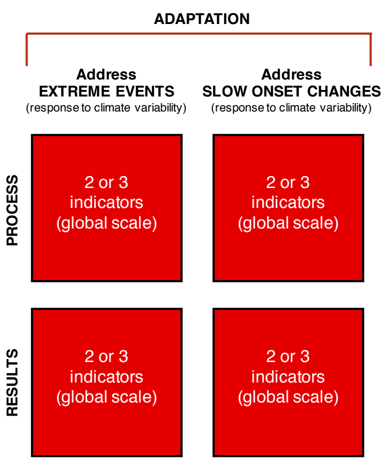
TABLE 1. Climate change-induced key risks at the global scale

KR-1 Risk to people	Risk to people (death, injury, ill-health, or disrupted livelihoods), including both developing and developed countries, due to all types of extreme events and slow onset changes – *inspired from KR(i) and KR(iv) in AR5 (Oppenheimer et al., 2014)*
KR-2 Risk to land-based food security	Risk to land-based food insecurity and the breakdown of land-based food systems linked to warming, drought, flooding, and precipitation variability and extremes – *inspired from KR(v) in AR5 (Oppenheimer et al., 2014)*
KR-3 Risk to ocean-based food security	Risk of ocean-based food insecurity and the breakdown of ocean-based food systems linked to ocean warming, ocean acidification, ocean deoxygenation and sea-level rise – *inspired from KR(v) in AR5 (Oppenheimer et al., 2014)*
KR-4 Risk to water security	Risk to drinking and irrigation water availability, and consequences in terms agricultural productivity and loss of rural livelihoods and income, from semi-arid regions to temperate large continental plains and high-latitude cultivated areas – *inspired from KR(vi) in AR5 (Oppenheimer et al., 2014)*
KR-5 Risk to urban systems	Risk of damages and disruptions to medium-to-large urban systems due to inland inundation, heat waves and marine flooding – *inspired from KR(ii) in AR5 (Oppenheimer et al., 2014)*
KR-6 Risks to functional networks	Systemic risks leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services – *KR(iii) in AR5 (Oppenheimer et al., 2014)*
KR-7 Risk to terrestrial biodiversity	Risk of loss of terrestrial and inland water ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for livelihoods – *inspired from KR(viii) in AR5 (Oppenheimer et al., 2014)*
KR-8 Risk to ocean biodiversity	Risk to of loss of marine and coastal ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for coastal livelihoods, especially for fishing communities in the tropics and the Arctic – *inspired from KR(vii) in AR5 (Oppenheimer et al., 2014)*

a +2°C warming scenario (~RCP2.6). Such a position reflects the objectives of the UNFCCC and the PA, in order to ensure a continued dialogue with the climate negotiation arena, and thus the policy relevance of the final results of the assessment.[1] Both the IPCC AR5 and the Sixth Assessment Special Reports (on +1.5°C, Land Use and Ocean/Cryosphere) as well as a large set of recent publications modelling the future impacts of climate change provide meaningful sources of information to describe forward-looking benchmarks.

Phase 3: Design relevant adaptation progress indicators – Phase 3 consists of an extensive and collaborative work to design a set of pragmatic indicators for each of the KRs described in Table 1, and in light of Phase 2. A preliminary consideration refers to the complexity of the adaptation issue, as framed in Figure 3, as KRs indicators must reflect adaptation to both extreme events and slow onset changes, as well as describe the fact of both adapting (process) and being adapted (results).

FIGURE 3. A frame for designing adaptation indicators



While this is not the purpose of this *Working Paper* to develop such a panel of indicators, an illustrative example could be the following (see Box 1). Let us consider the following forward-looking benchmark associated to risks to people (KR-1 in Table 1): the number of people (e.g., in billions of people, or % of the world population) that will be directly affected, at the end of the century, by climate change under a +2°C warming scenario. A possible indicator contributing to describe progress towards a minimisation of KR-1 could be coded KR-1.1 and described as 'the proportion of the world population directly affected (death, injury, illness, or disrupted livelihoods) by climate-related extreme events'. See Box 1 for other examples of indicators, e.g. related to the world population exposed to slow-onset changes and/or that have no access to early warning systems.

Phase 4: Measure adaptation progress – For each indicator (KR-1.1, KR-1.2, etc.), the challenge consists in developing both a one-off evaluation for the year of the assessment (e.g., in 2020) and an evaluation of a past-to-present trend (i.e. progress made compared to a specific baseline in time). In terms of the baseline for calculating past-to-present adaptation trends as well as past-to-future benchmarked trends, we suggest to use the 1990 year, in order to reflect the period of emergence of climate change concern in the international policy arena through the creation of the IPCC in 1988 and adoption of the UNFCCC in 1992. But again, this should be debated and collectively decided.

Bearing in mind that the assessment aims at informing both *(i)* recent progress on adaptation (backward-looking) and *(ii)* the extent to which such progress is sufficient to cope with the risks associated with a +2°C scenario (forward-looking), we propose to use the deviation between *(i)* and *(ii)* as a proxy for adaptation progress (or lack of). Such a deviation represents the gap in the indicator's level at the time of the assessment (e.g., KR-1.1 in 2020) compared to the theoretical benchmarked trend 1990-2100. As shown in Panel A of Figure 4, such a theoretical trend defines a line artificially joining a given indicator's observed level in 1990 to its projected level in 2100, and in the absence of substantial additional adaptation (*cf.* Phase 2). The 1990-2100 theoretical trend thus schematically describes the increase in the risk associated to a given indicator. Due to cumulative effects in risk, possible tipping points, etc., an exponential 1990-2100 curve would make more sense than a straight line (as in Fig. 4), but at this stage and for a purely illustrative purpose, we choose the simplest way of doing, i.e. a straight line.

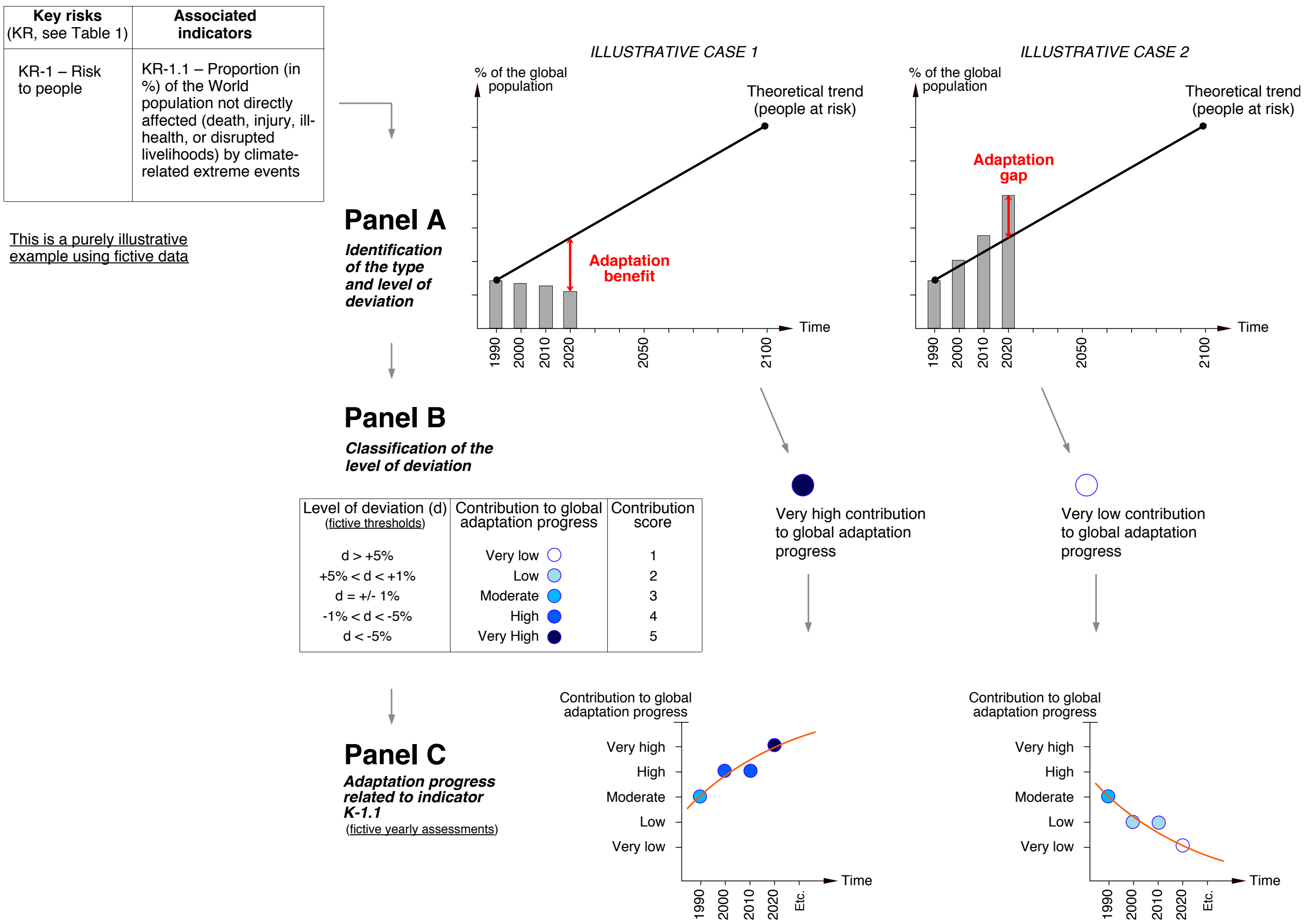
Next is to classify the deviation level of the one-off (yearly) assessment compared to the 1990-2100 theoretical trend (Panel B in Fig. 4). This level defines the order of magnitude of the contribution of the measures and strategies associated with a given indicator to end-century vulnerability reduction; and therefore of the contribution to progress in adaptation to climate change. A negative deviation (i.e. 2020 assessment < theoretical 1990-2100 trend; see illustrative case 1 in Panels A and B, Fig. 4) describes an adaptation benefit, i.e. a high to very high contribution to adaptation progress. At the opposite, a positive deviation (i.e. 2020 assessment > theoretical 1990-2100 trend; see illustrative case 2 in Panels A and B, Fig. 4) describes an adaptation gap, i.e. a low to very low contribution to adaptation progress. Adaptation progress can be considered as moderate when no deviation is observed (i.e. 2020 assessment ≈ theoretical 1990-2100 trend).

1 At a later stage, and based on the adaptation progress assessment grid, it will also be possible to analyse past-to-present adaptation progress in light of either the +1.5°C or various >+2°C warming scenarios.

Box 1. Illustrative examples of indicators for three Key Risks related to people (KR-1), urban systems (KR-5) and ocean biodiversity (KR8), and associated potential data sources and challenges.

Key Risk	Description	Potential indicators	Potential sources of data
KR-1 Risk to people	Risk to people (death, injury, ill-health, or disrupted livelihoods), including both developing and developed countries, due to all types of extreme events and slow onset changes	KR-1.1 – Proportion of the world population not directly affected (death, injury, illness, or disrupted livelihoods) by climate-related extreme events	Data: Based on the number of people affected by droughts, extreme air temperatures, flood, landslide, storms and wildfire Source: https://www.emdat.be/ (Emergency Events Database, EM-DAT)
		KR1.2 – World population estimated to not be directly exposed to climate-related slow-onset changes (e.g., sea level rise)	Data: Based on the density of human assets (buildings and infrastructures) within a 200-m coastal fringe (exposure to sea level rise) Source: Google Earth Imagery analysis Challenge: new database to be created. See examples of such approached for sandy beaches (Luijendijk *et al.*, 2018), tidal flats (Murray *et al.*, 2019) and wetlands (Schuerch *et al.*, 2018)
		KR-1.3 – World population at risk (cf. KR1.1) but with access to early warning systems	Data: % Source: Climate Risk and Early Warning Systems (CREWS, https://www.crews-initiative.org/en), Challenge: the challenge is to identify the above % not against the World population at large, but more specifically against the World population already at risk from climate-related hazards, i.e. KR1-1. That is, there is a need to *(i)* combine existing databases (currently often focussed on low-income countries such as Least Developed Countries and Small Islands Developing States, LDCs and SIDS respectively), and *(ii)* make them using KR-1.1 as a baseline (i.e. consider not only World population at large).
KR-5 Risk to urban systems	Risk of damages and disruptions to medium-to-large urban systems due to inland inundation, heat waves and marine flooding	KR-5.1 – Extent of water evacuation systems in urban areas	Data: Density of water evacuation systems per km^2 according to a X-year flooding event (with X depending, e.g., on climate thresholds identified in climate projections and as defined in Phase 2 of GAP-Track approach) Source: e.g., ND-Gain Index (https://gain-uaa.nd.edu/?referrer=gain.nd.edu), see also Chen *et al.* (2016). Challenge: Define a baseline, develop a data collection process and set up a global database.
		KR-5.2 – Strengthening of building and infrastructure resilience to Y-year flooding events in 2100	Data: % of building and infrastructure conceived to resist to an Y-year flooding event (with Y depending on climate thresholds identified in climate projections and as defined in Phase 2 of GAP-Track approach) Source: e.g. ND-Gain Index (https://gain-uaa.nd.edu/?referrer=gain.nd.edu), see also Chen et al (2016). Potential for linking with the SDG 11 on "Sustainable Cities and Communities" (https://sustainabledevelopment.un.org/sdg11). Challenge: Define a baseline, develop a data collection process and set up a global database.
		KR-5.3 – Degree of improvement in ventilation systems in buildings and streets, against a Z-year heatwave event	Data: % of building and streets benefiting from ventilation systems (e.g. technological or architectural) using a Z-year event reference. Source: to be identified. Challenge: new database to be created
		KR-5.4 – Extent of the emergency health care networks	Data: Number of health and social services personnel per 1,000 inhabitants in urban areas (and, e.g., according to estimated needs in 2100) Source: Data collection from official census statistics for all countries around the World (often hosted by cross-Ministries national statistical units). Potential for linking with SDG11 on "Sustainable Cities and Communities" (https://sustainabledevelopment.un.org/sdg11) and SDG3 on "Good health and well-being" (https://sustainabledevelopment.un.org/sdg3). Challenge: Develop estimation of health systems needs in 2100, and collect information on the current situation (cf. countries official census statistics).
KR-8 Risk to ocean biodiversity	Risk of loss of marine and coastal ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for coastal livelihoods, e.g., for fishing communities in the tropics and the Arctic	KR-8.1 – Progress towards a minimising of climate-related ocean changes, especially ocean warming, ocean acidification, ocean deoxygenation and sea-level rise.	Data: Multiple physical and chemical indicators of ocean health under climate change Source: Syntheses from the IPCC (e.g., chapter 5 of the Special report on Ocean and Cryopshere, https://www.ipcc.ch/report/srocc/; chapter 3 of the Working Group 2 contribution to the AR6, https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/) and the IPBES. See also the NERUS program (https://nereusprogram.org/), and potential for linking with SDG14 "Life under water" (Conserve and sustainably use the oceans, seas and marine resources for sustainable development): https://sustainabledevelopment.un.org/sdg14. See also Nash et al (2017). Challenge: Develop indices combining multiple climate-related ocean drivers
		KR-8.2 – Restoration and active relocation of endangered climate-sensitive coastal ecosystems (e.g. coral and oyster reefs, mangrove forests, etc.)	Data: % of endangered marine ecosystems and habitats under restoration or relocation active programs Source: Global data collection to be organized. See also Gattuso *et al.* (2018) Challenge: New databases to be created

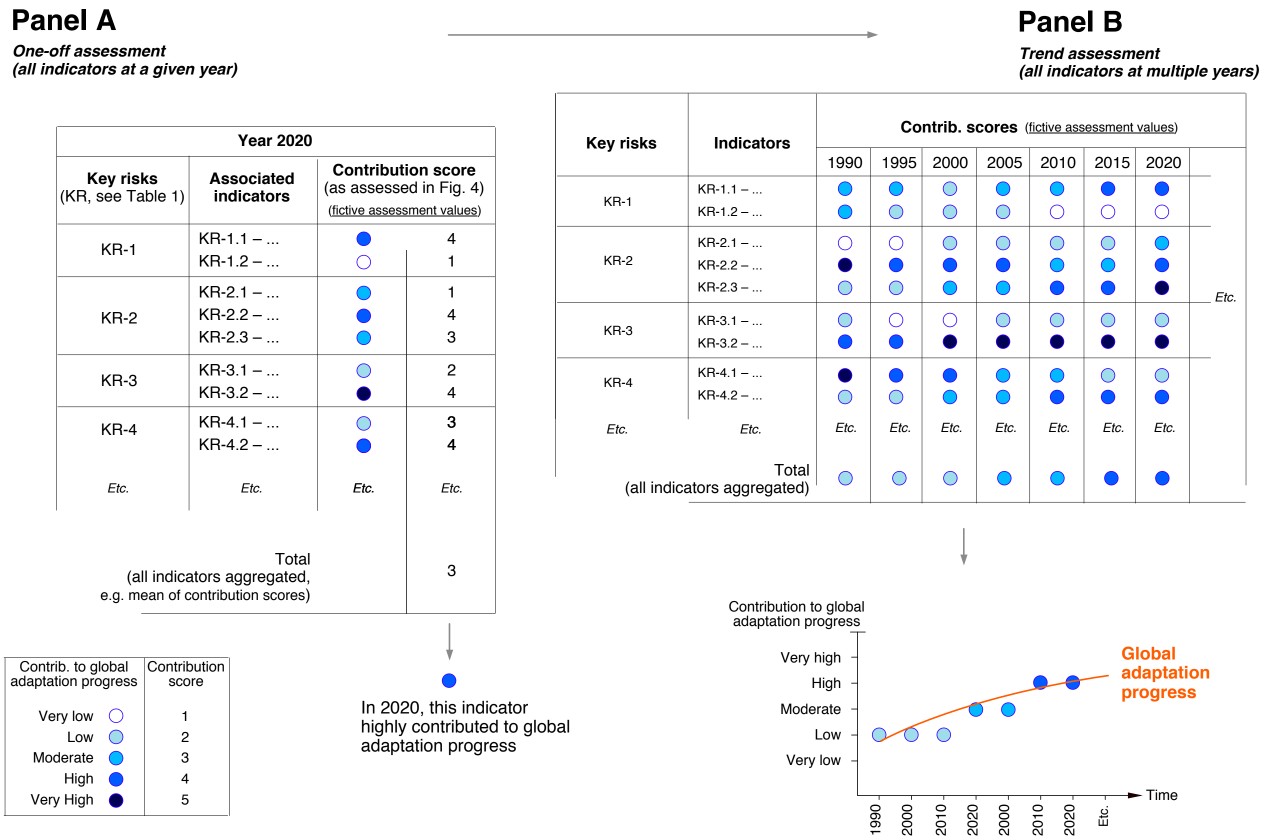
FIGURE 4. **Theoretical approach to assessing adaptation progress.**



Panel A compares yearly assessments for a given indicator (here, KR-1.1) to the theoretical benchmarked 1990-2100 trend derived from the observed level of the indicator in 1990 and projected risk in 2100. Two illustrations are presented, when adaptation efforts allow reducing future risk (illustrative case 1 on the left) and when adaptation progress are insufficient to address future risk (illustrative case 2 on the right). Based on the deviation level between a given year's score and the associated theoretical need (year-associated point on the 1990-2100 trend), **Panel B** classifies the contribution to risk reduction, i.e. to adaptation progress (scale of blue bullets). **Panel C** illustrates the possibility to highlight 'trajectories of adaptation' (red curves).

Two potential levels of analysis can be derived from the above. The first one focuses on the one-off (yearly) assessment approach to answer the question: to what extent are we in 2020 (e.g.) contributing to global adaptation? This could be particularly helpful to develop a ***Yearly State of Adaptation***. A second level of analysis moves a step further to answer the initial overarching question, i.e. are we globally on track to adaptation over the 21st century? In such a perspective, and as shown in Panel C of Figure 4, another step consists in applying the above-described approach (i.e. classification of the yearly deviations compared to the 1990-2100 trend) to intermediary dates, for example every 10 years (e.g., KR-1.1$_{1990}$, KR-1.1$_{2000}$, KR-1.1$_{2010}$, KR-1.1$_{2020}$)—or even 5 years to reflect the 5-year revision cycle embedded in the PA—to highlight trends in adaptation progress towards a given indicator. When applying the same approach to all indicators and all KRs, it becomes possible to highlight a ***Trajectory of Global Adaptation***. Figure 5 provides a fictive example of such a final assessment, only for an illustrative purpose.

FIGURE 5. Highlighting a trajectory of global adaptation progress



Panel A illustrates the whole assessment for a given year (e.g. 2020), and Panel B illustrates the past-to-present trend (e.g., from 1990 to 2020; red curve).

3. DISCUSSION: THE WAY FORWARD

The approach developed so far raises four major challenges towards a robust *Global Adaptation Progress Tracker (GAP-Track)*.

3.1. The narrative challenge

We still need a narrative at the global level to describe a common sense of what adaptation is, what our shared climate-specific targets are, how to reach them and at the end, what a global adaptation goal should be (Berrang-Ford *et al.,* 2019). The PA actually provides limited insights on this as it refers to "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development" (Article 7.1). Such a scope is too broad (adaptive capacity + resilience + vulnerability + sustainable development) and relies on concepts that remain hard to conceptualise and measure in a uniform way (Leiter *et al.,* 2017; UNEP, 2017). So that something more specific is needed. Building on our own previous works (Magnan *et al.,* 2015; Magnan and Ribera, 2016), reflecting the climate change-related key risks to the global society (see Table 1), and referring to a more precise issue (i.e. human security in relation to climate change-related risks in the future), a more pragmatic definition of the global adaptation goal could be:

> *The commitment of the international community to ensure climate-related human security, in the aim of achieving a sustainable future under a well below +2°C global warming scenario by the end of this century. Ensuring human security in the specific context of climate change means first, enhancing adaptation efforts when possible, and second, providing adequate answers for those whose security could not be covered in a well below +2°C world.*

Human security provides an interesting approach as it underscores the universality and interdependence of a set of freedoms that are fundamental to human life, as well as to societies' adaptive capacity to climate change (e.g., equity, access to safe environmental resources). From a more practical perspective, achieving high levels of reduction in the global society's vulnerability to the key risks described in Table 1 could define what "ensuring future human security" means. So that together, the above definition and Table 1 help clarifying the boundaries of the Global Adaptation Goal.

3.2. The indicator/data challenge

It is usually assumed that data availability forms a key characteristic of a relevant indicator (see SM1). Although fully recognising the importance of referring to data to be able to describe, qualitatively or quantitatively, a given indicator, we are concerned with using data availability as a starting point to define the nature of the indicators. For example, educational levels are informed through worldwide databases and usually involved in adaptive capacity assessments, assuming a positive correlation between education and adaptation. However, increasing examples challenge such a positive correlation, suggesting that educational levels are not necessarily the most suited proxy to describe adaptive capacity at work. At the opposite, the alternative approach promoted in this *Working Paper* advocates for, first, thinking about the key characteristics of adaptation progress and, then, identifying the most relevant indicators to describe these characteristics. This 'relevance-first' approach may lead to identify indicators for which data do not exist or have never been aggregated, i.e. out-of-the-box indicators. This should not prevent from using existing datasets and global-scale indicators if they really make sense in the context of a *Global Adaptation Progress Tracker* (e.g., economic losses due to climate-related disasters). However, we argue that it would be misleading to limit such a tool only to existing datasets and related indicators. Inspired from the repository of adaptation indicators developed by GIZ & IIED (2014), one example deals with the resistance of transportation and communication infrastructures to climate change-induced extreme events and slow onset changes. Such an indicator could usefully describe KR-6 in Table 2 (i.e. risks to functional networks). However, does a multi-climate hazards resistance index exist for such infrastructures, and has it ever been applied at the global scale? Or do we have information, e.g., on the percentage of transport and communication infrastructure standards revised according to future climate change impacts, at the global scale? If not, it would make sense to develop such data within the frame of a *Global Adaptation Progress Tracker*, simply because the resistance of infrastructures to climate change impacts deeply describes what adaptation could really look like.

In this perspective, the scientific community should assess the possible opportunities offered by the emergence of big data and increasing computational performances. 'There are a number of promising opportunities to engage with computational science, including automated analysis of large volumes of text, crowdsourcing, and scraping of digitally sourced data. To date, there has been negligible engagement by the adaptation community in exploring such sources of data, or collaboration with computational experts. The promise of "big data" may not resolve many of the fundamental conceptual challenges of adaptation tracking, but may provide new insights into data collection approaches and innovations that help address feasibility constraints to synthesizing large volumes of data' (Berrang-Ford, 2017: 47). Satellite imagery also opens new areas of data creation, e.g., to assess the number of built assets located in potentially risk-prone area in 2100 (e.g., within a 100-m or 200-m coastal fringe; Box 1).

3.3. The baseline and benchmark challenge

This *Working Paper* proposes to use 1990 as a baseline (backward-looking) and 2100 associated with a RCP2.6 scenario as a benchmark for future risks (forward-looking). Such baseline and benchmark are essential to assess past-to-present progress in global adaptation (see Fig. 4 and 5). This however raises two concerns. First, these are relatively arbitrary choices, made only for an illustrative purpose. Both the baseline and benchmark need more scientifically-based and collective discussions (across the scientific and the international governance arenas). Second, the projected levels of risk that help define the benchmarks for each indicator (or each KR) will probably change over time due to progress (or lack of) in global mitigation effort, as well as to scientific advances in understanding the impacts (e.g., geographical extent, tipping points and cascading effects). In addition, future risks will also depend on progress in adaptation, a dimension barely considered in modelling works. Such dynamics could lead to a lowering and/or a worsening of the estimated risks and therefore to modifications in the 1990-2100 trend, e.g., a steeper slope for the straight line in Figure 4, or a more curved exponential trend. This will change the benchmark itself, which could represent a problem in terms of ensuring consistency in the design and assessment of a multi-decadal *trajectory of global adaptation* (i.e. shifting references). Although this *Working Paper* starts to propose some ways to get around this problem—e.g., by assuming no additional adaptation efforts in defining the future risks benchmarks; see Phase 2—more investigations are needed on this shifting references issue.

3.4. The implementation challenge

The last challenge refers to who should be in charge of implementing the *Global Adaptation Progress Tracker* and assess the state of global adaptation on a regularly basis. In the case of a standardised national reporting process, it is obvious that Parties must play this role, with the UNFCCC support. In the case of the *GAP-Track*, there is a need for an external-to-UNFCCC body to be in charge of the assessment (Craft and Fisher, 2018). The implementing body or institution however needs to be sufficiently close to the UNFCCC arena to have an influence on climate negotiations. The Intergovernmental Panel on Climate Change (IPCC), which is both politically neutral and scientifically credible, could play such a function; as also suggested in a recent joint note from the UNFCCC Ad Hoc Working Group on the Paris Agreement, the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (APA-SBSTA-SBI, 2018, see draft Decision I.16, page 16).

The IPCC is however not necessarily equipped to drive the *Global Adaptation Progress Tracker* (e.g., lack of people and funds), and the development of new research (to design out-of-the-box indicators) might go beyond its official mandate. In parallel, the funding issue needs to be clarified: besides who can do it, how much will it cost and who should pay for it? As food-for-thought, maybe a percentage of the Global Environmental Facility (GEF) budget—and/or another international fund—could be dedicated to develop a *Global Adaptation Progress Tracker*.

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Towards a Global Adaptation Progress Tracker: first thoughts

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