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Standards for Official Statistics on Climate-Health Interactions (SOSCHI): Discovery phase report

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Introduction to the SOSCHI project

The impacts on health of rising temperatures, wildfires, extreme weather events and other direct and indirect effects of climate change are a major global concern. The most significant hazards and their impacts differ between countries and regions, as do the possibilities and priorities for climate change adaptation. National and local governments and other stakeholders need to have regular, reliable and comparable data to monitor climate impacts and inform adaptation strategies, based on a transparent and globally generalisable statistical framework. The SOSCHI project, led by the UK Office for National Statistics and funded by Wellcome, is developing a framework of indicators based on state-of-the-art statistical methods to measure climate-related health risks. To support global reporting and monitoring and we are also developing a knowledge-sharing platform, open-source tools and R code. Our findings will also help highlight data gaps and help set the agenda for future improvement of data sources and methods.

Project partners

African Institute for Mathematical Sciences, Kigali, Rwanda
Cochrane Planetary Health Thematic Group, University of Alberta, Edmonton, Canada
Office for National Statistics, Newport, United Kingdom
Regional Institute for Population Studies, University of Ghana, Accra, Ghana
UK Health Security Agency, London, United Kingdom
United Nations Global Platform, New York, United States of America

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Table of Contents

1. Abstract

This report outlines the research and engagement activities carried out during the Discovery Phase of the Standards for Official Statistics on Climate-Health Interactions (SOSCHI) project in 2022-23 and the main findings from those activities.

The Discovery Phase aimed to make sure we understood the needs for official statistics on health impacts of climate change among different types of users and identified existing indicator sets and statistical resources about climate and health. We explored the available data and methods for producing climate-health indicators and developed an initial approach for the project. The activities carried out included desk research, focus groups and individual consultations with leading experts.

The intended benefits from the project were confirmed as (a) stronger evidence on the health impacts of climate change being used in strategies and interventions, to help improve outcomes for people and society; (b) more regular and efficient production of relevant statistics globally; and (c) faster study development and a more coherent evidence base facilitated by shared methodological approaches. We clarified the organisation of the project into two workstreams, the development of the statistical framework with indicator definitions and methods, and creation of open-source code and tools to support implementation of these indicators.

We identified the importance of developing indicators which can meet the accepted quality criteria for official statistics, such as relevance, comparability and coherence, timeliness and accessibility. We also noted the need to 'join up' the proposed framework with existing indicator sets relating to the Paris Agreement, Sustainable Development Goals and the Sendai Framework, ensuring coherence and complementarity and sharing terminology and definitions wherever possible.

Based on expert input and comparison with existing approaches, we agreed to consider indicator development in the Alpha Phase under the following heading: Chemical and other contaminants; Heat- and cold-related mortality and morbidity including heatwaves; Impacts on health systems and facilities; Injury and mortality from extreme weather events including flooding, wildfires, drought and storms; Malnutrition and food-borne diseases; Mental health; Respiratory illnesses; Non-communicable diseases; Vector-borne diseases; Water-borne diseases and other water-related health impacts; and Zoonoses.

Important notes

(1) This report was originally produced for internal use during the Discovery Phase and informed the subsequent development of the project. It has been shortened and adapted for subsequent publication. Some of the issues, views, and plans mentioned have changed during subsequent project phases. Therefore, this should be read as a historical document which does not necessarily represent the current state of the SOSCHI project.

(2) The timeline of the project required the team to identify partner institutions in LMICs and engage with interested internationally as the Discovery Phase and early steps of the Alpha Phase progressed. As a result, there was limited direct involvement from interested parties in LMICs in the Discovery Phase. This is being addressed by the establishment of national steering committees, review of ways of working, and outreach to a wider range of global stakeholders as experts and partners.

Citation

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2. Abbreviations

A	API	Application Programming Interface
C	CES	Conference of European Statisticians
	CVD	Cardiovascular disease
D	DEFRA	Department for Environment, Food and Rural Affairs (UK)
F	FBDs	Food-borne diseases
	FDES	Framework for the Development of Environmental Statistics
I	IPCC	Intergovernmental Panel on Climate Change
L	LMICs	Low and Middle Income Countries
N	NCDs	Non-communicable diseases
	NSOs	National Statistical Offices
O	OECD	Organisation for Economic Co-operation and Development
	ONS	Office for National Statistics (UK)
R	RTIs	Respiratory tract infections
S	SDGs	Sustainable Development Goals
	SEEA	System of Environmental Economic Accounting
	SOSCHI	Standards for Official Statistics on Climate-Health Interactions
U	UK	United Kingdom of Great Britain and Northern Ireland
	UKCCC	UK Climate Change Committee
	UN	United Nations
	UNDRR	UN Office for Disaster Risk Reduction
	UNECE	UN Economic Commission for Europe
	UNFCCC	UN Framework Convention on Climate Change
	UNGP	UN Global Platform
	UNSC	UN Statistical Commission
	UNSD	UN Statistics Division
V	VBDs	Vector-borne diseases
W	WBDs	Water-borne diseases

3. Introduction

Aims of the Discovery Phase

The SOSCHI project has been divided into several phases, beginning with a Discovery Phase which ran from early 2022 to mid-2023. The aims of the Discovery Phase were to:

- understand the needs for official statistics on actual or likely health impacts of climate change among potential local, national and international users
- identify existing indicators, targets, statistical publications, websites and resources relevant to the impacts of climate change on health
- understand the wider context such as international agreements relating to climate change impacts, strategies of international organisations and government policies
- engage with interested groups and individuals concerned with researching or monitoring climate change and health or using statistics on the subject, especially international organisations, national government agencies and academic experts
- further develop our understanding of the potential benefits of official statistics on climate change and health and the current methodological issues, data gaps and other difficulties
- refine the aims, objectives and workstreams which had been set out in the initial SOSCHI funding proposal and develop a detailed project plan

In parallel with this phase of the project, project initiation activities were carried out including detailed resource planning, recruitment of staff, and agreement on contracts and management procedures between the partners.

Discovery Phase activities

Desk research

We reviewed several published statistical frameworks relevant to climate and health and identified six main sources to inform our findings and recommendations in this report. These sources were chosen as they are internationally recognised, offer recommended approaches for the development of indicators, and have already benefitted from many years of expert input and endorsement. All but one have been developed or endorsed by UN bodies:

- Global Set of Climate Change Statistics and Indicators is a framework for climate change statistics and indicators to be used by countries when preparing their own sets. It was developed by the UN Statistics Division (UNSD) and endorsed by the UN Statistical Commission (UNSC)C and draws on all relevant documents such as the Paris Agreement, Sustainable Development Goals (SDGs) and the Sendai Framework, covering the whole range of climate-related issues.
- Framework for the Development of Environment Statistics (FDES 2013) is a multi-purpose conceptual and statistical framework that provides a guide for the collection and compilation of environment statistics at the national level. It was developed by UNSD through an expert group process.
- CES Set of Core Climate Change-Related Indicators and Statistics using SEEA is an internationally comparable set of climate change-related indicators covering climate change drivers, emissions, impacts, mitigation and adaptation. It was developed by a task force of the UN Economic Commission for Europe (UNECE) and Conference of European Statisticians (CES).

- Sustainable Development Goals (SDGs) The SDG goals are supported by a global indicator framework for the SDGs and targets of the 2030 Agenda for Sustainable Development.
- Sendai Framework for Disaster Risk Reduction 2015-2030 The Sendai Framework is accompanied by Indicators to measure progress on seven targets on preventing disasters and reducing existing disaster risks. This area of work, which is not limited to climate-related risks, is managed by the UN Office for Disaster Risk Reduction (UNDRR).

The sixth main source was the Lancet Countdown on Health and Climate Change which is an international scientific collaboration that independently monitors the health consequences of a changing climate and the progress of the world's response. It was included because of its leading role in climate-health measurement and involvement of a wide range of high-profile academic experts.

Other selected frameworks and documents we drew on in the process of forming recommendations for this report included those from the Intergovernmental Panel on Climate Change (IPCC), particularly the Working Group II Contribution to the Sixth Assessment Report of the IPCC; the UK Climate Change Committee (UKCCC) including its 2021 Progress Report to Parliament and UK-China Cooperation on Climate Change Risk Assessment; the UK Department for Environment, Food and Rural Affairs (DEFRA) 25 Year Environment Plan and related Outcome Indicator Framework; and the OECD's Monitoring exposure to climate-related hazards – Indicator methodology and key results and related papers.

Also particularly important for considering definitions and terminology were the UN Climate Change (UNFCCC) report on Compilation and synthesis of indicators, approaches and metrics for reviewing overall progress in achieving the global goal on adaptation and the Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction.

Focus groups

We held three online focus groups with key stakeholders and experts, facilitated by members of the project team, each covering a different but related topic. The outputs of each group have informed our findings in this report.

- A list of participants (positions and organisations) is given in
- Annex A: Participants in the focus groups. Some of the most important themes and questions arising in the three focus groups are outlined in

Annex B: Key themes and questions from the focus groups.

Focus Group 1 - International indicator frameworks

We aimed to draw on the expertise and experience of participants to explore user needs and expectations for the SOSCHI statistical framework. The focus group was attended by 17 experts in the climate and health field, many of whom had direct experience in the development of international frameworks and standards. Other participants included public health specialists, statisticians, and experts involved in climate change mitigation and adaptation programmes. The themes of the group discussion were:

- what the scope of the framework should include
- what are the issues and gaps in existing frameworks
- what are the most important factors are to make the framework globally accessible

Focus Group 2 – Statistical methodology

We aimed to draw on participants' expertise to explore considerations around methods to provide estimates of climate-related health risk. The focus group was attended by 15 experts in various aspects of climate and health and potential framework users, including public health specialists, policy managers, research scientists, epidemiologists and statisticians. We explored three themes:

- what the scope of a statistical model for metrics on climate and health should include
- what are the main issues with existing statistical models and methods
- what resources are important to make statistical methodologies accessible to producers of statistics

Focus Group 3 – Online platforms and resources

We aimed to draw on the expertise and experience of participants related to using current climate and health online platforms and resources to help us develop our plans for a SOSCHI online platform. The focus group was attended by 11 experts in the climate and health field or in the development of online statistical platforms and information resources. The discussion explored three overarching questions:

- what websites or platforms are currently used for data or information about climate and health
- what are the most common issues and gaps with existing platforms
- what features would users like to see in a new online platform of this kind

Wider stakeholder engagement

We consulted with leading academic and government experts globally and established an Expert Advisory Group, whose membership is listed in Annex C: Members of the Expert Advisory Group. We are indebted to all members of the Group and many other colleagues for their support in the project.

We held a workshop with the climate and public health experts from the London region as an example of a major city, including national and local government and health system staff, to discuss their information needs to inform climate-related action on health at a local level. Their most important areas of interest are listed in Annex D: Main priorities of London region stakeholders.

In addition to the focus groups, the project team engaged (mostly through online or face-to-face bilateral meetings) with a wide variety of national, regional and international organisations involved with climate change and health policy and measurement and environmental epidemiology.

Note:

Engagement with stakeholders in Ghana and Rwanda took place mainly outside the Discovery Phase period. Our project partners the Regional Institute for Population Studies, Accra and African Institute for Mathematical Science, Kigali have set up advisory or steering groups with senior government officials and held engagement workshops including health sector stakeholders, academic experts, and regional and international organisations.

4. Project scope and structure

Based on the focus group discussions, input from the Expert Advisory Group and wider discussions with subject experts and potential users of the project's results, we confirmed the appropriateness of the initial project aims and overall workstreams (developed from the original funding proposal) as fitting well with user needs and priorities.

Project aims and benefits

The project aims to deliver three main benefits:

Improved interventions	Stronger evidence on the health impacts of climate change being used in strategies and interventions in the UK and other countries, especially LMICs, to help improve outcomes for people and society.
Improved statistics	More regular and efficient production of relevant statistics in the UK, LMIC partner countries, other countries globally, and by international organisations.
Improved scientific collaboration	Faster study development and a more coherent evidence base facilitated by shared methodological approaches and a more consistent 'language' for systematic communication of findings.

To achieve these benefits, we aim to deliver two final outputs from the project:

Statistical framework and methods (workstream 1)	A transparent and globally generalisable framework for official statistics on climate change and health, including statistical methods to provide estimates of climate-related health risk using real world data sources, including novel and big data, and modelling local impacts.
Global dissemination and knowledge-sharing platform (workstream 2)	A global dissemination and knowledge-sharing platform and open-source toolset to facilitate high quality research and official statistics in line with the agreed framework.

Figure 1 illustrates the logical pathways from the project outputs to the intended benefits.

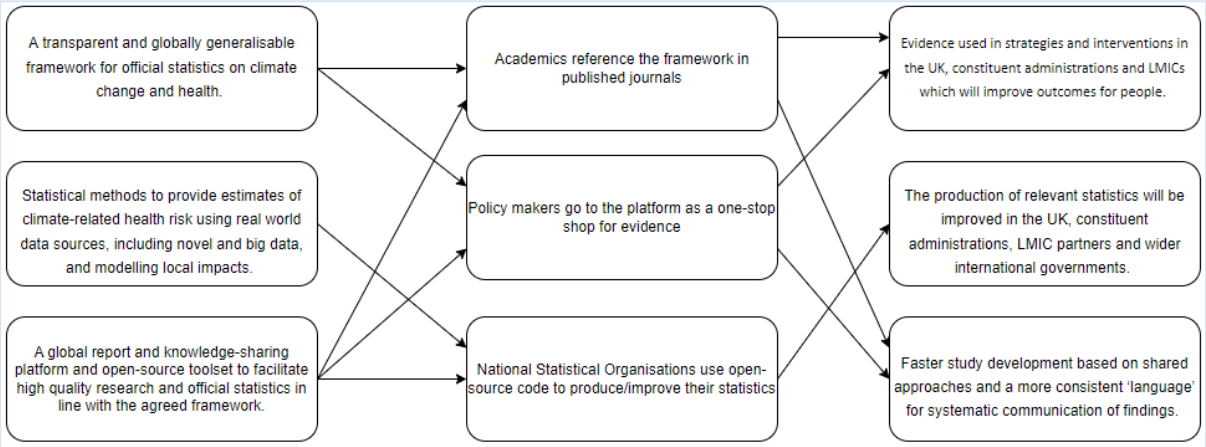

Figure 1: Project outputs and benefits

Statistical framework and methods (workstream 1)

To support the aim of developing a statistical framework, the discovery phase included analysing and comparing relevant existing frameworks and indicator sets; exploring producer, user and expert views on issues and data gaps; and comparing user needs for statistics at international, national and local levels.

To further support the aim of identifying or developing the most appropriate statistical methods, the discovery phase included engaging with experts on climate and health modelling; engaging with relevant processes e.g. Sendai indicators; reviewing key academic literature, government websites and online resources; identifying UK and global data sources relating to climate science and health data; as well as identifying promising approaches to modelling risk and impact in both high and low income settings.

Note:

The Cochrane Planetary Health Thematic Group is now a partner on this project and is undertaking agreed scoping reviews and evidence synthesis.

Global dissemination and knowledge-sharing platform (workstream 2)

A dedicated effort will be required for our proposed statistical framework to be adopted internationally. A key activity to drive adoption will be the development of a knowledge sharing platform. This platform will host the new statistical methodology and framework. It will also allow the upload and sharing of indicators produced using the methodologies outlined in the framework.

To support the aim of developing this online platform, the discovery phase included identifying, reviewing and comparing existing online resources relevant to climate and health; exploring producer and user views on how such platforms and resources are used, their strengths and weaknesses; and exploring the needs, preferences and constraints of potential users.

Some of the existing platforms we reviewed focused on providing a wide range of global data, others on describing the economic and societal impacts of and vulnerabilities to climate change, on the impact of climate change on health on a local level, on the health impacts of disasters, or specifically on the SDGs. The scope of our review of each platform included identifying the type of data and information held, examining the platform's capabilities such as downloading data in different formats, and assessing the support provided to users.

A list of the online platforms and resources we reviewed is in Annex E: Online platforms and resources reviewed. Additional tables describing the key features of all the platforms are in Annex I: Comparing the content and format of the online platforms reviewed.

Success criteria

To help summarise the aims and priorities of each part of the project we agreed brief minimum success criteria which had the support of those consulted.

The minimum success criteria for the statistical framework are that it:

- meets essential user needs identified in the discovery phase, and quality criteria to be determined in the course of the project
- links to other relevant statistical frameworks, standards, and reporting requirements
- it is widely accepted by global and national stakeholders

The minimum success criteria for the statistical methods are that they:

- reflect and extend global best practice, balancing state-of-the-art methods with realism about data availability and generalisability
- contribute to the understanding of climate-health risks
- can be applied effectively to high- and low-income national contexts

The minimum success criteria for the online platform are that it:

- reflects user requirements identified in the discovery phase, and prioritised and delivered according to an agreed agile project plan
- is sustainable after the project ends so that the benefits continue longer-term
- is widely used by stakeholders, evaluated using agreed metrics

5. Statistical framework and methods: main findings

Identifying user needs

Selection of topics and indicators

Our engagement with stakeholders and review of existing statistical frameworks relevant to climate and health suggested that the most important considerations for selecting topics and indicators to meet user needs are:

Relevance

- Topics (health risk or outcome) should be well-known and reported in the scientific literature as influenced by climate change, even if the exact causal mechanisms are not yet fully understood.
- Topics should be relevant and important for national and international policy agendas, for example useful in developing adaptation strategies, recognising that the relevance of particular health risks varies by country and region.

Comparability and coherence

- Concepts, topics and indicators should be comparable as far as possible with existing frameworks and indicator sets, and adopt internationally agreed definitions where these exist.
- The relevance of indicators to higher-level frameworks and targets, like the SDGs, should be explained along with differences and limitations.

Accuracy and reliability

- Indicators should be based on accepted climate science and statistical methods, be provided in formats such as quality assured and reproducible R code, and be realistic for NSOs and other national stakeholders to implement correctly.

Timeliness and punctuality

- Indicators should be measured as frequently as possible – for example measuring a monthly change in impact rather than an annual one – while recognising the limitations of data availability.

Accessibility

- Indicators should be described and presented in a simple manner to ensure understanding by a non-scientific audience, such as policymakers, and facilitate national and local adoption and practical application.

Conceptual framework and scope

A clear conceptual framework is important to focus and structure the indicators, guide decisions on scope, inform definitions and measurement concepts, and support communication. We explored the conceptual framework and models, indicator hierarchies and taxonomies which were present (sometimes implicitly) in the existing frameworks and indicator sets. Relevant models may focus on climate change impacts, determinants of health, or hazards and disaster risks. There was a great deal of commonality between the documents, partly because of explicit efforts by their authors to ensure coherence, but there were also differences in terminology and emphasis.

We identified as key points the need for:

- clearly explained and justified decisions on the scope of our statistical framework and indicators
- identification in our publications of the relationships between our statistical framework and indicators and other existing frameworks and indicator sets, covering differences in indicator structure and hierarchy as well as specific similarities and differences
- a simple model of the concepts involved in measuring climate-health impacts and the relationships between them, to inform analysis (for example by highlighting confounding factors) and help to communicate the place of indicators within the overall framework
- an easy-to-understand categorisation of indicator types in terms of their focus on hazards, vulnerability, exposure, risk, impacts and outcomes

In particular, we noted the relevance of the taxonomy of hazards produced by the UNDRR Hazard definition and classification review which developed common terminology relevant to indicators for the Sendai Framework, Sustainable Development Goals and Paris Agreement.

To help communicate the complex and interconnected aspects of climate change and its impacts on health, we considered a number of published schematics such as the WHO illustration reproduced in Figure 2 below.

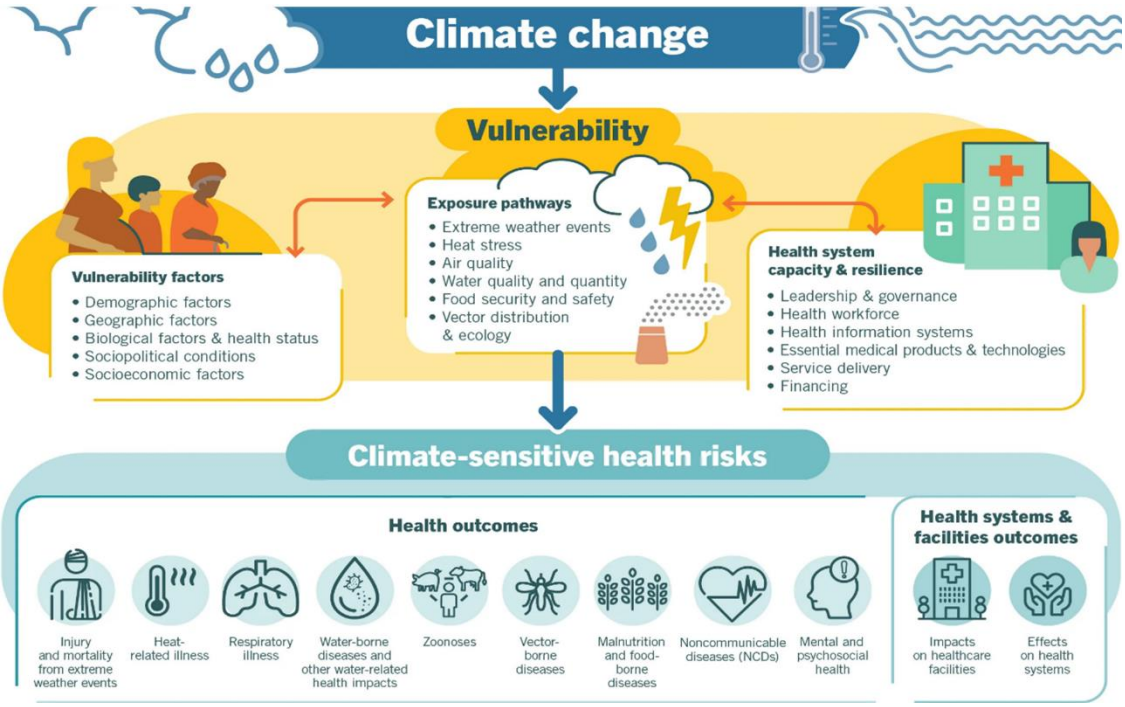

Figure 2: Schematic diagram of climate change vulnerability factors and climate-sensitive health risks (source: World Health Organisation)

We clarified that the area of interest for the project related to climate change adaptation and not mitigation, while recognising that there can be some overlap in practice between mitigation and adaptation actions. Stakeholders had differing opinions on the place of attribution in relation to our framework. We concluded that the state of attribution science at present is unlikely to allow direct attribution of the range of health outcomes in the framework to anthropogenic climate change on a routine basis. Therefore, our approach will be to apply accepted analytical methods which relate the measured outcomes to climate in the wider sense - that is, rising temperatures and the resulting environmental issues such as extreme

weather – on the basis that the role of anthropogenic climate change due to greenhouse gas emissions is well-established.

Developing proposals on topics and indicators

Topics in the statistical framework

Our desk research and discussions with experts suggested that indicator topics for the framework should be as shown below. A further sub-division of some of these topics to provide characterisation in more detail is shown in Annex F: Sub-division of selected main indicator topics.

Note that the text in this section is intended only to give a brief description of the scope of each topic and its relevance to climate change and health – separate, in-depth topic documents based on literature reviews and consultation with specialists in each relevant subject or methodology will be prepared for each topic and fully referenced.

Chemical and other contaminants	Climate change in northern regions is causing permafrost to thaw, creating the potential for mercury to enter the food chain via dietary uptake of fish, seafood and mammals. Mercury methylation processes in aquatic environments have been found to be exacerbated by ocean warming, coupled with more acidic and anoxic sediments. Consumption of mercury-contaminated fish has been found to be linked to neurological disorders. Climate change may also affect animal health management practices, potentially leading to an increased use of pesticides or veterinary drugs that could result in increased levels of residues in foods.
Heat- and cold-related mortality and morbidity including heatwaves	The effect of climate change on global temperatures is well known, and relationships between extreme heat or heatwave events and mortality have been studied extensively. For countries where data availability permits, there is strong evidence that both extreme heat and extreme cold lead to higher total mortality and higher rates of premature deaths. Heat- and cold-related health risks vary by location and demographics in addition to temperature, suggesting that outcomes are highly moderated by socioeconomic, occupational and other non-climatic determinants of health and socioeconomic vulnerability. Health outcomes of both heat and cold are partly but not primarily associated with specific diagnoses such as heat stroke or hypothermia. Larger effects at population level are due to the effects of temperature on physiological states, either increasing incidence of health problems or exacerbating pre-existing
Impacts on health systems and facilities	Extreme weather events can damage healthcare infrastructure including buildings, technology and equipment. Access to health facilities by the public and quality of care can also be reduced by damage to facilities, physical inaccessibility due to disruption to transport infrastructure, and disruption to supply chains. Longer-term effects of climate change may also include increased strain on health systems as a whole leading to reduce quality or accessibility of care.

Injury and mortality from extreme weather events including flooding, wildfires, drought and storms	Climate change makes the world increasingly susceptible to extreme weather events which impose a substantial morbidity and mortality burden. Impacts include traumatic injuries potentially leading to disability or death, drowning, burns, incidence of infectious diseases caused by e.g. disruption of water supplies and temporary or permanent displacement of populations, and mental health conditions associated with displacement, depression, and post-traumatic stress disorder. The total short- and long-term health burden associated with extreme weather events is not yet fully understood. Extreme weather events are also associated with reduced access to healthcare, including perinatal care. The latter can lead to unattended deliveries and decreased paediatric healthcare access, increasing the risk of adverse birth outcomes and maternal and child health.
Malnutrition and food-borne diseases	Climate variability and change contribute to food insecurity and poor access to nutrient-dense food that can lead to malnutrition, including undernutrition, overweight and obesity, and increase susceptibility to both infectious diseases and some non-communicable diseases (NCDs). Climate change can affect the four aspects of food security: food production and availability, stability of food supplies, access to food and food utilisation. Undernutrition exists when a combination of insufficient food intake, health, and care conditions results in one or more of the following: underweight for age, short for age, thin for height, or functionally deficient in vitamins and/ or minerals. Increasing temperatures could contribute to obesity through reduced physical activity, increased prices of produce or shifts in eating patterns of populations towards more processed foods. Food-borne diseases (FBDs) refer to any illness resulting from ingesting food that is spoiled or contaminated by pathogens such as salmonella, campylobacter, and cryptococcus. They most often arise due to contamination at source and from improper food handling, preparation and/or storage. FBD outbreaks can follow multiple causal pathways as climatic risk factors interact with food production and distribution systems.
Mental health	The pathways through which climatic events affect mental health are varied, complex and inter-connected with non-climatic influences that create vulnerability. Climate change can impact mental health directly through exposure to extreme weather events, prolonged high temperatures, as well as indirectly through undernutrition or population displacement. Exposure may also be vicarious, with people experiencing decreased mental health associated with observing the impact of climate change on others or simply by learning about climate change. Research suggests that climate change has already had negative effects on subjective well-being for many people.

	Climate change can affect well-being through a number of pathways, including loss of access to green and blue spaces due to damage from storms, coastal erosion, drought or wildfires; heat; decreased air quality; and disruptions to one's normal pattern of behaviour, residence, occupation or social interactions.
Respiratory illnesses	Respiratory illnesses that can be affected by climate change include both communicable diseases such as respiratory tract infections (RTIs) and non-communicable respiratory diseases such as asthma. Among RTIs, pneumonia and influenza represent a significant disease burden. Climatic risk factors for RTIs include the interaction between pathogens and temperature and humidity extremes, dust storms, extreme precipitation events and increased climate variability. Non-climatic factors may also modify or confound these relationships. Climate-related exposure pathways which contribute to non-communicable respiratory diseases include mobilisation and transport of dust; changes in concentrations of air pollutants formed by reactions sensitive to temperature; increased wildfires and related smoke exposure; increased exposure to ambient heat driving reduced lung function and exacerbations of chronic lung disease; and modification of aeroallergen production and duration of exposure.
Non-communicable diseases	The key non-communicable diseases affected by climate change are cardiovascular disease (CVD), cancer, diabetes, and non-communicable respiratory diseases (above). High temperatures affect the risk of CVD through stress on the cardio-vascular system, while other mechanisms such as exposure to air pollutants including wildfire smoke can be relevant. Sea-level rise may also lead to saline intrusion of groundwater which increases the salt intake of populations and thus the risk of hypertension. Climate hazards affect exposure pathways for chemical hazards associated with the formation of cancer. For example, increased flooding related to extreme precipitation events may mobilise sediment where carcinogens have accumulated. Extreme weather events and rising temperatures have been found to increase morbidity and mortality in patients living with diabetes. Diabetes may slow the skin blood flow and diminish thermoregulatory sweating, impairing the body's ability to regulate its heat.
Vector-borne diseases	Vector-borne diseases (VBDs) such as malaria and dengue are climate sensitive because of elevated proliferation and reproduction rates at higher temperatures, longer transmission seasons, and changes in the ecology and climate-related migration of vectors, reservoir hosts or human populations.

Water-borne diseases and other water-related health impacts	Water-borne diseases (WBDs) such as diarrhea and cholera are attributable to a combination of the presence of particular pathogens and the characteristics of drinking water systems. The causal linkages between climate change and incidence of WBDs follow multiple direct and indirect pathways, often as part of a cascading series of risks. There is a significant positive association observed between WBDs and elevated temperatures, especially in areas where water, sanitation and hygiene (WASH) deficiencies are significant. Intense or prolonged precipitation can also flush pathogens in the environment from pastures and fields to groundwater, rivers and lakes, consequently infiltrating water treatment and distribution systems.
Zoonoses	A zoonosis is an infectious disease that has transitioned from a vertebrate animal to humans. Some of the most dangerous zoonotic diseases include COVID-19, avian influenza and Ebola. Climate change alters the conditions for hosts, pathogens and vectors of zoonotic diseases and rising temperatures, increased flooding and precipitation all create favourable conditions for breeding disease vectors.

Choosing and categorising indicators

Following our exploration of user needs and consideration of the relevance and scope of potential topic areas, we conducted further desk research on the detailed contents of existing indicator sets and frameworks and consulted stakeholders about the value of different types of indicators, broad approaches to indicator development, questions around feasibility, and issues of interpretation and usability.

We identified 128 relevant existing indicators based on the six frameworks and indicator sets reviewed (see Discovery Phase activities). Some indicators were shared by more than one indicator set. The UN Global set is intended to bring together several frameworks and indicator sets into a single coherent system. The full list of indicators is shown in Annex G: Relevant indicators in existing frameworks and indicator sets.

We further categorised the identified indicators into types depending on their main focus in the causal pathway and sequence of events, which for this purpose we divided into outcome, hazard, exposure, vulnerability and adaptation. The resulting full mapping between the identified indicators, topics and indicator types is shown in Annex H: Mapping of identified indicators by topic and indicator type.

The numbers of indicators when cross-referenced in this way cannot be accurately aggregated to show the total indicators on any particular topic or indicator type, because of the different ways each framework and its contents are constructed. However, it is clear that there is both a great deal of commonality or overlap, and also topic areas which are under-represented. Some of the topics which were suggested by our consultations to be important to users were not clearly represented in the available indicators.

Combining these results with the input from our focus groups and other sources of information, we can conclude that:

- the existing ad hoc ‘system’ of indicators is complex and draws on a range of different and potentially contradictory approaches and methods despite efforts towards coherence
- a high proportion of existing indicators focus on risk, vulnerability or wider contextual factors, while there is insufficient information available on health outcomes

- the relevance of some indicators in existing frameworks is not necessarily clear to users
- there is a need to develop new indicators to address gaps between user needs and the content of existing frameworks, particularly to strengthen some aspects such as indirect and longer-term impacts
- policy and health system users would benefit from more indicators based on health outcomes or proximal risk factors, especially at a local level
- there is demand for indicators that can be disaggregated by geography, social and demographic characteristics

Some of the frameworks we reviewed incorporated a three-tier system for their indicators based on methodological soundness and either country priorities and relevance or availability of country data. For example, the tiering system used for the SDG indicators is:

> Tier 1: Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.
>
> Tier 2: Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.
>
> Tier 3: No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested.

The main benefit of a tiering system is that potential users of the indicators are made clearly aware of their quality and likely feasibility, while data gaps and the value of indicators which are not yet feasible can be made more visible.

Way forward

During the Alpha Phase of the project we will:

- review ways of working and stakeholder relationships, with particular emphasis on broadening the representation of LMICs in the project
- engage with international stakeholders about consistency of concepts, terminology and definitions
- clarify the scope and conceptual framework to be applied in the project and communicate these clearly to potential users
- develop proposed indicators which cover the full range of climate-related health outcomes as far as possible, while identifying data gaps and other difficulties
- for each indicator, clarify the type of measurement concept and the place of the indicator in the relevant causal pathways
- maximise coherence with existing frameworks and indicator sets and make the relationships with those transparent
- develop objective criteria for the allocation of each indicator to an informative tier system

6. Global dissemination and knowledge-sharing platform: main findings

Identifying user needs

Following the desk research, discussion on user needs focussed particularly on questions around:

- How would different users find, navigate and make use of the SOSCHI platform
- what would be unique benefits of the SOSCHI platform to potential users and how would this be distinct from other, existing online resources on climate and health
- what are the known strengths and weaknesses of existing platforms, and how could the SOSCHI platform address the issues to provide the best service and user experience
- the need to 'democratise' complex methods by making open data and software tools widely available to users with differing levels of technical knowledge
- how to help users access tools to calculate the indicators through different technical means, for example interactive calculators and downloadable program code
- technical and information governance issues to be clarified, such as the secure handling of datasets users might upload to the platform

Choice of online platform for the project

After investigation of different technical options, we settled on the UN Global Platform to host the majority of project's online resources. The benefits of the UNGP were identified as:

Strategic

- The UN is a globally recognised institution with extensive reach and influence.
- The UNGP is guided by the UN Global Working Group on Big Data for Official Statistics to provide strategic vision, direction and coordination, which is in line with our aims and outlook.
- The UN's resources and profile will help ensure the sustainability of the project outputs in the long-term.

Technical

- The UNGP is a highly flexible platform, supporting a wide range of options for website architecture and layout, technology stack, user access control, data storage, and computation.
- The platform is designed for data and statistical applications, supporting integration with GitHub for code libraries, automated integration through APIs, and efficient interaction with datasets and programming languages.
- Main languages used for development are Jupyter notebooks and the R and Python languages, along with industry-standard web development technologies.
- Cloud-based with scalable storage options, supporting future development as an interactive data platform and helping to ensure sustainability.

Operational

- The UNGP's approach is well suited to agile project development and iterative, experimental creation of web-based tools and services.
- Integration with other tools and databases hosted in the UN's wide online resources is relatively straightforward.
- Knowledge of the UNGP platform's technical aspects and also its wider organisational context is already available within ONS because UK data science experts were closely involved in its original design and creation.

Way forward

During the Alpha and Beta Phases of the project we will:

- work with the UNGP team to develop the online dissemination platform for the project, using an agile development approach
- develop interactive tools for users to calculate indicators using their own data (for one pilot indicator during the Alpha Phase)
- consult with users and stakeholders through a cyclical testing and develop process, to ensure that the platform structure, presentation and content meet expected needs

Online dissemination of information about the project will also be through the ONS website, where a SOSCHI project home page has been created, and potentially through the websites of other partners and of Wellcome.

We will develop a communication and publications plan which takes account of different user needs for communication about the project and its results, including the statistical framework itself and scientific findings produced by the project partners from testing and applying the agreed methods.

7. Annexes

Annex A: Participants in the focus groups

Focus Group 1 - International indicator frameworks

Associate Professor in Climate and Health, University of Bristol, UK

Biostatistics team leader, Ottawa, Canada

Chief, Environment Statistics Section, United Nations Statistics Division

Executive Director of the Lancet Countdown, UCL, UK

Head of Analytics for the Greener NHS programme, NHS England, UK

Head of Partnerships and Communications, SDSN TReNDS, USA

Head of Public Health Intelligence, City and Hackney, UK

Head of SDGs Today, UN Sustainable Development Solutions Network, USA

Lead for monitoring and evaluation of international climate finance, FCDO, UK

Professor of Climate and Health, University of Leeds, UK

Public Health Consultant, London Borough of Newham, UK

Public Health Lecturer, UCL, UK

Research Assistant on Climate Change, Health and Adaptation, University of Exeter, UK

Senior Advisor on Climate Change and Health Equity, DHHS, USA

Senior Director of Programs, Global Partnership for Sustainable Development Data, Kenya

Senior Programme Management Officer, UN Environment Programme, Kenya

Statistics adviser on health systems and One Health policy lead, FCDO, UK

Focus Group 2 – Statistical methodology

Climate and Health Team, World Health Organization

Cochrane Network climate change and human health committee, Ottawa, Canada

Consultant in Public Health, Greater London Authority, UK

COP26 Climate Policy Manager, FCDO, Rwanda

Director, UN Sustainable Development Solutions Research Network on Data and Statistics, USA

Economist, Data Production and Methods Unit, World Bank

Global Health Security Team at UK Health Security Agency, UK

Head of SDGs Today, UN Sustainable Development Solutions Network, USA

Health Research Scientist, Met Office, UK

Lead of the WHO/WMO Joint Climate and Health Office, World Health Organisation

Met Office Principal Fellow and head of climate services for government, Met Office, UK

Professor of Biostatistics and Epidemiology, LSHTM, UK

Professor of Climate and Health, University of Leeds, UK

Public Health and Air Quality Team, Environment Agency, UK

Public Health Lecturer, UCL, UK

Public Health Specialist Registrar at UK Health Security Agency, UK

Statistics Adviser on International Climate Finance, FCDO, UK

Focus Group 3 – Online platforms and resources

Co-Chair, Climate and Health Council, UK

Assistant Director, United Nations Statistics Division

Clinical Research Fellow in Public Health, Cambridge, UK

Consultant in Public Health, Greater London Authority, UK

COP26 Climate Policy Manager, FCDO, Rwanda

Executive Director of the Lancet Countdown, UCL, UK

Global Health Security Team at UK Health Security Agency, UK

Head of Partnerships and Communications, SDSN TReNDS, USA

Health Research Scientist, Met Office, UK

Public Health Lecturer, UCL, UK

Public Health Specialist Registrar at UK Health Security Agency, UK

Annex B: Key themes and questions from the focus groups

Scope and structure of the framework and related issues

- Will the project focus only on impacts or include risks, hazards, vulnerability, and exposure?
- Are we looking at ‘climate-change related impacts’ or ‘climate-related impacts’? Need to clearly define this.
- Attribution - causal factors difficult to distil from available statistics. Methodologies around this (temporal and cumulative attribution) are big challenges in the field.
- Attribution is extremely complex – more helpful, for our purpose to focus on indicators where attribution is more well-known and therefore more easily implemented by users.
- Cannot disentangle adaptation from impacts. Impacts result from risk, which is a combination of hazard, exposure and vulnerability. All of which can be modified through adaptation.
- Effectiveness of many interventions is a current unknown.
- Need to link scope to international discussions – how have health impacts of climate changed been defined internationally?
- Ensure the framework aligns with and compliments existing frameworks and documents.

Meeting global user needs

- Accurate statistics at a local level, which are key for driving policy change.
- Simplicity of final metric is key as has to satisfy end user (policymakers). Message can get lost otherwise.
- International comparability – suggestion to translate Lancet Countdown's indicators and metrics into something NSOs can use. Make these standardised and comparable for different countries.
- Differentiate between indicators that are global and those that are targeted for specific regions with particular issues. Ensure indicators are not too complex.
- Must support end users to be able to prioritise their own core risks and focus areas. Important to categorise geospatially the climate/health interactions likely to occur in those localised circumstances – mapping this would help support prioritisation.
- Some countries may prefer more complex indicators, but we have to balance this with ensuring global relevance.
- Start with a smaller sub-set of countries, identify what indicators are helpful for these, and which will be transferrable to the rest of the world.
- Differentiate between indicators that are easy to produce and indicators for which not all countries will have the data infrastructure.
- Publishing the framework in multiple languages. We would have to ensure the translation aligns to translations made for other related frameworks.

Choosing appropriate indicators and methods

- Could have a tiered approach to measuring – first looking at impact and then assessing the level of adaptation to see if it played a role in reducing the impact.
- The availability of disaggregated and spatial/geo-spatial/spatial-temporal data will impact usefulness due to the need to bridge a generalised framework with localised action focussed on out-/in-door environment and human behaviour.
- Location based modelling will lead to most success with endorsement. Use of earth observation data to create localised statistics is key. This is of greatest use to policy makers.
- Ways to handle missing/sparce spatial data – UK Met Office has techniques for this. Though varying quality of input data will cause issues for standardisation of modelling.
- Context for considering differing exposures and difficulty of one size fits all approach. Could provide a small core group of statistics with supplementary recommendations on how/when to apply local variables e.g. tropical, temperate environments, concurrent risks etc.
- Accounting for external influences will prove very difficult. Adaptation and mitigation will need clear definitions. Perhaps best to place them 'next' to main (possibly minimum recommended) metrics.

Methodological and data issues to overcome

- Scarcity of data and limited reporting capacity in certain countries. Suggestion to include a metric of countries' capacity to engage with our framework along with implementation guidance for how to build their data collection and reporting capacity.
- Countries lacking local data are often some of the most heavily impacted by climate/health.

Dissemination of the framework

- UN Statistics Commission certification will be required to stimulate international adoption. Recent Ecosystem Accounts is a good example.
- Both publishing in and drawing on peer-reviewed literature. Possibly through a panel of representatives at the early stages to ensure fitness for purpose.
- Open source, FAIR principles (findable, accessible, interoperable and reusable), guidance alongside the tools as well as multiple coding languages if resource allows.
- Connectivity between users – being able to share experiences of linking climate data and surveys on health.
- Ethics and data protection needs to be considered early – can be very resource intensive to go through necessary processes. Otherwise might have excellent data but cannot share it.

Design of online platforms and resources

- Cannot assume common knowledge on statistical and technical considerations – guidance should be clear and detailed.
- Data must be presented clearly, especially when moving beyond a technical audience.
- Reference needs to be made to original research papers, sources etc.
- Direct linkage to the methodologies and descriptions that is accessible to non-experts.
- Communication is crucial e.g., limitations and caveats of the methodology along with comparisons, where possible.

Limitations of existing online platforms

- Metadata can remain inaccessible even when underlying data is available.
- Ability to download data can be restricted (e.g. Lancet Countdown data is shared on a case-by-case basis).
- Disaggregation capability is hugely important - but so are privacy and ethical considerations.
- Lack of visibility on protected characteristics hides effects on vulnerable groups.

Annex C: Members of the Expert Advisory Group

(as of 1st October 2024)

Professor Sir Andy Haines, Professor of Environmental Change & Public Health, London School of Hygiene and Tropical Medicine, UK *Chair of the Expert Advisory Group*

Kanza Ahmed, UK Health Security Agency

Ceren Barlas, University of Exeter, UK

Kathryn Bowen, University of Melbourne, Australia

Isabella Tortora Brayda, Public Health Scotland, UK

Hannah Chirgwin, Foreign, Commonwealth & Development Office, UK

Paul Davies, Met Office, UK

Jess Dicken, University of Exeter, UK

Benjamin Dovie, Regional Institute for Population Studies, University of Ghana

Faustina Frempong-Ainguah, Ghana Statistical Service

Frederike Garbe, Public Health Scotland, UK

Antonio Gasparrini, London School of Hygiene & Tropical Medicine, UK

Anya Gopfert, Foreign, Commonwealth & Development Office, UK

Claire Greszczuk, London Borough of Newham, UK

Emil Ivanov, Environmental and Climate Change Statistics, United Nations

Kaveh Jahanshahi, Data Science Campus, Office for National Statistics, UK

Ronald Jansen, UN Global Platform, United Nations

Joleene King, Association of Directors of Public Health, UK

Greg Kuzmac, Rockefeller Foundation, USA

Jason Lowe, Met Office, UK

Angelique Mavrodaris, University of Cambridge, UK

Julius Mugwagwa, UCL, UK

Joseph Ndiritu, African Institute for Mathematical Sciences, Rwanda

Bernice Ofosubaadu, Ghana Statistical Service

Anna Rom, UK Health Security Agency

Marina Belen Romanello, Lancet Global Countdown, UCL, UK

Christian Schweizer, Climate and Health team, World Health Organisation

Reena Shah, Environmental and Climate Change Statistics, United Nations

Anna Freni Sterrantino, The Alan Turing Institute, UK

Denise Thompson, Cochrane Planetary Health Theme Group

Richard Webster, Cochrane Planetary Health Theme Group

Belle Workman, University of Melbourne, Australia

Felipe Colon Gonzalez, Wellcome, UK *Observer*

Myer Glickman, Climate and Health team, Office for National Statistics, UK *Project lead*

Vijendra Ingole, Climate and Health team, Office for National Statistics, UK *Team leader*

Bonnie Lewis, Climate and Health team, Office for National Statistics, UK *Team leader*

Annex D: Main priorities of London region stakeholders

Topic areas	Possible indicators
Mortality	Deaths related to air pollution
	Correlation of CO2 emissions deaths/hospital admissions
	Heat and cold related deaths, heatwave impact on specific groups
Morbidity	Diseases – respiratory, new ones due to climate change

Topic areas	Possible indicators
	Neurological – due to pollution, dementia, mental health impacts
	Premature birth and low birth rate
	Allergies, eye conditions
	Food poverty related conditions
	Ultraviolet light (UV) exposure-related impacts e.g. skin cancer rates
Burden to the health system	Service use – Accident and emergency attendances, hospital admissions (head stress, dehydration)
	Cost of direct climate impacts on health services
	Demand for medication e.g. respiratory
Other areas	Water shortages, insecurity and droughts impacts
	Vulnerability – heat, electricity need, air quality, noise pollution
	Cooling poverty due to overheating home
	Blue badge (disabled driver permit) eligibility (needed for traffic interventions)
	Positive outcomes e.g. physical activity

Annex E: Online platforms and resources reviewed

Some websites which are outdated or not publicly available have not been included in this list.

Platform or resource	Comments
Climate Change in Australia	A data dissemination site which provides climate information, projections, tools and data about climate change in Australia.
Climate Futures Tool	An analytical platform hosted within Climate Change in Australia, which provides advanced functionality for users to model local climate impacts.
Integrated Data Service Climate Change Portal	A dissemination portal for data and insights on climate change in the UK. The focus groups noted a need to manage the translation of global impacts to local level for and sites like this may help support the hosting of domestic of data.
Lancet Countdown on Health and Climate Change data explorer	A dissemination platform which allows users to engage with the Lancet Countdown on Health and Climate Change's annual findings and explore the most recent data at country-specific, regional and income group levels.
Local Climate Adaptation Tool	A data dissemination tool which gives climate change forecasts for local areas in Great Britain, the expected impacts on health and wellbeing, and suggested adaptation priorities.
Medical and Environmental Data Mash-up Infrastructure (MEDMI)	The Medical and Environmental Data Mash-up Infrastructure (MEDMI) project led by the University of Exeter aimed to connect diverse databases to improve understanding of the links between climate, environment, and human health.

Platform or resource	Comments
NIH Literature Portal	An integrated, curated qualitative database of global peer-reviewed research and grey literature on the science of climate impacts on human health. Provided by the US National Institute of Environmental Health Services.
Open SDG	A collaborative toolset and template for managing and publishing data and statistics related to SDG – a 'platform in a box' type initiative for bridging the global to local gap. The system was developed by ONS for the UNGP and UK SDGs is an example of its output.
SDG Global Database and Data Futures Platform	The most comparable UNGP Task Forces to our project. Analytical platforms which give access to data on more than 210 SDG indicators for countries across the globe, by indicator, country, region, or time period based on agreed frameworks.
SDG Knowledge Platform	A dissemination platform for the Sustainable Development Goals, set up by the UN Department of Economic and Social Affairs. The original version of this platform has now been archived and replaced.
UN Data platform	A web-based database platform for the global user community containing a variety of statistical resources compiled by the United Nations (UN) statistical system and other international agencies. It brings international statistical databases within easy reach of users through a single-entry point.
UN Global Platform	UNGP is not a single platform but an umbrella covering multiple independent Task Forces such as Digital Earth Africa and Global SGDs reporting. It is a cloud-service ecosystem to support international collaboration in the development of Official Statistics using new data sources. Some aspects are presented via GitHub and need authorised access to view, whereas other areas are public websites.
UNDRR DesInventar Sendai	DesInventar is a conceptual and methodological analytical tool for the generation of National Disaster Inventories and the construction of databases of damage, losses and in general the effects of disasters. DesInventar Sendai implements all the indicators and data required for the monitoring of targets A to D of the Sendai Framework for Disaster Risk Reduction.
UNDRR PreventionWeb	UNDRR is an extensive international collaboration, but this public-facing element is primarily for dissemination with some limited functionality.
World Bank Climate Change Knowledge Portal	A data dissemination service based on global datasets relating to historical and future climate, vulnerabilities, and impacts.

Annex F: Sub-division of selected main indicator topics

Heat- and cold-related mortality and morbidity	
Heat-related mortality and morbidity	Extreme heat events and extreme temperature have well-documented, observed impacts on health, mortality and morbidity. Under extreme heat conditions, increases in hospitalisations have been observed for fluid disorders,

	cardiovascular disorders, respiratory disorders, renal failure, urinary tract infections, septicaemia, general heat stroke, and unintentional injuries. Temperature interacts with heat-sensitive physiological mechanisms via multiple pathways to affect health. In the worst cases, these lead to organ failure and death. Excess deaths during extreme heat events occur predominantly in older individuals. In fact, trends in heat sensitivity are generally believed to be scale- and situation- dependent.
Cold-related mortality and morbidity	Climate change and its impact on temperatures may change rates of cold-related mortality. However, to date there is variable evidence for a consequential reduction in winter mortality and susceptibility to cold over time due to milder winters; some countries demonstrate decreasing trends, while other countries show stable or even increasing trends in cold-attributable mortality fractions over time.
Injury and mortality from extreme weather events	
Injury and mortality from flooding	Floods arising from climate change can impact health by causing drowning, injuries, waterborne diseases, hypothermia, animal bites, infectious diseases, undernutrition, and mental health problems. Flooding may lead to sewage overflow and damages to water supply and sanitation facilities. Contaminated drinking water can lead to typhoid fever, cholera and hepatitis A. Coastal flooding may cause salt-water intrusion to drinking water which increases the risk of hypertension and eclampsia. The stagnant water which is left after floodwaters recede, can become a breeding ground for mosquitos and lead to diseases such as dengue or malaria. Flooding may also cause displacement and thus health problems associated with overcrowding and poor living conditions. Among the mental health problems which arise from flooding are anxiety, depression, post-traumatic stress disorder or PTSD, psychosis and insomnia. Under- or malnutrition can also arise following flooding because of the impact on agriculture and the access to regular food supplies.
Injury and mortality from wildfires	The risk of wildfires increases in extremely dry conditions, such as drought, and during high winds, and the size and frequency of wildfires is growing due to climate change. Wildfires can cause deaths, burns and injuries. The resulting air pollution can cause a range of health issues, including respiratory and cardiovascular problems. Another significant health effect of wildfires is on mental health and psychosocial well-being. Wildfires also release significant amounts of mercury into the air, which can lead to impairment of speech, hearing and walking, muscle weakness and vision problems for people of all ages.
Injury and mortality from drought	Rising temperatures caused by climate change are making already dry regions drier, and thus increases the risk of drought or prolongs periods of drought. Drought may have acute and chronic health effects, including malnutrition due

	to the decreased availability of food, increased risk of infectious diseases, such as cholera, diarrhoea, and pneumonia, due to acute malnutrition, lack of water and sanitation, and displacement, psycho-social stress and mental health disorders, disruption of local health services due to a lack of water supplies, loss of buying power, migration and/or health workers being forced to leave local areas.
Injury and mortality from storms	The rise in global temperature is associated with more intense storms. Storms can bring deadly winds, extreme precipitation, and storm surges which temporarily and locally raise sea levels and can inundate low-lying shorelines. They can generate projectiles and debris that can cause injury during the event.
Vector-borne diseases	
Mosquito-borne diseases	Dengue fever, malaria and other mosquito-borne diseases are affected by climate change. Their vectorial capacity has increased and changes in temperature, precipitation, and relative humidity are making wider geographic areas more suitable for transmission. Non-climatic socioeconomic factors and health system responses can counteract the climatic drivers.
Rodent-borne diseases	Rodent-borne disease outbreaks, e.g. plague and hantavirus, have been linked to weather and climate conditions in a small number of studies, but more research is needed in this area. Changes in precipitation patterns and rodent density due to climate change seem to affect pathogens in rodents.
Tick-borne diseases	Climate change has contributed to the spread of the Lyme disease and tick-borne encephalitis vectors, and a corresponding increase in cases. A strong correlation has been identified between temperature and humidity, and the emergence of tick populations, their range and geographic spread.

Annex G: Relevant indicators in existing frameworks and indicator sets

No.	Indicator title	Framework(s)
1	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population	UN Global Set, SDGs
2	Frequency of hazardous events and disasters	UN Global Set
3	Proportion of urban population living in slums, informal settlements or inadequate housing	UN Global Set, SDGs
4	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	UN Global Set, Sendai Framework, SDGs

No.	Indicator title	Framework(s)
5	Coverage of disaster shelters per capita	UN Global Set
6	Coverage of early warning systems	UN Global Set
7	Coastal area vulnerable to climate change	UN Global Set
8**	Area protected through storm surge infrastructure	UN Global Set
9**	Area (length) of storm mitigation ecosystem services	UN Global Set
10**	Area of coastal protection services	UN Global Set
11**	Area equipped with drainage systems	UN Global Set
12**	Area of river flood mitigation services	UN Global Set
13	Share of green urban areas in the total area of cities	UN Global Set, CES
14	Total rainfall anomaly	UN Global Set
15	Proportion of population living in coastal areas	UN Global Set
16	Islands vulnerable to climate change	UN Global Set
17	Incidence of heat- and cold-related illnesses or excess mortality	UN Global Set
18	Mean (surface) temperature anomaly	UN Global Set, CES
19	Temperature records (cold nights, warm days)	UN Global Set
20	Buildings (settlements) vulnerable to climate change	UN Global Set
21	Proportion of population with access to heating/cooling	UN Global Set
22	Buildings adapted to climate change	UN Global Set
23	Climate-induced air pollution	UN Global Set
24**	Incidence of cases of water-related diseases and conditions	UN Global Set, FDES 2013
25	Water quality	UN Global Set
26	Renewable freshwater resources per capita	UN Global Set
27	Proportion of population using safely managed drinking water services	UN Global Set
28	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	UN Global Set
29	Proportion of population living in non-coastal hazard-prone areas	UN Global Set
30	Water monitoring systems	UN Global Set
31	Water use per capita	UN Global Set
32**	Incidence of cases of climate-related vector-borne diseases and conditions	UN Global Set, FDES 2013
33	Crop loss due to climate extremes	UN Global Set
34	Prevalence of undernourishment	UN Global Set, SDGs
35**	Incidence of cases of airborne diseases and conditions	UN Global Set, FDES 2013
36	Number of climate refugees, climate migrants and persons displaced by climate change	UN Global Set
37	Population relying on subsistence and pastoral farming	UN Global Set

No.	Indicator title	Framework(s)
38	Coverage of essential public health services	UN Global Set
39	People affected by natural extreme events and disasters	FDES 2013
40	Maximum monthly average temperature	FDES 2013
41	Occurrence of natural extreme events and disasters	FDES 2013
42	Population living in hazard-prone areas	FDES 2013
43	Preparedness for natural extreme events and disasters	FDES 2013
44	Minimum monthly average temperature	FDES 2013
45	Population living in urban areas	FDES 2013
46	Total urban area	FDES 2013
47	Concentration level of particulate matter	FDES 2013
48	Concentration level of tropospheric ozone (O_3)	FDES 2013
49	Concentration level of carbon monoxide (CO)	FDES 2013
50	Concentration level of sulphur dioxide (SO_2)	FDES 2013
51	Concentration levels of nitrogen oxides (NO_x)	FDES 2013
52	Population exposed to air pollution in main cities	FDES 2013
53	Prevalence of water-related diseases and conditions	FDES 2013
54	Mortality of water-related diseases and conditions	FDES 2013
55	Annual/monthly average precipitation	FDES 2013
56	Freshwater quality	FDES 2013
57	Population using an improved drinking water source	FDES 2013
58	Monthly average temperature	FDES 2013
59	Prevalence of vector-borne diseases	FDES 2013
60	Mortality of vector-borne diseases	FDES 2013
61	Maximum monthly relative humidity	FDES 2013
62	Wind speed	FDES 2013
63	Occurrence of El Niño/La Niña events	FDES 2013
64	Freshwater temperature	FDES 2013
65	Amount produced from main annual and perennial crops	FDES 2013
66	Amount produced from monoculture/resource-intensive farming systems	FDES 2013
67	Imports of crops	FDES 2013
68	Prevalence of airborne diseases and conditions	FDES 2013
69	Mortality of airborne diseases and conditions	FDES 2013
70	Concentration levels of heavy metals	FDES 2013
71	Incidence of problems associated with excessive UV radiation exposure	FDES 2013
72	Prevalence of problems associated with excessive UV radiation exposure	FDES 2013

No.	Indicator title	Framework(s)
73	UV radiation	FDES 2013
74	Economic losses due to natural extreme events and disasters	FDES 2013
75	Occurrence of extremes of temperatures and precipitation	CES
76	Number of deaths and missing persons attributed to disasters, per 100,000 population	Sendai Framework
77	Number of deaths attributed to disasters, per 100,000 population	Sendai Framework
78	Number of missing persons attributed to disasters, per 100,000 population	Sendai Framework
79	Number of injured or ill people attributed to disasters, per 100,000 population	Sendai Framework
80	Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework	Sendai Framework, SDGs
81	Number of countries that have multi-hazard early warning systems	Sendai Framework
82	Number of countries that have multi-hazard monitoring and forecasting systems	Sendai Framework
83	Number of people per 100,000 that are covered by early warning information through local governments or national dissemination mechanisms	Sendai Framework
84	Percentage of local governments having a plan to act on early warnings	Sendai Framework
85	Number of countries that have accessible, understandable, usable and relevant disaster risk information and assessment available to the people at the national and local levels	Sendai Framework
86	Percentage of population exposed to or at risk from disasters protected through pre-emptive evacuation following early warning	Sendai Framework
87	Number of disruptions to health services attributed to disasters	Sendai Framework
88	Number of deaths and missing persons attributed to hydro-meteorological disasters, per 100,000 population	CES
89	Incidence of climate-related vector-borne diseases	CES
90	Excess mortality related to heat	CES
91	Direct agricultural loss attributed to hydro-meteorological disasters	CES
92	Proportion of population living in dwellings with air conditioners or air conditioning	CES
93	Proportion of agricultural area under productive and sustainable agriculture	CES, SDGs
94	Proportion of population exposed to hazards	CES
95	Estimated number of cases of the selected vector-borne diseases	CES
96	Reported number of cases of the selected vector-borne diseases	CES
97	Share of people working outside	CES
98	Share of green spaces in nationally defined urban areas	CES

No.	Indicator title	Framework(s)
99	Share of population living in cities	CES
100	Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)	SDG
101	Proportion of population living below the national poverty line, by sex and age	SDGs
102	Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale	SDGs
103	Prevalence of malnutrition among children under 5 years of age, by type (wasting and overweight)	SDGs
104	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene	SDGs
105	Proportion of population using safely managed drinking water services	SDGs
106	Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	SDGs
107	Exposure to warming	Lancet Countdown 2022
108	Exposure of vulnerable populations to heatwaves	Lancet Countdown 2022
109	Heat and physical activity (heat stress risk)	Lancet Countdown 2022
110	Heat-related mortality	Lancet Countdown 2022
111	Exposure to wildfires and wildfire smoke	Lancet Countdown 2022
112	Drought	Lancet Countdown 2022
113	Extreme weather and sentiment	Lancet Countdown 2022
114	Climate suitability for infectious disease transmission: dengue, chikungunya, and zika	Lancet Countdown 2022
115	Climate suitability for infectious disease transmission: malaria	Lancet Countdown 2022
116	Climate suitability for infectious disease transmission: vibrio	Lancet Countdown 2022
117	Climate suitability for infectious disease transmission: vibrio cholerae	Lancet Countdown 2022
118	Food security and undernutrition: crop yield potential	Lancet Countdown 2022
119	Food security and undernutrition: food insecurity	Lancet Countdown 2022
120	National assessments of climate change impacts, vulnerability, and adaptation for health	Lancet Countdown 2022

No.	Indicator title	Framework(s)
121	Climate information for health	Lancet Countdown 2022
122	Urban green space	Lancet Countdown 2022
123	Vulnerability to mosquito-borne diseases	Lancet Countdown 2022
124	Lethality to extreme events	Lancet Countdown 2022
125	Clean household energy: use of clean fuels in the domestic sector	Lancet Countdown 2022
126	Clean household energy: household air pollution	Lancet Countdown 2022
127	Mortality from ambient air pollution by sector	Lancet Countdown 2022

** As part of a wider indicator in the relevant framework

Annex H: Mapping of identified indicators by topic and indicator type

Indicator numbers refer to Annex F above.

Topic	Sub-topic	Indicator type				
		Outcome	Hazard	Exposure	Vulnerability	Adaptation
Air-borne diseases	All or unspecified	35, 68, 69				121
	Respiratory tract infections		18, 40, 44, 55, 61, 75	109	108	
Heat- or cold-related illnesses	All or unspecified	17, 90, 110	18, 19, 40, 44, 75	45, 46, 109	3, 20, 21, 97, 99, 108	13, 22, 92, 98, 121, 122
	Exertional heat illness		18, 40, 75	97, 109	108	
	Increases in hospitalisations		18, 40, 75	106, 109, 125, 126	108	
	Myocardial infarction and stroke		18, 40, 44, 75	109	108	
Impacts on healthcare systems and facilities	All or unspecified		87	38		121
Injury and mortality from extreme weather events and disasters	All or unspecified	1, 39, 76, 77, 78, 79, 88, 124	2, 40, 41	42, 94, 111	3, 100, 101	4, 5, 6, 43, 80, 81, 82, 83, 84, 85, 86, 121

Topic	Sub-topic	Indicator type				
		Outcome	Hazard	Exposure	Vulnerability	Adaptation
	Flooding	88, 124	14		3, 7, 15, 16	11, 12, 13, 98, 122
	Wildfires	124		111		
	Drought	124	112			
	Other or unspecified events	39, 88, 124	41		3, 7	8, 9, 10
Malnutrition and food-borne diseases	All or unspecified	103	18, 33, 40, 63, 64, 65, 66, 67, 118, 119	34, 102, 107	28, 29, 91, 99	6, 93, 121
	Salmonella		18, 58	107		
	Obesity		18, 40, 55, 119	107, 109		
Mental health	All or unspecified	113	18, 41, 75	34, 39, 74, 94		121
	Discrete climate hazards impact on mental health		41, 75, 112	36, 39, 94, 111	20, 37	
	Heat-associated mental health outcomes		18, 40, 75	109		
	Result of climate impacts on economic, social and food systems		41, 64, 66, 67, 112, 119	39, 74, 102, 103	37	
Noncommunicable diseases	All or unspecified					121
	Cancer	71, 72	73		97	
	Cardiovascular diseases		18, 40, 47, 48, 49, 50, 51, 70, 75	52, 106, 109, 111, 125, 126	108	
	Maternal, foetal, and neonatal health		18, 40, 41	108		
Respiratory illness	All or unspecified	127	18, 23, 40, 47, 48, 49, 50, 51	52, 107, 125, 126		
Vector-borne diseases	All or unspecified	32, 59, 60, 89, 95, 96	114, 115, 116, 117	107	18, 40	121
	Malaria		115	107	40, 100, 101	
	Dengue		40, 55, 61, 62, 63, 114	107	123	

Topic	Sub-topic	Indicator type				
		Outcome	Hazard	Exposure	Vulnerability	Adaptation
	Chikungunya virus, Zika, Japanese encephalitis and Rift Valley Fever		114	107		
	Lyme disease and Tick-Borne Encephalitis			107	40, 61	
Water-borne diseases and other water-related health impacts	All or unspecified	24, 53, 54, 104	18, 25, 40, 55, 56, 112	26, 27, 105, 107	28, 29	30, 31, 57, 121
	Diarrheal diseases		18, 55, 58, 112	105, 107		
	Cholera		18, 40, 55, 75, 117	105, 107		
	Other gastro-intestinal infections		18, 55, 58, 112	105, 107		
Zoonoses	All or unspecified					121

Annex I: Comparing the content and format of the online platforms reviewed

SEE TABLES ON FOLLOWING PAGES

Relevant online platforms	NIH Literature Portal	Prevention Web	DesInventar	SDG Knowledge Platform	ECEHH Local Climate Adaptation	SDG ONS	SDG indicators database	UN Data	Climate Change Knowledge Portal	Climate Change Portal ONS	Climate change Australia	Lancet Countdown
Data held												
Data												
Varying geographical levels (global, regional, national, watershed, local)			Y				Y	Y	Y			Y
Timeseries (past and/or projections)			Y		Y	Y	Y	Y	Y	Y	Y	Y
Yearly and seasonal data			Y		Y			Y	Y		Y	
Country summaries of the platform data			Y				Y	Y	Y		Y	
Metadata	Y		Y		Y	Y	Y	Y	Y	Y		Y
Metadata for the initially proposed indicators						Y	Y					
List of data sources								Y			Y	Y
Availability of data						Y	Y					
Earlier versions of the database							Y					
Dataset of the geographical structure											Y	
Shape files											Y	
Data structure							Y					
Frameworks												
Framework and its indicators		Y		Y		Y	Y		Y			Y
Rationale behind an indicator and its relevance to climate change										Y		Y
Framework tiering system							Y					
Related frameworks		Y					Y					
Methods for each indicator or dataset			Y			Y	Y	Y			Y	

Methodology summary			Y									
Presentation												
Data presented in tables, graphs, maps and/or charts			Y		Y	Y	Y	Y	Y	Y	Y	Y
List or map of all geographies to choose from			Y		Y		Y	Y	Y		Y	
Matrix of projections scenarios											Y	
Indicator statistics (e.g. average, min, max)			Y		Y				Y			
Reports, brochures and/or pamphlets of the main findings								Y	Y		Y	Y
Indicator and overall key findings												Y
Type of information												
Background												
Climate change overview									Y		Y	
Health and climate change hazards classification			Y									
Motivating policies and global agreements		Y	Y	Y		Y			Y			
Background to framework development		Y	Y	Y		Y	Y					Y
Relevant peer-reviewed and grey literature, documents, and publications database	Y	Y		Y								
Key reference materials/documents/papers		Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
Relevant news and announcements		Y		Y				Y				Y
Related projects			Y	Y		Y	Y				Y	Y
Impacts of climate change					Y						Y	Y
Reasoning behind regional groupings used							Y					
General country information for each country							Y	Y	Y			
Projection scenarios and rationale behind them									Y		Y	

Stakeholders												
List of stakeholders		Y	Y	Y				Y				Y
Stakeholder profiles		Y		Y								
Key existing partnerships				Y			Y				Y	
Funding sources											Y	Y
Updates												
Updates to the platform, framework, and its measurement						Y	Y	Y			Y	
Planned updates to the framework and its measurement							Y					Y
Educational												
Textbooks, lesson plans, educational games, etc		Y										
Resources to draw on for communication		Y									Y	Y
Platform Capabilities												
Visualisation												
Search	Y	Y	Y			Y	Y	Y		Y	Y	Y
Sort	Y	Y	Y					Y		Y		
Filter	Y	Y	Y			Y	Y	Y		Y	Y	Y
Interaction												
Download data (.csv, .pdf etc.)	Y		Y		Y	Y	Y	Y	Y	Y	Y	
Download metadata							Y	Y	Y			
Download charts/maps						Y	Y		Y	Y		
Save and retrieve data queries			Y				Y					
Print feature	Y								Y			
Upload content		Y	Y	Y								
Analysis tools			Y				Y				Y	
SPARQL query tool										Y		

Interactive map			Y		Y		Y		Y		Y	Y
Interactive diagram of health impacts and links between them					Y							
Engagement												
Sign-in for access to more data											Y	
Social media links/share feature		Y					Y	Y				Y
Alerts/mailing lists		Y		Y								
Consultancy/collaboration options				Y								
Academic programmes (BSc, MSc, Diplomas, etc)		Y										
Events and training calendar		Y		Y			Y					Y
Support provided												
'How-to' guidance												
Introduction video explaining how to use the portal and what it can be used for	Y								Y			
Tutorial for types of questions and explorations the portal can help answer	Y								Y			
Platform e-handbook							Y					
Written guidance on how to use the data, platform, methods, framework			Y		Y		Y		Y		Y	
Decision tree for how to use the platform/data											Y	
Guidance on how to interpret the data											Y	
Tips for effective communication											Y	
Statistics and projections good practices and common mistakes							Y				Y	
Training to use framework and platform							Y				Y	

Toolkit with relevant information and links to use the platform as needed		Y	Y				Y	Y				
Step-by-step guidance under each analysis tool about how to use it											Y	
Help page detailing system requirements to use the portal and its features	Y											
Acknowledgement and citation to use if using the portal data											Y	Y
Other support and guidance												
'About' page describing the portal and the motivations behind it	Y		Y					Y	Y	Y	Y	Y
Description of what each data visualisation shows and why it is useful									Y			
Hovering over filter buttons gives description of filter meaning	Y											
Describing the data file naming convention											Y	
FAQs	Y					Y	Y	Y			Y	
Glossary	Y	Y	Y				Y	Y	Y		Y	
Choice of different languages			Y				Y					Y
Contact details	Y	Y	Y			Y	Y	Y	Y		Y	Y
Feedback survey						Y		Y				
Link to source code			Y		Y							
Link to API							Y	Y				