GEO Work Programme Integration and Post-2025 Incubators

This document is submitted to the Programme Board for discussion.

The Programme Board was updated at its 25th meeting on 6-7 February 2023 on the GEO Work Programme and the post-2025 incubators. Recognizing that detailed planning is underway, the Board requested that information on process, governance, partners and next steps in relation to the development of the two post-2025 incubators should be presented to the next Board meeting. They also requested other emerging incubators are considered through a process proposed to the Board.

Following the Board's guidance and decisions, the GEO Secretariat is providing an update on the two ongoing post-2025 incubators as well as proposing a way forward for considering emerging incubators.

1 THE POST-2025 INCUBATORS

Post-2025 incubators are experimental integration efforts between GEO Work Programme activities and other partners, under thematic areas and across the Earth observation value chain. The incubation goal is to co-design demand-driven, integrated solutions to pressing and complex global challenges.

The overall objective of the post-2025 incubators is to feed into the design of the new post-2025 GEO Work Programme. Between 2023 and 2025 (when the 2026-2028 GEO Work Programme development will start), the incubation process will ensure that the post-2025 GEO Work Programme is more focused on delivering value against major policy priorities and has more flagships and strong initiatives. Successful incubators will have attracted donor funding and become part of the GEO Work Programme, following the Programme Board's process of review.

The incubator approach is directly responding to the draft of the GEO Post-2025 Strategy, that identifies the GEO mission as leveraging its unique position as an established intergovernmental organization to co-produce user-driven solutions that inform decisions and accelerate action on global societal and environmental challenges. The first of the five goal that are identified in the strategy is: "Co-produce transformative programmes that provide trusted Earth Intelligence: GEO will deliver a portfolio of programmes that provide the Earth intelligence needed to unlock transformational change in the way that societies interact with the planet. These programmes will be co-produced with inputs from multiple disciplines, including social sciences, and produce tools for coherent environmental and societal policy decisions, aiming to unlock social innovation and sustainable economic growth. They will be characterized by efficiency, effectiveness, impact and additionality."

This approaches advances the implementation of the Independent Mid-Term Evaluation of the GEO Strategic Plan 2016-25, which found that the GEO Work Programme, while

marked by bottom-up approaches and driven by coalitions of willing communities of practice, needs to be balanced with GEO's ability to maintain a clear vision and focus. The Evaluation recommended that the "…Executive Committee and Programme Board need to focus more on overarching thematic areas, and concrete goals for GEO providing more top-down direction, while balancing that with a bottom-up approach."

The post-2025 incubators also implement of the GEO Engagement Strategy (GEO-XIII-4.1) with the convening and engagement of target stakeholders from within and outside of GEO community to develop strategic partnerships leading to a "robust framework for collaboration in the medium and long term, which can be in the form of, forming a basis for a GEO Initiative or Flagship."

The GEO Secretariat has been coordinating the identification of possible incubators since the 2022 GEO Symposium and validating these ideas with the community. This approach has received the endorsement of GEO's governing bodies (see ExCom 60-13). Thematic areas or nexus areas that are being explored include Nature-based Solutions/Climate-Biodiversity, Land-Ocean-Pollution, Multi-Hazard Risk, One Health/Urban Resilience. Given current GEO Secretariat capacities, progress has been made on two incubators since Q4 2022 (named Global Ecosystems Atlas and Global Integrated Heat and Health Service[1]). A coordination workshop on multi-hazard risks/disaster risk reduction took place on 16 March 2023 to scope pathways for possible future incubators in this area.

2 INCUBATOR UPDATE: GLOBAL ECOSYSTEMS ATLAS

The inception of the Global Ecosystems Atlas can be traced back to the needs expressed by numerous stakeholders involved in monitoring and reporting under environmental agreements. Crucially, the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD), and the Ramsar Convention on Wetlands have expressed their support for the Global Ecosystems Atlas.

The Decision adopting the Global Biodiversity Framework (GBF) by the Convention on Biological Diversity (CBD) at COP 15 in December 2022, invites the Group on Earth Observations Biodiversity Observation Network (GEO BON), among others, to support the operationalization of the monitoring framework. The Atlas will also support wetland inventories under the Ramsar Convention on Wetlands, nature-based solutions under the UNFCCC, land degradation monitoring under the UNCCD, and other applications.

To start shaping the vision and design of the program, the GEO Secretariat had organized a workshop in October 2022, bringing together representatives from various GEO Work Programme activities and regional GEOs. Attendees included representatives from GEO BON, GEO-LDN, GFOI, GEOGLAM, GEO Mountains, GEO Blue Planet, EO4SDGs, AquaWatch, and Regional GEOs. The outcomes of this workshop led to the drafting of a concept note, which was subsequently shared for feedback and input from the GEO Work Programme activities.

The keynote address by the CBD Secretariat at the GEO Plenary session on Nature-based Solutions at GEO Week in Ghana on 1 November 2022 reiterated the need for a global

[1] Incubator title to be possibly revised.

ecosystem extent mapping and monitoring product that could respond to this data and monitoring gap and advance knowledge of interdependencies between ecosystems. The panelists agreed that ecosystem extent mapping and monitoring was a strategic need for multiple multilateral environmental agreements and the implementation of Nature-based Solutions. Recognizing the urgency to act, the session concluded that GEO is uniquely placed to lead the development of this programme through integration, coordination and consensus building.

Since GEO Week 2022, in addition to the conversations with the secretariats of the conventions, bilateral conversations have been held with key potential partners that have validated the need and rationale for creating the Global Ecosystems Atlas. Discussions have also explored the potential contribution of the Committee on Earth Observation Satellites (CEOS) Ecosystem Extent activity to the Global Ecosystems Atlas.

The Atlas concept was further discussed during a session at the Earth observations for Ecosystem Accounting (EO4EA) workshop hosted by the European Space Agency on 29 November 2022.

In December 2022, the GEO Secretariat and GEO BON team participated in CBD COP15 to further the engagement on the Atlas, resulting in the involvement in the GBF implementation.

The First Global Ecosystems Atlas Convening Meeting, held on 17-18 May 2023 in Geneva, Switzerland, marked a significant milestone in the development of the Atlas. In preparation for this meeting, a detailed concept note was developed that outlined among other things, the rationale, the scope of the Atlas, its phases, a potential governance approach. The latter was modelled on governance mechanisms adopted and utilized by several collaborative initiatives including GEO Flagships. See Annex 1 for this concept note, which is currently being revised in line with the feedback received at the meeting.

The meeting brought together 70 participants from, inter alia, governments, space agencies, commercial satellite and geospatial companies, technology providers, conservation organizations, philanthropic foundations, UN bodies, multilateral environmental agreements and regional organizations.[2] The meeting facilitated insightful discussions and collaboration, with both in-person and online participation, reflecting the collective effort and commitment to revolutionize the management of Earth's ecosystems. The agenda of the event can be found here.

The project approach and plan with workstreams, implementation, governance and budget for the Atlas will be determined over the next few months as the project is co-designed. The next Atlas meeting will be a project design workshop, which will take place in August/September (dates tbd).

[2] Government of Maldives, Government of New Caledonia, UNCBD, UNCCD, UNFCCC, NASA, ESA, JAXA, ISRO, UNEP-WCMC, Planet Labs, TNFD Global, UNSD, GEF, Esri, Climate Engine, DG Environment European Commission, DG Research & Innovation European Commission, Vulcan, WRI, IUCN – CI, IUCN – UNSW, IUCN – James Cook University, IUCN – WCPA, IUCN – The University of Melbourne, South African National Biodiversity Institute, SDSN, Ramsar Convention on Wetlands, USGS, WWF, WCS, Villars Institute, SBTN, MERMAID, SPREP, BC3, GEO-LDN, GEO EO4EA, GEOBON, Microsoft, soloEO, Sparkgeo, Airbus, Walder Wyss Ltd., Maxar Technologies, Chinese Academy of Sciences, NOAA, The Eco Org.

The GEO Secretariat provides regular updates to GEO governing bodies on the work under this incubator. It informed the ExCom at its special session during GEO Week on 4 November 2022, and the Programme Board at its 25th meeting on 6-7 February 2023. A further update was provided to the ExCom at its 60th meeting on 22-23 March 2023, and Programme Board at its 26th meeting on 15-16 June 2023. The GEO Secretariat will also be making a request to ExCom at its 61st meeting in July 2023 seeking seed funding to take this initiative off the ground.

The following key milestones have happened, or are foreseen to take place over the course of 2023:

February	• Programme Board updated on the post-2025 incubators, including Atlas
March	• ExCom updated on the post-2025 incubators, including Atlas
April	• E-shape co-design team and GEO Secretariat had a diagnosis workshop • Detailed concept note of the Global Ecosystems Atlas developed • Dedicated webpage on the Atlas created
May	• First Convening Meeting took place on 17-18 May with possible partners, stakeholders and contributors
June	• Atlas project design commences based on feedback to Concept Note received at First Convening Meeting • Discussion on the Atlas takes place at GEO Symposium • Programme Board gets updated on the Atlas
July	• ExCom gets updated on the Atlas and requested for support • Preparations for Second Atlas Convening Meeting (Atlas Design Workshop) ongoing
August/September	• Programme Board gets updated on the Atlas at PB-27 • Atlas Design Workshop takes place (Villars Institute, timing tbd), expected outcome is to advance on project design
November	• Global Ecosystems Atlas is presented at GEO Week
December	• Possible Atlas side event takes place at UNFCCC COP28 (and resources permitting, Atlas mock-up shared) • Atlas project design is complete

3 INCUBATOR UPDATE: GLOBAL INTEGRATED HEAT AND HEALTH SERVICE

See Annex 2 for a summary brief of the Global Integrated Heat and Health Service ("Heat and Health Service").

The GEO community has been advocating for integrating Earth observation-derived heat and health data to fill significant knowledge and intelligence gaps relating to urban heat resilience planning – when and how to respond in emergencies, as well as how to plan strategically for avoiding, mitigating, and adapting to risk from heat and related negative health outcomes. Examples where the community has been advancing innovative solutions that can serve as models include include Extrema and the U.S. National Integrated Heat and Health Information System.

In response to this identified gap, the GEO Secretariat convened a coordination workshop in October 2022 under the Climate-Urban-Health nexus area to discuss the need, purpose and possible design of an integrated global service. Attendees included representatives from EO4Health, GUOI, Human Planet Initiative, GEO VENER, ECMWF and Regional GEOs. Prior to the workshop, interest in this concept was communities during the Twelfth Session of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM).

Based on the discussions at the workshop, a draft concept note has been developed with representatives from the EO4Health and the Global Heat Health Information Network (GHHIN), including WMO and NOAA.[3]

The work on the Heat and Health Service has taken on an increased tempo following the onboarding of the Urban Coordinator, who began working at the GEO Secretariat on 16 January 2023.

The idea for the service was also discussed at a round table organized by GHHIN on Heat Early Warning Systems on 27 February bringing together key partners working on heat and health. The GEO Secretariat presented an overview of the concept in the context of other initiatives being taken forward by meteorological agencies, public health, climate change researchers, and other organisations supporting resilience and disaster risk reduction efforts in cities including the World Bank, Arsht-Rockefeller, OCHA, and the Red Cross.

The Secretariat updated the ExCom on the work under this incubator at its special session during GEO Week on 4 November 2022 and the Programme Board at its 25th meeting on 6-7 February 2023. A further update was provided to the ExCom during 22nd and 23rd of March 2023.

Following presentation of the concept at ExCom the concept has been more widely socialized with various work programme activity groups, including: EO4SDG Toolkit, Human Planet Initiative, EO4Health / Community of Practice, Urban Heritage Climate Observatory (UHCO), Global Urban Observatory Initiative (GUOI). The concept was also discussed with CEOS working group on SDGs.

Bilateral conversations have also been held with key external potential partners in the last months that have validated the need and rationale for creating the Service. These include: UN-SDSN, WHO, UN-HABITAT's Global Chief Heat Officer, Arsht-Rockefeller Foundation Resilience Centre, C40 Cities Network, ICLEI, the Cities Alliance, the Global Green Growth Initiative, ESRI. These discussions are informing revisions to the Heat & Health concept note.

The following key milestones have happened, or are foreseen to take place over the course of 2023:

March	• GEO community provided input and feedback on draft concept note

[3] The Global Heat Health Information Network (GHHIN) is an independent, member-driven forum of scientists, practitioners, and policy makers focused on improving capacity to protect populations from the avoidable health risks of extreme heat in a changing climate. The Network was launched in 2016 by experts from over a dozen founding institutions, spearheaded by the World Health Organization and World Meteorological Organization Joint Office for Climate and Health, and the United States National Oceanic and Atmospheric Administration (NOAA) Climate Program Office.

April	• Engagement around the concept note with wider heat & health community, shaping and seeking endorsement for the concept
May	• GEO Secretariat made revisions to concept note, including literature review to evidence the scientific basis for the project, developing a work plan for the design stage of the project • GEO Secretariat produced a non-technical summary 'brochure' to help communicate the project to a wider audience
June	• Discussion on Heat and Health Service takes place at GEO Symposium • Programme Board gets updated on the Heat and Health Service
July	• ExCom gets updated on the Heat and Health Service
August	• Project design team is identified, convening workshop held, endorsement of concept, delineation of potential technical approaches to implementation, seeking contributions to workstreams, and co-design on community/ youth engagement and communications aspects of the project • Resource mobilization plan is initiated • Develop ideas around a soft launch/ pilot campaign to promote the project concept in the lead up to GEO Week i.e., possible youth hackathon (subject to funding)
October	• Detailed design of the project ongoing • Project design team continues to present and discuss Heat & Health incubator at various fora • Programme Board gets updated on the Heat and Health Service
November	• Heat and Health Service is presented at GEO Week with partners
December	• Possible Atlas side event takes place at UNFCCC COP28

4 IDENTIFYING AND DEVELOPING FUTURE POST-2025 INCUBATORS

To recall, the first of the five goals of the draft Post-2025 Strategy is to co-produce transformative programmes that provide trusted Earth Intelligence. The Strategy further identifies indicators of success, of which is a transformed, and well-resourced GEO Work Programme that responds to the goals identified in the strategy with activities that demonstrate integration across thematic areas and along the Earth observations value chain, with an unrelenting focus on users.

The post-2025 incubators are designed to support this goal. The Programme Board has been discussing this approach since the 2022 Symposium and two incubators are being supported in 2023. The Secretariat has been learning important lessons in this process, including with respect to the capacities required to develop and sustain an incubator to mature into a funded project that will be absorbed into the GEO Work Programme. For example, following the multi-hazard risks/disaster risk reduction workshop in March, there has not been much initiative from the community to advance this work without dedicated additional support.

In anticipation of the adoption of GEO Post-2025 Strategy by GEO Plenary and Ministerial Summit at GEO Week 2023, the Programme Board is uniquely positioned to spearhead the

development of the GEO Post-2025 Work Programme. This work will need to create a transition from the current GEO Work Programme 2023-2025 to the Post-2025 Work Programme. This effort should be the defining focus of Programme Board's activity through 2025. Identification and development of the post-2025 incubators presents a viable approach to this seminal work.

In light of this, the Programme Board is invited to develop a strategic and tactical plan of action for the next two years that focuses the work of the Board towards supporting a post-2025 Work Programme that responds to the direction of the Post-2025 Strategy. Following the 26th meeting, the Board co-chairs and/or a wider working group will begin thinking on this action plan to present at the 27th meeting of the Programme Board.

ANNEX 1

CONCEPT NOTE: GLOBAL ECOSYSTEMS ATLAS

This **Concept Note** introduces the GEO Global Ecosystems Atlas (the Atlas) – a collaborative initiative to develop an integrated collection of global, regional, and national scale maps of ecosystem types for terrestrial, freshwater, coastal marine and oceanic marine environments to support applications requiring information on ecosystem extent and distribution. This document provides the vision for the Atlas and discusses why it is needed and major considerations for its development. Anticipated partnerships and a simple initial governance structure are proposed. A phased approach to implementation is then presented, and the document concludes with a discussion of anticipated uses of the Atlas and an illustrative list of ecosystem-related map layers as a vision for potential Atlas content.

1. Vision

The vision for the Atlas is to create a trusted and consensus-based approach for developing a digital compendium of maps of the Earth's ecosystem types to support many applications that require information on the extent and distribution of ecosystem types. These applications include *research* to better understand why ecosystems are distributed where they are, nature-based solutions for improved *management* of natural resources, *assessments* of ecosystem impairment and vulnerability to support *conservation* planning and priority setting, and ecosystem *accounting* as an addition to traditional economic accounting.

The Atlas will be an open geospatial data repository and information system. It will contain a compendium of maps depicting the distributions of Earth's terrestrial, freshwater, and marine ecosystem types. Maps included within the Atlas will be derived from multiple sources. The compendium will include the many important global, regional, and national maps of ecosystem types in use today, as well as updatable data cubes that facilitate ecosystem monitoring. Further information on the proposed scope of the Atlas is presented in Section 6 below.

The Atlas will allow users to query any location on Earth, produce summary statistics and track trends on ecosystem extent for user-specified areas. The query will also return useful statistics on changes in ecosystem extent when time series data are available. The Atlas will include functionality based on artificial intelligence (AI) and machine learning that will mine the totality of information contained in all the Atlas ecosystem layers for a particular area of interest and provide both a quantitative and textual summary characterization of the ecosystems occurring there. The development of the Atlas will leverage world class science to provide a trusted foundation for measuring and reporting on changes in the extent and distribution of ecosystems.

2. Need and Urgency

It is increasingly important to understand the types, locations, and condition of Earth's ecosystems because they are fundamental elements of biodiversity in and of themselves

(along with species and genes), and because they provide ecosystem services that are important for human welfare. These ecosystem services include provisioning services (e.g., food, fiber, fuel, water, etc.) regulating services (e.g. pollination, flood control, carbon sequestration, etc.), and cultural services (e.g. spiritual enrichment, recreation, aesthetic experiences, etc.). As such, ecosystems must be managed so they persist into the future in a condition which permits the continued delivery of these ecosystem services so important for human well-being. However, ecosystems are increasingly compromised due to direct loss or alteration of natural areas and impacts from climate change (e.g. increased frequency of extreme fire and flooding events), alteration of flow regimes, pollution, unsustainable resource extraction, invasive species, and other factors contributing to ecosystem decline.

Fortunately, increasing recognition of the importance of biodiversity and the degree to which it is compromised and imperiled has led to the emergence of important global and regional commitments for the management, restoration, and protection of ecosystems. A number of the intergovernmental conventions and multilateral environmental agreements under the United Nations, including the Convention on Biological Diversity (CBD), the UN Framework Convention on Climate Change (UNFCCC), the Convention on Wetlands, the UN Convention to Combat Desertification (UNCCD), and the Sustainable Development Goals (SDGs) contain strong commitments related to ecosystem conservation. Moreover, the UN System for Environmental and Economic Accounting (SEEA) provides a framework for nations to account for (among other things) ecosystem extent, ecosystem condition, and ecosystem services. Reporting progress on these commitments requires a quantitative, spatially explicit, and multi-temporal determination of ecosystem extent in order to measure and document changes in ecosystems area. These analyses are urgently needed because changes in ecosystem distributions (and condition) result in species declines and decreased production of vitally important ecosystem services.

3. Problem Statement

The CBD defines an ecosystem as a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. This core definition of ecosystem concept also serves other global agreements that pertain to ecosystems, including the SDGs, the Ramsar Convention on Wetlands, UNCCD and the UNFCCC. Broad interpretation of the CBD definition for ecosystems, however, has resulted in a diversity of ecosystem concepts and a proliferation of terms like habitats, biomes, biogeographic regions, ecoregions, land cover, plant functional types, etc., which are often used interchangeably with the term ecosystems. Ecosystems conceptualized as biotic communities and their associated physical environment are complex spatial entities which have been challenging to identify and map. Moreover, the magnitude and nature of the mapping challenge varies between different ecosystem types.

The Classification Challenge

Ecosystems are understood to have three very important dimensions – structure, function, and composition. Different approaches to the spatial delineation of ecosystems have emerged, with varying emphases on the degree of incorporation and mixing of these three ecosystem properties. For example, the IUCN Global Ecosystem Typology (GET) is an a priori classification that integrates all three components of ecosystems in its units (structure, function, composition),whereas the U.S. Geological Survey/Esri/TNC World Terrestrial Ecosystems (WTEs) are an *a posteriori*, map overlay-derived ecosystems classification and global map based on ecosystem structure. The World Wildlife Fund Global Ecoregions product is largely a composition-based approach to mapping global, macro-scale ecosystems for terrestrial, freshwater, and marine environments.

These examples of different approaches to conceptualizing and mapping ecosystems illustrate the challenges inherent in trying to produce a singular, definitive, global ecosystems map. These examples are valid and scientifically rigorous and have been widely vetted, including publication in the peer reviewed literature. However, the existence of these three different classifications and map products can be confusing for the many non-expert users and communities who understand the need for an authoritative map, and may believe that 'one true map surely exists'.

The Mapping Scales Challenge

The Atlas will incorporate available ecosystem mapping into an integrated information resource. This is essential to leverage the benefits of past investments and recent advances. Three broad types of mapping exist: 1) sub-global data sets that map all ecosystem types within a specified area (e.g. 'wall to wall' national ecosystem maps); 2) global data sets for specific ecosystem types, some of which incorporate time series (e.g. mangrove watch), and 3) global wall-to-wall maps of ecosystems, usually at coarse spatial scales. The first type of mapping has never been compiled globally, yet is critical to the Atlas because it is integrated into national policies that implement international agreements. The second type of mapping is rapidly growing as modelling, remote sensing methods and computing technology advance. These maps are already being reviewed and compiled into an existing repository linked to IUCN GET (https://zenodo.org/record/5090419#.ZE7qkHZBy5c). The Atlas will leverage this repository.

The compilation and leveraging of existing maps brings two related challenges to the fore. Firstly, how will the fitness for purpose of existing maps be reviewed to ensure they warrant inclusion in the Atlas. While the Atlas is intended to be accommodating and inclusive, some maps may not be appropriate for inclusion in the Atlas for a variety of reasons relating to conceptual rigor and data accuracy. Maps entail varying error rates related to their methods and data sources. Quality assurance is pivotal to trust in the Atlas and will require development and application of a scientifically rigorous review protocol. Secondly, how will existing maps be synthesized into a coherent global information system, given that they were developed with a disparate range of methods and data? Integration will also need to address significant spatial and thematic gaps where no ecosystem mapping currently exists. Development and implementation of a

rigorous integration process will require world class science engaging a collaborative network of world leaders in ecology, remote sensing, environmental modelling and software development. The established global networks of GEO and key partner

Maps of IUCN GET Ecosystem Types as Key Atlas Content

The need for an agreed, comprehensive, globally consistent classification of ecosystem types across land, freshwaters and oceans has been one of the barriers to developing a fit-for-purpose global ecosystem atlas. The IUCN Global Ecosystem Typology (GET) emerged as an agreed solution to this need. The ecosystem types comprising the hierarchical IUCN GET are classified according to differences in ecosystem functions and compositions and have been identified a priori through a rigorous global cross-disciplinary collaboration among leading ecosystem scientists and an exhaustive review process.

The GET has been endorsed by IUCN as the global standard for ecosystem classification, adopted by the UN Statistics Commission as the reference classification for ecosystem assets in SEEA-EA, and underpins the Headline Indicator for ecosystems in the CBD Global Biodiversity Framework. As such, maps of GET ecosystem types represent an important contribution to the Atlas, and the development of UN SEEA-compliant (e.g. spatially mutually exclusive, comprehensive across terrestrial, freshwater, and marine domains, etc.) GET ecosystem type data layers will represent a key part of the larger Atlas content.

It is anticipated that many of the non-GET layers that will be included in the Atlas will be useful for developing maps of GET ecosystems at global, regional, and national scales through the contribution of linework, cross-walking and harmonization frameworks, and imagery data.

A subset of the Atlas will be focused on providing users with global, regional, and national maps of GET ecosystem types and tools for assessing changes in GET ecosystem type distributions. An early and sustained emphasis on populating the Atlas with data layers on GET ecosystem types at multiple scales will be supported alongside the population of other ecosystem data layers into the Atlas.

In general, maps of GET ecosystem types will need to be developed from both cross-walking of other ecosystem data layers in the Atlas, and separate exercises to model GET ecosystem types from remotely-sensed imagery, etc.

Ultimately, in addition to a number of other ecosystem type map layers, users of the Atlas will be able to retrieve global, regional, and national maps of IUCN GET ecosystems suitable for many applications.

organizations, e.g. IUCN GET, World Conservation Monitoring Center, Global Forest Observation Initiative, the Committee on Earth Observation Satellites, etc., provide a model for this aspiration.

Finally, to serve the monitoring needs of its many users, the Atlas will require a temporal dimension. The processes that drive ecosystem change and the expression of change vary between different ecosystem types (e.g. forests vs deserts vs seagrass beds), as to the most effective methods of change detection. Recent advances define a path to solving this problem through production of ecosystem data cubes, in which a base map is sustainably updated with ecosystem-specific remote sensing indices. The recently produced data cubes are the outcome of major scientific endeavors over several years. The Atlas therefore requires a strategic approach to leverage recent and forthcoming products and prioritize the most important ecosystem types for data cube development, while establishing interim resources for the remainder to be addressed at later stages.

4. Developing the Solution: A Proposed Process

Plans to create the Global Ecosystems Atlas were triggered by the enormous potential of a single, operational and reliable platform providing information on ecosystem extent and distribution to support a number of assessment, monitoring, and accounting applications. Since October 2022, the Group on Earth Observations (GEO) has been advancing thinking on this solution. The consultative activity led by GEO has included: a workshop in October 2022 with the Earth observations community working on biodiversity, land degradation, wetlands, coastal monitoring among others; a session at the Earth Observations for Ecosystem Accounting workshop, presentation to the Committee on Earth Observations satellites; and a session at the GEO Plenary in November 2022. These have been complemented by a series of bilateral conversations with key organizations that have validated the need to advance this work based on their advancement of similar thinking such as the IUCN's establishment of a web-based map application in 2020 to support spatial query and analysis of the global ecosystem typology.

These consultations have fed into the overall concept and scope of the Global Ecosystems Atlas, which is elaborated in this concept note. Importantly, the secretariats of the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, UN Convention on Combating Desertification (UNCCD) and the United Nations Framework Convention on Climate Change (UNFCCC) have all offered their endorsement and support for the concept of an Atlas.

The first Convening Meeting of the Atlas will take place on 17-18 May 2023 bringing together representatives from, inter alia, the UN Conventions secretariats, science-based conservation organizations, data and technology providers, GEO experts, public and private sector users and donors. The purpose of this meeting will be to agree on the vision for the Atlas, establish the consortium, agree on the broad approach and next steps.

Subsequent convening meetings, including technical meetings for the workstreams to be established under the project, will be organized.

By the end of 2023, the vision and implementation plan for the Atlas will be presented at the 2023 GEO Week and COP28, for further discussion and to elicit contributions to the Atlas. The intention is to produce a demonstrable mock-up or sample of the Atlas by December 2023.

4.1 Phased Approach

The Atlas will be implemented in three major phases, each with several stages:

Phase 1: Design, Data Collection and Review, and Prototype Development (duration 18 months)

Phase 2: Classification Reconciliation and Spatial Integration and Modeling (duration 24 months)

Phase 3: Operationalization and Capacity Development (duration 18 months)

Phase 1 will commence with the *Design stage*, which will produce a detailed technical strategy for execution of the project. The strategy will resolve details on the major outputs identified by stakeholders as essential to meet core applications of the Atlas. It will identify development pathways, data requirements, shape workflows, identify specialist collaborators, identify risks and constraints and estimate resources required for each component of the project. A technical workshop scheduled for the second half of 2023 will engage leading expertise in the task, which will be completed within 6 months for presentation to stakeholders.

The *Data Collection* stage of **Phase 1** will collect and review existing data sets. Two types of data will be collected: i) on-ground records of ecosystem types; ii) ecosystem maps. On-ground records are essential for training and validation of the integration products, as well as evaluation of existing maps. They will be compiled from multiple sources, including existing repositories, citizen science subprojects and gap-filling data acquisition. Three types of ecosystem maps will be collated and reviewed: subglobal comprehensive (wall-to-wall maps); global and subglobal thematic maps and data cubes that map one or a few related individual ecosystem types, and global maps of multiple, fully-tesselated (wall-to-wall ecosystems). Data sources include government agencies NGOs, research organizations and existing repositories. Once identified, candidate data sets will be subject to a rigorous review process to ensure they are fit for purpose and meet required scientific standards for quality assurance. Review criteria and standards will be developed by a technical committee, which will oversee the process. Access and licensing will be negotiated for data sets that meet review requirements, which is expected to require appreciable time and resources.

In addition to developing a digital compendium of maps of ecosystem types, new maps will be developed for areas where ecosystem distributions are relatively unknown. This work will involve exploiting increasingly higher spectral, spatial, and temporal resolution satellite imagery and increasingly sophisticated artificial intelligence (AI) and machine learning (ML) to better characterize ecosystems across a variety of scales and classification approaches, especially in areas where ecosystem maps are lacking. This will necessitate collaborations with imagery providers and AI/ML technologists for critical

support to enable the mapping of ecosystem 'dark spots'. Similarly, and in a larger sense, collaborations will be necessary for the engagement of field ecologists familiar with the actual distributions of ecosystem types on-the-ground and in-the-water. That knowledge is critical for both supporting interpretation of satellite imagery and for the elaboration of baseline distribution maps of ecosystem extent, against which changes in extent could be assessed.

The *Prototype Development* stage of **Phase 1** will develop the software infrastructure for the Atlas, and will commence in parallel with *Data Collection*. Exemplar data sets will inform the design to specifications shaped by the core functions framed by the Vision and stakeholder needs. This stage will involve specialists in bioinformatics and software design working closely with ecosystem specialists in the project team and expert networks. Prototype development will occur in parallel with data collection and is planned for completion 5 months after commencement.

Phase 2 includes the *Classification Reconciliation* stage. After the many maps of ecosystem types have been input into a geodatabase which serves as a common geographic framework, experts will commence an effort to crosswalk, to the extent possible, the ecosystem units from the various classifications. The cross-walking effort is an attempt to translate ecosystem units from one system to another. This work will also include creating new global ecosystem maps from unmapped classifications (e.g. the IUCN Global Ecosystem Typology) using spatial linework and criteria from other mapped classifications. All data sets will be incorporated into a centralized geodatabase. A large network of interpreters will need to be engaged on the attribution task to ensure timely delivery. Standards and protocols to guide this process will be developed by a technical committee with relevant expertise to ensure consistency and rigour and appropriate review of this important stage.

The *Spatial Integration and Modeling* stage of **Phase 2** is the major challenge of the entire Atlas project and the component most critical to success. It will engage leading experts in ecosystem ecology, remote sensing, environmental modelling, and bioinformatics overseen by a technical committee to develop and implement models that integrate training data with spatial data and refine outputs with cross validation. Assembly protocols will be developed to produce composite maps of ecosystem types from different source inputs. The approach will seek to maximise compatibility of the modelled output with detailed national and local maps, enabling seamless integration of maps and generation of time series from satellite archives for ecosystem monitoring.

The Atlas will become increasingly operational as data sets are included after review as integration progresses, and as the number of active users increases. **Phase 3** involves launch, outreach, and capacity development to encourage maximum use of the Atlas by the broadest possible usership, acknowledging that preliminary outreach and capacity development can be planned into earlier phases as well. Phase 3 will include targeted capacity building for the convention-level stakeholders (e.g. CBD, Ramsar Convention on Wetlands) and multilateral environmental agreement communities (e.g. UN SEEA, UN SDGs), particularly country level communities, and the private sector. That targeted outreach will include training workshops/courses, collaborative analysis and reporting

on ecosystem extent for a variety of biodiversity conservation and ecosystem accounting applications.

4.2 Partnerships and Governance

Development of the Atlas will be convened and hosted by GEO, partnering in leadership with key authoritative organizations, known collectively as the **Global Ecosystems Atlas Consortium**. The governance of the Atlas will be determined following a collaborative co-design process with key global, regional, and national partners and users. Participation from all regions, including the global south, is valued and will be proactively sought.

Early thinking on governance is that the overall leadership and oversight for the implementation will be provided by a high-level **Steering Committee** that may include leading conservation organizations, e.g. IUCN, supporting UN conventions, government representatives, key conservation organizations, data and technology providers, and major donors.

Overall coordination and close interaction between the different workstreams and committees will be vital. One option is to establish high-level technical committee, reporting to the steering committee, with representation of diverse expertise across Atlas activities, including ecologists, statisticians, data and GIS specialists, software developers, etc. The technical committee would have decision-making responsibility on approaches and methods, consistent with direction set by the steering committee, and oversight of implementation teams. These implementation teams would implement the workflows of different components of the Atlas project and would generate important input to the Steering Committee via the Technical committee.

A broader **Friends of the Global Ecosystems Atlas community** will be key stakeholders opting for periodic engagement in the production of Atlas.

The governance of the Atlas will be supported by a project management office (PMO) initially located at the GEO Secretariat.

4.3 National and Local Data and National Assessments

A crucial aspect of the Atlas is to ensure compatibility of global data products with national and local data sets. Where national ecosystem maps exist, they are closely integrated into government policies, regulations, ecosystem management programs and other instruments that implement obligations to international agreements. These detailed data sets are also the product of considerable national investment maintenance and local knowledge. Meaningful integration of these products is therefore central to developing the Atlas as a trusted resource. Many data projects and initiatives meet local, national and regional needs, but are not sufficiently and systematically linked to realize important potential in international or global analyses. In addition, national data sets can inform how important gaps are filled in nearby countries currently without comprehensive national data.

The Atlas will offer the opportunity to make existing national maps of ecosystem types more readily accessible for ecosystem extent reporting. The Atlas project envisions a federated system for geospatial data alignment and analysis for further development. The federated approach would ensure that any international application of the Atlas was compatible with in-country assessments. In the *Data Collection Stage* of Phase 1, the Atlas Consortium will ensure a quality review process for new elements of the federated system according to the agreed technical and content standards. This approach will be tested through pilot projects with an initial set of countries that, for example, will be reporting on biodiversity and have already established ecosystem reporting based on wall-to-wall maps and classifications of ecosystem types, ideally in more than one environmental domain.

The Consortium will identify suitable approaches for effective engagement with national entities leveraging existing architectures that offer connections to countries, such as GEOBON, UN SEEA, IUCN, UNEP-WCMC, etc.

One option to organize, manage and ensure national engagement in the development and operationalization of the Atlas, is to establish regional nodes to represent a federated user community with delegated decision-making on Atlas content aligned with review criteria and data standards.

The development of the Atlas is based on the acknowledgement and respect of the original occupation of Earth's lands and waters by humans. The knowledge and traditions from these first peoples, which also often include ecological classification of landscapes and seascapes, is very much valued and will be incorporated as appropriate. Any classification and mapping developed during this project is in no way an assertion that indigenous or other classifications are invalid. In this project, we acknowledge and respect the indigenous cultures of the world and their deep connections with the lands and waters which we now seek to classify and map from an ecosystems geography perspective.

5. Anticipated Uses of the Atlas

The Atlas is designed to support a range of applications including biodiversity conservation, ecosystem accounting, natural resource management, research, education, and policy formulation. The Atlas is intended to:

- Support monitoring and reporting on the CBD Global Biodiversity Framework headline indicator for ecosystems.
- Support reporting on other ecosystem targets in the GBF, including the '30 by 30' Targets 2 and 3, which effectively aim to protect, conserve or restore 30% of the planet's global ecosystems by 2030.
- Support the implementation of the UN System for Environmental-Economic Accounting (UN SEEA-EA) ecosystem accounts framework with spatial information on the reference classification for ecosystem assets.

- Support risk assessments undertaken for the IUCN's Red List of Ecosystems, the Headline indicator for ecosystems in the GBF.
- Support the UN 2030 Agenda for Sustainable Development and associated Sustainable Development Goals (SDGs) targeting conservation of freshwater (SDG 6), coastal and marine (SDG 14), and terrestrial (SDG 15) ecosystems, by providing ecosystem extent data for the monitoring and reporting on indicators for these goals.
- Support ecosystem-related stocktaking exercises as a fundamental element of the UN Framework Convention on Climate Change (UNFCCC) and associated Paris Agreement.
- Support analyses of land degradation and sustainable land management associated with the UN Convention to Combat Desertification (UNCCD)
- Support the development and/or refinement of National Wetlands Inventories aligned with the Ramsar treaty for the conservation and sustainable use of wetlands and other freshwater aquatic ecosystems (rivers and streams; lakes and ponds).
- Support the design and operation of Nature-based Solutions (NbS) seeking to enhance the management and use of ecosystems and natural capital for societal benefit.
- Support the modeling of ecosystem distributions under future climate scenarios.
- Support the emerging needs for corporations to understand risks, impacts, and dependencies on ecosystems of current and planned activities in order to develop mitigation and offset strategies.
- Provide features for conservation planning at multiple scales, especially cross border efforts.

Because the data core of the Atlas is a geodatabase, it could, in the future, be extended through both additional attribution and combination with other (e.g. species distributions data) resources. For example, the CBD has commissioned GEO's Biodiversity Observation Network (GEO BON) to develop GBiOS – the Global Biodiversity Observation System, which would necessarily track the distribution and condition of species- and ecosystem-level biodiversity.

These applications all require time-series of robust and transparent characterizations of ecosystem extent for analysis and reporting, and the Atlas, as conceptualized herein, is intended to systematize, and where necessary develop, the data to meet that requirement, primarily through its functionality developed in the Spatial integration and modelling stage of Phase 2.

6. Bounding the Atlas – Scoping Dimensions

Domain Scope – The Atlas will include mapped characterizations of ecosystems in the three primary environmental domains: terrestrial, freshwater, and coastal and marine. Maps of subterranean ecosystems are scarce, but could be accommodated in the Atlas when suitable data emerge. Natural/semi-natural and intensively modified/anthropogenic ecosystem types will be included in the Atlas.

Geographic Scope – The Atlas will include 2D ecosystem maps across all land masses and the coastal and inshore zone out to the edge of the continental shelf. The open ocean (beyond the shelf) ecosystems in the surface, pelagic (water column), and benthic (seafloor) environments will be included as well in the Atlas, using a 2D stacking approach wherein attributes from different depths are carried at corresponding X,Y locations on the surface. All areas of the planet will be addressable in the Atlas.

Mapping Scales – The Atlas will contain hundreds of spatial datalayers representing maps of ecosystem types. Some will be globally comprehensive, some will be continental in extent, others regional, and many will represent national ecosystem maps. These 'operating' scales – global, regional, and national – will serve many ecosystem accounting and reporting needs ranging from national ecosystem accounting to reporting on global ecosystem conservation status. The Atlas will be centrally maintained and curated, and will not include local maps of ecosystem types due to limitations on resourcing and system capacity.

Temporal Scope – The Atlas will aim to include maps of ecosystem type distributions at different times. Where metadata permits, maps will be 'timestamped', representing the distributions of ecosystem types during specific timeframes (usually years) or during a certain time period (e.g. "pre-settlement" or "pre-industrial"). The geodatabase, as the spatial engine of the Atlas, will also include the ability to track changes in ecosystem distributions types over time, data permitting, potentially through contributed maps, but particularly through the integration outputs. The data format which will permit the tracking of changes in ecosystem distributions of ecosystem types over both space and time is commonly referred to as a data cube, where the first two dimensions are x and y (longitude and latitude), and the third dimension is t (time). Some maps of ecosystem types ecosystem datalayers will also represent 'baseline' distributions derived from long-term historical averages or modeled 'pre-industrial or pre-settlement disturbance' extents.

Ecosystem Condition – The Atlas is fundamentally a resource to identify the distributional area of ecosystem types at different points in time and for identifying changes in those ecosystem extents. While reductions in ecosystem area are certainly related to ecosystem condition, there are several other factors that also contribute to the condition of ecosystems at both the individual ecosystem occurrence (patch) level and the whole ecosystem type (all occurrences) level. These factors include biotic composition and interactions, disturbance, the nature of fragmentation, etc. Typically, maps of ecosystem types do not contain the necessary information to assess the condition of either individual occurrences of an ecosystem type or of the whole ecosystem type, and additional attribution is generally required to develop, for example, spatial assessments of ecosystem condition for ecosystem risk assessments or ecosystem

condition accounts. As such, ecosystem condition is out of scope for the Atlas development effort. However, the collection of maps of ecosystem types into a common geographic framework represents an ideal starting point resource for the subsequent attribution of ecosystem occurrences with condition attributes.

Ecosystem Vulnerability – There are several pressures and threats (e.g. climate change, invasive species, alteration and loss of natural areas, alteration of flow regimes, pollution, unsustainable resource extraction, extreme fire events, etc.) with the potential to negatively impact ecosystems, and best ecosystem management practices typically include pressure or threat abatement strategies and attempts to reduce ecosystem vulnerability to stresses. Similar to ecosystem condition, ecosystem vulnerability is also out of scope for the Atlas as this information rarely exists as attribute information for ecosystem occurrence data. Ecosystem extent information from the Atlas, however, could be useful in ecosystem risk assessments such as the IUCN RLE process.

7. Remote Sensing and Land Cover/Land Use mapping

In the absence of detailed maps characterizing the distribution of global ecosystems, society has relied for years on satellite image-derived maps of land cover and land use as a proxy for ecosystem distributions. Typically, land cover proxies represent generalized depictions of ecosystems at coarse levels (forests, grasslands, etc.). There has been a steady evolution in image-based land cover and land use classification towards increased spatial and classification resolution. These constant improvements in image-derived land cover and land use classification are potentially very useful for analysis of terrestrial ecosystem extent. Still, land-use and land-cover maps do not capture the diversity of ecosystems distinguished by their characteristic species, environments and functions. Moreover, land cover and land use classifications are generally poorly suited for the delineation of ecosystem extent for freshwater ecosystem types. However, other remote sensing approaches focused specifically on changes in surface water extent could be helpful for mapping freshwater ecosystem types. Land cover and land use data are generally well suited for identifying extent and changes in extent of anthropogenic ecosystem types. The Atlas will incorporate earth observations (remotely sensed and *in situ*) for the analysis of changes in ecosystem extent.

8. Layers in the Atlas – An Illustrative List of Maps of Ecosystem Types

Organization of Datalayers in the Atlas

The logic for organizing maps of ecosystem types as layers in the Atlas is presented herein, followed by an illustrative list of candidate input maps. The first level of organization is by multiple (wall-to-wall) vs. individual ecosystems, denoted by an A or B upper case letter. The second level of organization is by environmental domain, i.e. terrestrial, freshwater, or coastal and marine, denoted by a 1 for Terrestrial, a 2 for Freshwater, and a 3 for Coastal and Marine. The third level of organization is by operating scale into global, regional, or national products, denoted by a lowercase a for

Global, b for Regional, and c for National. The unpopulated hierarchy is first presented below for an at-a-glance understanding of the organization of ecosystem data categories.

A Multiple, Fully Tessellated Ecosystems (Wall-to-Wall)

1 Terrestrial

a Global

b Regional

c National

2 Freshwater

a Global

b Regional

c National

3 Coastal/Marine

a Global

b Regional

c National

B Individual Ecosystems

1 Terrestrial

a Global

b Regional

c National

2 Freshwater

a Global

b Regional

c National

3 Coastal/Marine

a Global

b Regional

c National

Illustrative List of Datalayers Representing Potential Sources of Ecosystem Type Information (Pending Consultation)

Herein we present an initial list of candidate datalayers representing maps of ecosystem types for inclusion in the Atlas using the organizing framework above. This list is illustrative, for purposes of understanding, and is by no means exhaustive. The Atlas, as a digital compendium, is considered to be a living resource which is added to and improved over time. We anticipate adding many more layers than are included here. Note – fully tessellated maps of terrestrial ecosystems often contain embedded freshwater ecosystems.

A Multiple, Fully Tessellated Ecosystems (Wall-to-Wall)

1 Terrestrial

a Global

Global Ecosystem Typology (IUCN) (to be developed) (various hierarchical levels as available)

Global Land Cover (ESA CCI) timeseries (2000 – 2023)

World Terrestrial Ecosystems (USGS/Esri/The Nature Conservancy) 2020

World Terrestrial Ecosystems (USGS/Esri/The Nature Conservancy) 2050

World Vegetation Formations (NatureServe)

Global Ecological Land Units (USGS/Esri)

Global Agro-Ecological Zones (FAO)

Global Map of Terrestrial Habitats (IUCN)

Terrestrial Ecoregions (WWF)

Ecoregions of the Continents (Bailey)

Floristic Regions (Takhtajan)

Biogeographical Provinces and Realms (Udvardy)

Life Zones (Holdridge)

Major World Ecosystem Complexes (Oak Ridge National Laboratory)

Global Potential Vegetation (Hengl)

b Regional

Tropical Andes Macrogroup and Formation Ecosystems (NatureServe)

Temperate and Tropical North America Ecosystems (NatureServe)

Vegetation Macrogroups of South America (Nature Serve)

Terrestrial Ecosystems of Africa (U.S. Geological Survey)

European Union Ecosystems (MAES)

European Ecosystem Types (EUNIS)

Ecological Regions of North America (CEC)

Ecosystems of South America (The Nature Conservancy)

c National

Terrestrial Ecosystems of the United States (GAP/LandFire)

Ecosystems of Colombia (Humboldt Institute)

Terrestrial Vegetation of China (China Academy of Sciences)

Ecosystems of Liberia (Liberia, Conservation International, NASA)

Ecosystems of Costa Rica (Kappelle)

Ecosystems of The Netherlands (Statistics Netherlands)

Canadian Ecozones and Ecoprovinces (Statistics Canada)

2 Freshwater

a Global

Ecologically Classified River Reaches (GloRIC)

HydroBasins and HydroAtlas (HydroSheds)

Global Wetlands (Hydrosheds)

MERIT Hydro Global Rivers (Yamazaki)

Freshwater Ecoregions of the World (WWF)

b Regional

c National

National Wetland Inventories

3 Coastal/Marine

a Global

Open Ocean Ecological Marine Units (USGS/Esri)

Ecological Coastal Units (USGS/Esri)

Global Seascapes (GEO BON/MBON)

Marine Ecoregions of the World (WWF)

Ocean Biochemical Provinces (Longhurst)

Marine Biogeographic Regions (Costello)

Large Marine Ecosystems (Sherman)

b Regional

c National

B Individual Ecosystems

1 Terrestrial

a Global

Global Forests (Hansen)

Global Forest Watch (WRI)

Global Grassland Types (IVC)

b Regional

c National

2 Freshwater

a Global

b Regional

c National

3 Coastal/Marine

a Global

Global Mangroves (WCMC/Global Mangrove Watch)

Global Corals (Allen/WCMC)

Global Seagrasses (WCMC)

Global Salt Marshes (WCMC)

Global Estuaries (Laruelle et al.)

b Regional

c National

ANNEX 2

GLOBAL INTEGRATED HEAT AND HEALTH SERVICE

What is the Service?
GEO and partners are developing a service that will provide every urban area in the world with data and knowledge on the health risks from extreme heat. This "Earth intelligence" will help cities develop plans to adapt to heat and reduce the impact on citizens' health and local economies.

Drawing on data from Earth observation satellites and other sources, the service will use the expertise and technology of multiple partners to conduct analysis and produce reports for each city: neighbourhood by neighbourhood.

What is the impact of heat on health and society?
As global temperatures rise, hot days and extreme heat events are becoming, more intense and more frequent. The impacts of these events are amplified in cities, where the urban heat island effect can create temperatures of up to 20 degrees Celsius higher than surrounding areas.

Heat has significant impacts on health and the economy. Extreme heat is the deadliest weather event, responsible for an estimated 500,000 excess deaths each year.[i] Direct exposure to heat limits the body's ability to regulate temperature and can result in heat-related illnesses and death. The elderly, young children, pregnant women, and people with chronic health conditions are particularly vulnerable.

Public health is further impacted by effects on air quality, disease transmission, workplace injury, mental health and of the interruption to essential services such as energy, water and transport.

The impact of extreme heat on health, agriculture, productivity and infrastructure is estimated to cost the global economy $2.4 trillion by 2030. UNICEF estimate that around 800 million children are highly exposed to heatwaves, which during early years has been linked to children attending fewer years of schooling.

The poor are worst affected. Two thirds of global exposure to extreme heat occurs in urban areas in the global south where rapid urbanization and climatic changes are more pronounced.[ii] These areas tend to have less financial and technical capacity to mitigate and adapt to climate risks. Economic losses from heat are four times higher in low-income counties than world's wealthiest regions.[iii] Within cities, low-income neighbourhoods may experience greater heat exposure due to overcrowding, lower construction standards and a lack of green spaces.[iv]

Why do we need a Global Heat and Health Service?

Death and illness caused by extreme heat can be prevented with strategies that are tailored to specific cities. Investing in green spaces in vulnerable areas, for example, can help provide respite from extreme heat.

However most cities don't have comprehensive strategies in place. A key reason for this is that they don't have the resources to gather local knowledge and assess risk.

Some cities have local climate/ heat vulnerability maps and services to inform early warning systems. But these are often one-off, costly exercises. Even in richer countries, it's
challenging for cities to collect and analyze data on the full range of variables—weather, climate, urban heat islands, health, the economy and coping capacities—then turn that data into intelligence that can inform strategies and other actions.

The Heat and Heath Service aims to fill these gaps. It also aims to help unlock funding for cities. It's more cost-effective to prepare cities for extreme heat now than to deal with the impacts later. But currently only around 7-8% of global urban climate financing needs are being met, with far less still (2% of total urban climate financing) flowing to urban areas in the global south.[v] A key barrier to accessing this climate finance is a lack of appropriate data and information with which to develop feasible plans and projects to mitigate risks. Climate and heat vulnerability and risk information is essential if cities and communities are to unlock financing to fund heat resilience initiatives.

About the Global Heat and Health Service
GEO is leading a project to develop a Global Heat and Health Service to deliver high-quality, city-specific information to inform improved public health, economic resilience and sustainable urban development, now and into the future.

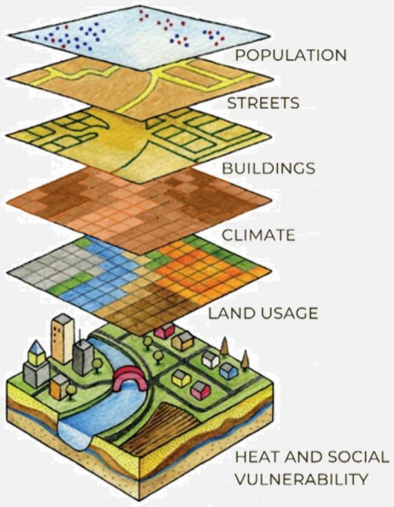
The service will provide a trusted, free and open-access decision-support tool for all cities around the world. The service will support cities in both preparing for emergencies and through longer-term planning to prevent heat-related risks. It will allow them to collect, analyse and integrate global, regional and local data and knowledge, on weather, health, demographics, the built environment, infrastructure and the social factors to be able to better understand the health-risks from extreme heat. Input data will come from Earth Observations (satellites and in-situ), existing statistical and geospatial data, and local surveys and field measurements. Citizen-science and data collection initiatives will offer the opportunity to empower communities, including youth and young people, to contribute to information on heat vulnerability in their cities.

Analysis-ready data will be made available through the service at a suitable spatial-scale to highlight local variations in heat risk from street to street, neighbourhood to neighbourhood. Cities will also be able to incorporate their own data within the service to inform local decision making in advance of and during extreme heat events. Information and additional support provided by the service will be used by a range of city stakeholders to interpret and translate risk information into policies, plans and investments to increase resilience to heat, reducing the burden of heat-related illnesses, deaths and economic losses.

Involving communities and importantly, young people, will ensure awareness of heat-related risks can be disseminated through schools and colleges. The project will also provide an opportunity to develop local technology sectors through hackathons that develop tailored data-driven apps and services for specific community needs.

Global Integrated Urban Heat & Health Service

Earth-observation (satellite & in-situ) and other data inputs



Outputs of the service:

- Seasonal heat forecasts programmed at least four times a year
- City-level spatial data, products, and tools that define and map trends and dynamics related to exposure and vulnerability to heat
- Assessment of existing city-level coping capacity, including health service infrastructure, green and blue infrastructure, etc.
- Integration of urban health data to better understand the relationship between urban heat islands/events and health and well-being
- Accessible interface to explore and understand the drivers of heat-related vulnerability
- Scenario-based planning tools to capture uncertainty related to future climatic and non-climatic conditions, including population growth and urbanization
- Supporting cities to identify practical solutions to build heat resilience, providing the evidence needed to develop project feasibility
- APIs to allow use of data for the development of local mobile or web-based applications
- Means to raise awareness and communicate risks and approaches to risk management for various users, including city officials, emergency services, communities, and local businesses

Why now?

Digital tools, data and analytical techniques now exist to help understand the impacts of extreme heat events at a range of scales, global/regional, national, city-level, and neighbourhood; and on increasingly shorter timescales. At the same time, advances in data science and analytics, cloud-based computing and the application of Artificial Intelligence/Machine Learning enable the integration of relevant information including Earth observation data (satellite-based and on-the-ground measurements) and statistical, survey and public health data to predict with increasing accuracy when and where extreme heat events will occur and who will be most vulnerable.

There is an urgent need for information to improve the efficacy of early warning systems and adaptation plans, such as the UN's Early Warning for All initiative. The increased frequency and intensity of heat waves around the world, coupled with rapid urbanisation threatens to significantly increase mortality rates in the near future.[ii]

Without a global service to deliver locally-specific information, complete coverage of the world's urban areas is not achievable. Without affordable and equitable access to information, cities and their communities are unable to effectively plan to mitigate the socio-economic impacts of extreme heat, further exacerbating existing inequalities and the disproportionate impacts of climate change.

Who will use the service?

- City governments to understand the value of investments in heat resilience to mobilize finance for climate adaptation
- Public health authorities to communicate risks and mitigation actions to reduce health impacts
- City and regional planners to develop targeted adaptation and mitigation strategies and plans that help mitigate the impact of heat in the urban environment, through design and construction of buildings and infrastructure to minimize risks from heat, use of green and blue infrastructure, nature-based solutions.
- Health care providers and emergency services to prepare and respond to heat-related emergencies - preparing for increases in heat-related illnesses and injuries
- Community members to understand the risks of heat waves and protect themselves and their families.
- Private sector to develop products and services related to cooling and other risk reduction initiatives
- Governments to design policies to mitigate risk on populations and improve the efficacy of early warning systems
- National governments to track progress against international agreements and unlock climate finance
- Insurance companies in designing appropriate insurance products to offset losses from heat
- Researchers who need access to data on heat waves and their health impacts to inform policy and research.
- Non-Government Organisations to inform development and humanitarian projects in urban environments with local communities
- Intergovernmental agencies to inform policies and initiatives to support governments in adaptation and mitigation
- International conventions such as the UNFCCC to monitor the impacts of climate change on public health and inform activities

About the project

The Group on Earth Observations will convene a small, multidisciplinary team to lead the development of the service. This project team will comprise of global scientific and policy experts on the use of Earth observations for climate change, urbanization, and health who fill facilitate the co-design of the service in partnership with representatives of health, meteorological and emergency management agencies, local governments and their communities, statistical and mapping agencies, experts in data analytics, software development and user experience design.

The key stages of the project will be project design (to be completed by early 2024), data collection and processing, interface development, piloting and scale-up.

The project will require funding at each stage to cover costs including personnel, data acquisition and analysis, software development and hardware infrastructure, operations and maintenance.

The Service will be a key input for the delivery of a Global Early Warning System for All to be developed by 2027 as part of a commitment by the UN Secretary General.

GEO is seeking partners to collaborate on the project. In the current design stage, we are looking for active city-level partners to test and refine approaches to mapping and understanding health-related risk from heat. Collaboration will also be sought throughout design and implementation phases with those who can provide the following support: scientific/technical (earth observation methods tools, data management); policy & advocacy; stakeholder & community/ youth engagement; capacity building; funding and investment.

About GEO

The Group on Earth Observations (GEO) is a global partnership comprised of 114 governments, 162 international, private sector and civil society organizations and thousands of scientists collaborating to provide equitable access to Earth observation information as a basis for evidence-based decision making. The Secretariat is hosted by the World Meteorological Organization (WMO).

Group on Earth Observations, 7 bis, avenue de la Paix, Case postale 2300, CH-1211 Geneva,

Switzerland

E-mail: secretariat@geosec.org www.earthobservations.org

[i] Qi Zhao et al., "Global, Regional, and National Burden of Mortality Associated with Non-Optimal Ambient Temperatures from 2000 to 2019: A Three-Stage Modelling Study," *The Lancet Planetary Health* 5, no. 7 (July 1, 2021): e415–25, https://doi.org/10.1016/S2542-5196(21)00081-4.

[ii] Cascade Tuholske et al., "Global Urban Population Exposure to Extreme Heat," *Proceedings of the National Academy of Sciences* 118, no. 41 (October 12, 2021): e2024792118, https://doi.org/10.1073/pnas.2024792118.

[iii] Christopher W. Callahan and Justin S. Mankin, "National Attribution of Historical Climate Damages," *Climatic Change* 172, no. 3 (July 12, 2022): 40, https://doi.org/10.1007/s10584-022-03387-y.

[iv] T. Chakraborty et al., "Disproportionately Higher Exposure to Urban Heat in Lower-Income Neighborhoods: A Multi-City Perspective," *Environmental Research Letters* 14, no. 10 (September 2019): 105003, https://doi.org/10.1088/1748-9326/ab3b99.

[v] Climate Policy Initiative, "The State of Cities Climate Financing 2021," 2021.