

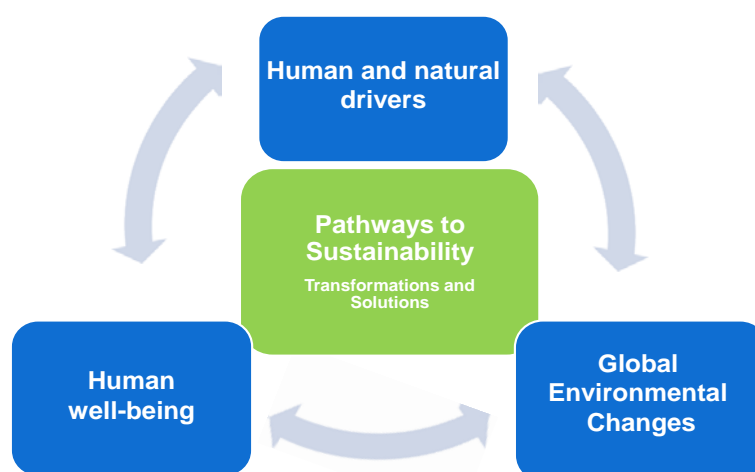


## Research framework for Future Earth<sup>1</sup>

Future Earth is the new international initiative on Earth system research for global sustainability conceived by an alliance of international research organizations. The goal of Future Earth is to develop the knowledge required for societies worldwide to face challenges posed by global environmental change and to identify and implement solutions and opportunities for a transition to global sustainability. Future Earth must answer fundamental questions about **how and why the global environment is changing, what are likely future changes, what are the implications for humans and other species, and what opportunities reduce risks and vulnerabilities, enhance resilience, and create prosperous and equitable futures**. Future Earth will show how this knowledge can inform and support actions for sustainable developments that enhance human wellbeing.

### *Conceptual framework*

The proposed conceptual framework for Future Earth, illustrated in Figure 1, describes an interconnected system in which both natural systems and human activity are driving changes in the regional and global environment, with significant implications for human wellbeing. Changes in wellbeing – such as incomes and health – are affected directly by human and natural drivers. They can also alter these drivers, for example as income and dietary changes alter energy use, land use, and emissions. Finding solutions and identifying transformations that reduce the risks of negative changes and enhance positive outcomes are central to this conceptual framework and can focus on all or any of the three other elements, altering trajectories of human drivers, mitigating global environmental change, or fostering human wellbeing. The framework is designed to embrace the range of interdisciplinary and disciplinary expertise, knowledge about society, Earth science, and ecology, and the expertise from many regions and sectors needed to understand and track the dynamics and state of the planet and its people, support development, and advance solutions for a transition to global sustainability.



**Figure 1:** Schematics of the conceptual framework for Future Earth

<sup>1</sup> This document is a draft for consultation. It takes into account the most recent discussions of the Future Earth Transition Team, and is agreed by its co-Chairs.

## ***Principles guiding the research design of Future Earth***

Future Earth supports an inclusive, integrative and solution-oriented research agenda that emphasizes the following principles:

- *Scientific excellence*: a commitment to support science of the highest quality.
- *International scope*: a focus on areas where international research co-ordination is needed for successful analysis and solutions.
- *Environmental sustainability*: an emphasis on global environmental change and its intersection with human wellbeing and sustainable development.
- *Integration*: draws on expertise in natural and social science, as well as engineering, humanities, sustainability science, and professions such as planning, law, and business. This must be complemented by strong disciplinary excellence that contributes insights to integrated projects.
- *Co-design and co-production*: expects that the research agenda and programmes will be co-designed, and where appropriate co-produced, by researchers in collaboration with various stakeholders— in governments, industry and business, and civil society.
- *'Bottom-up' inspiration*: depends on ideas and innovative approaches generated by the research community.
- *Solution-oriented*: by listening to the needs of decision makers, providing foresight of changes and risks, testing the effectiveness of responses and providing a knowledge base for innovations, Future Earth will seek solutions to the grand challenges of environmental change and development.
- *Inclusion and enhancement*: embraces and enhances the existing international Global Environmental Change (GEC) projects and related national activities, connects them to the global environmental change and sustainability programmes of allied organizations, and provides new opportunities for international collaboration and research initiatives. Regional engagement, geographic and gender balance, capacity building, supporting new generations of researchers and networking are priorities.

## ***Future Earth Research Themes***

The proposal is to organize Future Earth research around three broad and integrated Research Themes: *Dynamic Planet*; *Global Development*; and *Transformations toward Sustainability*. Each research theme will address a series of research questions that build on the overall conceptual framework of Future Earth. Examples of research questions – some already addressed within and across existing GEC projects – are provided below and the community is encouraged to suggest other high priority questions.

*Dynamic Planet* – This theme includes observing, explaining, understanding, projecting Earth, environmental and societal system trends, drivers and processes and their interactions; anticipating global thresholds and risks.

Example research questions include:

- What are the states and trends of key environmental components such as biodiversity, climate, soils, cryosphere, biogeochemistry, air quality, hydrology, and oceans, and in the social foundations of sustainable development such as wellbeing, equality, health, education, human security? How and why do these vary across time, space, and social context?
- What approaches, theories, and models allow us to explain the functioning of Earth and socio-ecological systems, understand the interactions between them, make projections for the future, and anticipate critical thresholds?

- What can be understood and anticipated about the condition and future for critical zones and biomes such as coasts, tropical forests, or polar regions?

*Global Development* – This theme seeks to provide the knowledge for sustainable, secure and fair stewardship of biodiversity, food, water, health, energy, materials and other ecosystem services.

Example research questions include:

- What are the patterns, trade-offs and options for equitable and sustainable use of resources, and how can we ensure sustainable access to food, water, land, clean air, energy and materials for current and future populations?
- What are the implications of climate change for food, water, health, human settlements, and ecosystems? How can climate services and disaster risk reduction reduce these impacts and facilitate adaptation?
- What are the links between biodiversity, ecosystems, human wellbeing and sustainable development?
- What options are available to provide energy for all with reduced environmental impacts, and what are the social implications of these energy choices?

*Transformations toward Sustainability* – This theme focuses on understanding transformation processes and options, assessing how these relate to human values, emerging technologies and economic ideas, and evaluating strategies for governing and managing the global environment across sectors and scales.

Example research questions include:

- How can governance and decision-making be aligned across different levels, issues, and places to manage global environmental change and promote sustainable development?
- Can emerging technologies provide viable solutions to global environmental change and promote sustainable development? How can technology and infrastructure choices be combined with changes in institutions and behaviors to achieve low carbon transitions, food security and safe water?
- How do values, beliefs and worldviews influence individual and collective behaviour to more sustainable lifestyles, patterns of trade, production and consumption? What facilitates deliberate transformations at the individual, organizational, and systems levels; what socio-political and ecological risks does it entail?
- What are the longer-term pathways towards sustainable urban futures and landscapes?
- What economic systems and measures are required to foster transformations for sustainable development?
- What are the implications of efforts to govern and manage the Earth system for sustainability for scientific observations, monitoring, indicators and analysis? What science is needed to evaluate and assess policies and facilitate and legitimate transformation?

The research themes will function as major integrating units under Future Earth, each hosting a collection of existing as well as new, co-designed international research projects.

Each research theme calls for collaboration across a range of research areas and disciplines, yet links to critical areas of disciplinary expertise. For example, an integrated understanding of environmental and social trends in the Anthropocene will require research contributions from a wide spectrum of disciplines, such as atmospheric and ocean sciences, hydrology, geology, ecology, biogeochemistry, economics, geography, sociology, anthropology, environmental ethics and engineering.

## ***Crosscutting Capabilities***

The ICSU-ISSC Visioning project and the Belmont challenge identified several core capabilities needed to respond to the grand challenges of global environmental change including modeling and observations. The Future Earth Transition Team has identified additional cross cutting capabilities needed to advance the science of global environmental change and translate it into useful knowledge for decision making and sustainable development. Many of these capabilities lie beyond the boundaries of the Future Earth initiative, residing in national and international observing systems, modeling centers, training programs, and disciplines.

The proposed research themes for Future Earth critically depend on access to these capabilities such as observing networks, high performance computing, Earth system models, theoretical frameworks, data management systems and research infrastructures; appropriate arrangements need to be made to enable access. Future Earth science might place new demands on existing systems or might contribute insights and ideas about how existing platforms could be enhanced or all together new systems be established. Cross cutting capabilities may provide fruitful opportunities for workshops and collaborative research plans, and for bringing and training new groups of researchers into international global change research. Proposed crosscutting capabilities, that might be advanced through collaborations and workshops, include:

- *Observing systems*

Future Earth research requires access to a sustained capability to observe changes across the Earth system, to discover unknown relationships, and to drive Earth system models.

- *Data Systems*

Future Earth will need access and will bring large volumes of diverse environmental or social data together.

- *Earth system modeling*

Future Earth will depend on access to state of the art Earth system and integrated assessment models and will contribute to a next generation of models that better capture the dynamics of human-environment interactions, feedbacks and thresholds in the Earth system.

- *Theory development*

Future Earth will need to engage with theoretical debates, drawing from a wide range of disciplines, on how natural systems function and on the fundamental explanations of social, economic and political behaviour and institutions, to the extent that these debates influence approaches to research, provide insights and solutions and encourage or prevent collaboration across disciplines.

In addition to these crosscutting research capabilities Future Earth will prioritize :

- *Synthesis and assessments*

Future Earth projects will be asked to consider how their results will contribute to key assessments at national and international levels and to respond to the research gaps and agendas that have been identified in assessments

- *Capacity development and education*

Future Earth projects will involve a degree of capacity building that will train researchers in new techniques, involve early career scientists and students, and support stakeholders in developing their abilities and contributing to the training of researchers.

- *Communication*

With knowledge exchange as one of its pivotal functions, Future Earth will deliver a step-change in making research more useful and accessible to decision makers in business, government and civil society.

- *Science-policy interface and interaction*

Future Earth will co-design research with the users of that research and connect research to decision making, promoting the evolution and delivery of collaborative research agendas and knowledge that emerge from sustained engagement.