



A vision for integrative global-change research for a sustainable future

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Introduction

IGBP's vision is to provide essential scientific leadership and knowledge of the Earth system to help guide society onto a sustainable pathway during rapid global change.

For over 20 years, the International Geosphere-Biosphere Programme has assembled overwhelming evidence of the unprecedented scale of changes to Earth's most important biological, chemical and physical, processes. The pace of change has accelerated since the 1950s. A growing population, exponential resource use and rapid industrialisation are responsible for most of the global changes and strongly influence others. The planet's human population is set to hit nine billion by 2050.

The world's decision makers require information urgently on how the Earth's social, ecological and physical systems are linked, how they are changing and what sustainable solutions can be applied. The reason for the urgent need for this new knowledge is threefold: humans are now the prime driver of change on the planet; population growth is set to continue upwards putting increasing pressure on food, energy and water supplies; and, there is evidence that society is pushing the planet's climate and other critical physical processes towards thresholds. If these thresholds are crossed, society risks planetary-scale and regional-scale state changes with a potential to cause large-scale economic and ecological disruptions and unprecedented humanitarian challenges.

Earth system: the planet's interacting biological, chemical, physical and socio-economic processes.

A sustainable future for the planet and an end to poverty are the overarching challenges for society, as recognised by the Millennium Development Goals. To date, knowledge of how to meet the challenges remains limited. The knowledge that does exist could be used more widely and more effectively. In addition, a complete understanding of how the Earth system works, including human interactions within the system, remains an elusive but essential target if we are to achieve genuine sustainability.

IGBP's sponsor, the International Council for Science (ICSU), recognises that the international research community needs to fundamentally transform the way it defines and carries out global-environmental-change research. This transformation is an essential part of a much wider societal transformation towards global sustainability and poverty eradication.

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ICSU is developing an ambitious ten-year programme of global sustainability research to contribute to this transformation. Driving this programme are five grand challenges the international scientific community must address.

1. Improve the usefulness of forecasts of future environmental conditions and their consequences.
2. Develop the observation systems needed to manage global and regional environmental change.
3. Determine how to anticipate, avoid and cope with dangerous global environmental change.
4. Determine what institutional and behavioural changes can best ensure global sustainability.
5. Develop and evaluate innovative technological and social responses to achieve global sustainability.

In light of new and emerging challenges, IGBP is updating its strategic vision. It must move from global-environmental-change research to a focus on global sustainability research. IGBP's contribution is centred around its strengths in two key areas: knowledge of Earth's biogeochemical cycles; and the links between Earth's major cycles, ecosystems and humanity. The first three grand challenges relate closely to IGBP's existing research strategy. Indeed, IGBP along with other international global-change partners have coordinated and strategically driven these areas of research for more than 20 years.

Vision

The **vision** of IGBP is to provide essential scientific leadership and knowledge of the Earth system to help guide society onto a sustainable pathway during rapid global change.

In the next ten years, IGBP, **working with our partners**, will provide the knowledge, expertise and coordination to identify and assess risks posed to society and ecosystems by major changes in the Earth's biological, chemical and physical cycles and processes, and communicate this to society.

IGBP will seek deeper understanding of the links and feedbacks between Earth-system processes, with a focus on socio-economic forcings. IGBP will actively promote a new era of inter- and trans-disciplinary research and will work with relevant partners to support solutions to societal transformation.

IGBP will work with international partners and funding agencies to develop research priorities and co-design projects and initiatives.

IGBP will help coordinate and deliver the Earth-system observation systems required for greater understanding. IGBP will work to ensure Earth-system data is stored effectively and that data is freely available.

It is recognised that no single country has the research capacity to answer the most urgent questions in sustainability and global environmental change research. But, global environmental change will affect all countries to some degree. Since its inception in 1987, IGBP has provided the vision to enable effective and coordinated research across national boundaries and traditional academic disciplines. It has achieved this by developing ambitious, policy-relevant and far-reaching research agendas and mobilising

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a coordinated network of over fifty national committees, scientific committees and international project offices.

IGBP's strengths are its vision, its global perspective and its truly international reach. The results of its vision and approach have been widely recognised. An independent review of IGBP published in 2009 concluded, "The success and recognition of the Intergovernmental Panel on Climate Change and the Millennium Ecosystem Assessment both owe a huge amount to the work of IGBP."

The word "Anthropocene" first appeared in IGBP literature. IGBP's first synthesis, *Global Change and the Earth System* (Steffen *et al*, 2004), marked a pivotal shift in people's perceptions of their relationship with the planet. The synthesis provided stark evidence that, on a planetary scale, humanity's actions are unsustainable. Since 1987, IGBP has moved from a research strategy focusing on disciplinary science, to an Earth-system view, and now to an Earth-system view that connects to policy decisions.

Part of IGBP's success lies in its concept of the Earth as a complex system with human society and the environment intrinsically linked. The concept of a human dimension to the Earth system is now highly regarded as a powerful way to analyse problems and identify long-term sustainable solutions to society's most pressing challenges.

Effective development of this concept requires successful interdisciplinary and trans-disciplinary approaches. **IGBP, as part of the Earth System Science Partnership, has pioneered many of these approaches.** But IGBP recognises that it must develop further, and with renewed vigour, to work with others to break down the traditional walls between scientific disciplines and between science and policy.

Moreover, guiding society's shift to a sustainable model requires unprecedented international cooperation that needs to be informed by a visionary and integrative science agenda. It is in this context that IGBP is updating its ten-year strategic vision.

IGBP's grand challenges and research questions

The global challenges for the IGBP research community are:

The planet: increase fundamental knowledge of the Earth system and how it changes.

The planet under pressure: increase knowledge of how humans affect the Earth system, how the system will respond, and potential consequences for global cycles, ecosystems and people.

Transformation in an era of rapid global change: provide relevant and timely information to decision makers that will contribute towards sustainable solutions.

Through IGBP's expertise, coordination and communication, the scientific community has already made substantial progress in many of these areas, particularly on the fundamental research required to understand the Earth system. **The new vision provides a step process to allow basic research to flow through to applied research, from science through to policy.**

The planet

How does planet Earth function as a complex adaptive system?

Priorities

- How are Earth's ecosystem processes, society and biogeochemical cycles linked, and how will they behave in the future?
- What and where are the boundaries, tipping elements and thresholds in the Earth system?
- How are Earth's marine, terrestrial, atmospheric and cryospheric systems linked?
- What global observation systems are needed to monitor the natural and socio-economic systems?

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- What are the limitations when attempting to predict the behaviour of complex adaptive systems?

The planet under pressure

How is human activity affecting Earth's biogeochemical cycles? And, how are Earth-system changes affecting society?

Priorities

- What are the critical social-ecological tipping points and thresholds in the Earth system functioning?
- How do social and ecological systems interact?
- What ecosystems are most at risk?
- What significant environmental changes are likely to result from human actions?
- How will global environmental change affect human well-being?
- How can society adapt to and mitigate global environmental change?

Transformation in an era of rapid global change

How can new and existing global-change research findings most effectively inform, catalyse and support appropriate actions at all governance scales, local, national, regional and global?

Priorities

- How can IGBP science be more tailored towards sustainability and poverty eradication?
- What are the plausible scenarios for addressing climate change and more widely, global environmental change?
- How can resources be managed sustainably in an Earth system context? What are the barriers to achieving this?
- What changes would contribute most to improving global sustainability?
- What is the effectiveness of mitigation and adaptation strategies and what are the impacts on social-ecological systems at local, regional and global scales?
- What are the Earth-system consequences of the most plausible potential geoengineering schemes?

Communications

Scientists

The international global-change programmes need to develop stronger global networks of both researchers and their institutes. IGBP must develop, strengthen and expand its network, and encourage greater participation from developing-world researchers. The programme must make more use of the latest technological networking tools to achieve this.

Decision makers

For two decades, IGBP has successfully engaged with the key international environmental assessments. But, the links between research and policy are not as strong as they need to be at all scales, local, national, regional and international. This needs to be addressed. IGBP has good links with major international organisations involved in policy, including UNEP, UNESCO, UNFCCC and the Commission for Sustainable Development (through links to the 2012 Earth Summit and previous Earth Summits). But limited engagement with many of the major international actors that can bring about economic and social change, for example WTO, IMF and the World Bank. IGBP can build stronger international networks outside of the immediate research community and find new ways of communicating with

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stakeholders. IGBP will work with ICSU to develop closer relationships with key international organisations.

The world

Two decades of research from IGBP and many other research programmes has provided ample evidence that society must move to a more sustainable model. Communication of global-change research must inform, inspire and motivate people and institutions to change. For more than 20 years, IGBP has successfully developed and maintained a large network of scientists; it has strong mechanisms for informing international policy through the Intergovernmental Panel on Climate Change and other assessment processes; and its work is published in the world's leading journals. But, the speed and scale of global-change needs to be communicated to a much wider audience. IGBP will develop strategies to raise the profile of its research, for example through the Rio Earth Summit in 2012, a new more interactive website, publications, other UN routes and other activities that will aim to inform, inspire and engage the wider world in a dialogue.

Communication objectives

Do decision-makers and society at large perceive global environmental change to be a real and imminent threat to human well-being and sustainable development? What strategies could be employed to overcome obstacles and inertia?

The IGBP secretariat will:

- Help IGBP communicate more effectively to regional, national and local stakeholders
- Develop new products to help IGBP science be used more effectively by those involved in the sustainability challenge
- Work out ways for the global-change research community to reach a much broader audience
- Develop new products that will be useful to a wider audience and speed societal transformation

Implementing the vision

IGBP must remain a flexible, responsive organisation. The strategic vision will adapt to changing conditions and new information.

To implement this vision IGBP will work with international partners and funding agencies to develop research priorities and co-design projects and initiatives.

Continued development of this strategic vision will take into consideration the ICSU visioning process for Earth-system science, the Belmont Challenge and the ongoing related work of all ICSU's global-change programmes, other strategic partners and the wider research community. To address these key inter/trans-disciplinary issues, IGBP will need to build on its strong disciplinary foundation and reach out to a broad community. The involvement of stakeholders in all stages of research – from inception to implementation – will ensure that the approach is relevant. IGBP, ICSU and all relevant partners will need to develop a structure able to support this new vision.

Research needed to address the issues highlighted above will require substantial improvements in monitoring the evolution of interacting physical, chemical, biological and social systems at different spatial and temporal scales. It will also require better prediction of the evolution of the Earth system and consensus on the best practises for ensuring sustainability. IGBP will need to continue to develop its ongoing dialogue with its partner programmes and other stakeholders in its quest, including clear and timely two-way communication of results and needs. In doing so, it will inevitably need to find ways of stimulating science-based decision-making.

Part of implementing the new strategy will be prioritising our work. IGBP's process to develop its priorities for the next decade works along three parallel and interlinked strands:

1. Synthesis

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2. ICSU vision/Belmont challenge
3. Earth summit/Open science conference 2012

Synthesis

IGBP's first synthesis was a landmark achievement in global-change science. Its influence has gone far beyond the boundaries of the Earth system science research community.

IGBP is now undertaking a second major international synthesis of key policy-relevant areas within global-environmental-change research with a view to providing a snapshot of the state of the Earth. The synthesis will help IGBP prioritise its work in the coming decade by indicating gaps in knowledge.

The synthesis topics were selected by IGBP's scientific committee with input from key stakeholders, including other international research programmes and the Intergovernmental Panel on Climate Change. The topics will cover research under IGBP's core projects, joint projects and beyond. This initiative will help identify gaps in our knowledge of the Earth system and contribute to a baseline for international research and policy in the area of global environmental change in the coming decades.

The synthesis topic leaders are currently putting together working groups made up of scientists from many disciplines (natural and social sciences), as well as policymakers and other stakeholders. Findings of the activity will be communicated via a range of products, including peer-reviewed publications and summaries for policymakers.

Synthesis themes

- Earth-system impacts from changes in the cryosphere
- Megacities in the coastal zone
- Global environmental change and sustainable development: needs of least developed countries
- Geoengineering impacts
- Nitrogen and climate
- Acting on adaptation to global environmental change
- The role of changing nutrient loads in coastal zones and the open ocean in an increased-CO₂ world
- Impacts of land-use-induced land-cover changes on the functioning of the Earth System
- Air pollution and climate
- Changing aerosols in the Earth System

ICSU vision/Belmont Challenge

In 2009 and 2010, IGBP contributed to developing the ICSU vision and Belmont Challenge (the latter led by the US National Science Foundation and the UK Natural Environment Research Council). These two complimentary processes have set out the challenges to the international research community in the coming decades. IGBP's specific niche lies in understanding Earth's biogeochemical cycles and their interfaces with social systems. For twenty years IGBP has begun bridging the gap between natural and social science communities. IGBP will strive for ever closer integration.

Earth Summit and the Global Change Open Science Conference

In May 2012 the UN will hold the next "Earth Summit" in Rio. The themes of the Earth Summit are: emerging issues, the green economy and institutional frameworks for sustainable development. The international global-change research community will provide a high-profile contribution to the Earth Summit through the 2012 London Global Change Open Science Conference. This conference has been driven by IGBP and our global-change partners.

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The vision is for a conference that brings together leading social and natural scientists, to create a new understanding and environment for tackling global sustainability challenges. Working across scales will be a strong theme for the conference. The event will include strong policy interaction. The programme will be designed to attract not only the scientific community, but also policymakers, industry, health specialists, and many others. Scientists will be encouraged to discuss options and solutions.

The scientific community will stress that there must be many governance and technological solutions at many scales, from local and national, to regional and global. It will stress that while there are many threats, global change also provides many opportunities.

The London conference will act as a platform to strengthen and enlarge the global-change research community and mark a move to a new vision for global-change research.