

Blue Oceans, Green Cities

UK Research priorities in global change research

This workshop was a contribution to UK Future Earth, organised under the auspices of the Royal Society's Global Environment Research Committee (GERC). It was held at The Kavli Royal Society International Centre, Chicheley Hall, on 27-28 October 2016. The Steering Group consisted of Professors Eric Wolff FRS (chair), Frans Berkhout, Karen Heywood, and Tim O'Riordan FBA. Professors Dani Schmidt and Tim Jickells convened and reported respectively on the oceans breakout, while Professor Gareth Jones and Dr Eszter Kraznai Kovacs took these roles for the cities group.

The aim was to bring together an interdisciplinary group, consisting of both practitioners and stakeholders to address:

- UK interdisciplinary research priorities in global change research
- How the UK global change research fits into the wider international sustainability /environment agenda
- How the Global Change Research Fund (GCRF) could help deliver this international research agenda.
- Finding pathways and solutions for UK society, government and other stakeholders, and identifying additional relevant themes questions and partners

The topics of oceans and cities were chosen to reflect two of the topics highlighted as priorities by Future Earth through their Knowledge Action Networks (KANs). Just over 40 invitees attended, split between those with a primary interest in oceans and in cities. Strenuous efforts were made to include, for each topic, practitioners from each UK academy (Royal Society, British Academy, Royal Academy of Engineering and Academy of Medical Sciences) as well as representatives from industry and commerce, funding agencies, government and civil society, and early career researchers.

The meeting provided an excellent opportunity to compare and integrate across disciplines. Given the differences in language and approach, this is not an easy task, but good progress was made, and participants certainly left with an increased understanding of the wider complexities around the topics. Some of the research topics identified are expressed in a much broader context than is usually the case, emphasising the synergy between global change "issues" and approaches to solving them. They would certainly warrant serious consideration for funding across research councils or by the GCRF, and we intend to disseminate the ideas widely.

Despite excellent input from the few non-academic attendees, the meeting was rather less successful as an exercise in co-design with funders and end users. We concluded that this style of meeting, with an open-ended agenda, is not attractive to many stakeholders, who each have specific topics they want to address with a more targeted group. Although it seems somewhat at odds with the underlying philosophy, it appeared that a tiered approach to co-design would be more successful. This implies that further workshops of this sort should concentrate on interdisciplinarity, but seek to inform or benefit from a parallel or sequential process of discussing specific topics with selected stakeholders. As an example, in late spring there will be a meeting with the reinsurance industry to address some of the issues raised.

In the remainder of this report we present the conclusions of the two breakout groups (oceans and cities) who were tasked with finding and describing a small number of actionable interdisciplinary research topics that might be attractive to funding agencies.

Blue Oceans

The group discussed research priorities and knowledge gaps in the broad oceans area. The goal was to identify issues that can

- be addressed by the UK research community in an interdisciplinary manner,
- yield results of value to society and help the UK and the global community,
- address the UN Sustainable Development Goals (SDGs), and
- sustain the ecosystem services we derive from the oceans.

The timescales of interest were set at 10-50 years. We aimed at integrating the many scientific and societal interests into a systems approach and focused on a few broad themes which are briefly discussed below. While defining these themes we also noted the inter-relationships between them.

1. **Coastal Cities.** Human populations are growing and also migrating to coastal cities. This leads to increasing pressures and vulnerabilities within and around these conurbations, many of which are directly related to the oceans, such as issues of food supply, trade and commerce, flooding, pollution, waste disposal, harmful algal blooms, rising sea levels, sinking deltaic sediments, waste discharges, and human health. We suggest that there are novel and exciting research areas to explore between marine and urban scientists in collaboration with civil society, commerce and governments on how to manage some of these issues and their changing importance over the next decades in specific locations. Co-producing robustly managed and equitable cities of the future requires analysis and modelling of the interplay between biophysical and socio-economic systems in the specific context of coastal cities.
2. **Sustainable management of shelf sea systems.** Shelf sea systems are under multiple pressures from the increasing societal activities around them which affect their biodiversity and ecosystem services for other organisms, biogeochemical cycles and humans. These pressures range in scale from
 - those acting primarily at a global scale (such as sea level rise, ocean warming, and ocean acidification),
 - through those arising from within the catchment of the coastal system, which may extend for 1000s of km in some cases (such as nutrient and sediment run off from agriculture),
 - to the impact of activities within the coastal systems themselves or immediately adjacent to them. Activities such as offshore extraction of minerals and energy, including renewables, and waste disposal (including novel pollutants and pharmaceuticals) have impacts on food supply, recreation, visual and noise environment, and health.

The research challenges include trying to quantify the multiple impacts at various scales including the synergies and trade-offs between them in the context of management and governance tools.

The challenge will be to manage, locally and regionally, issues which may be driven globally.

Governance questions around the management of shelf sea systems reflect the multiple stakeholders and jurisdictions with interests in these areas and the fact that water flows may cross these man-made boundaries leading to transboundary resource and pollution issues. Management and governance systems also need to ensure the resilience and sustainability of the coastal systems while addressing equity, resilience and vulnerability for the many stakeholders involved. New observing systems, including those that integrate global and local observations, offer great opportunities to support management in these areas. However, we need to have the process understanding in both the natural and social science to apply this information in problem-solving and to understand the relevant space and time scales on which the multiple pressures act and interact.

3. **Heterogeneity of impacts/hot spots.** Managing anthropogenic impacts on the coastal to open ocean presents a challenge to science, society and business. The differing motivations of these three sectors, and the traditional separation of scientific research focussed on particular pressures, leaves society generally poorly equipped to deal with multiple interacting pressures. Not all global change pressures are exerted equally in all regions. Indeed some pressures have very little impact in some areas, but represent a major threat in others. Regional differences in hotspots and bright spots of pressures and impacts require a particular focus of attention regionally and locally, within a systematic whole. We suggest that developing visualisations (such as maps and other media) to describe these multiple pressures at scales that are appropriate to managers and relevant governance structures (which may range from an individual estuary to an entire sea) would be valuable. Co-designed with users, these systems could be of considerable societal benefit, and encourage a focus on actively managing the key challenges appropriate for that area within wider management strategies. Such visualisations are challenging to create and sustain and this represents a major research challenge. However, developing computing power and new ways to deal with the relevant “big data” (which will range from physical data through to social science data) offer an opportunity to now undertake this timely task.
4. **The Blue Economy.** There are many opportunities for the development of economic activity within the marine environment including transport, commerce, food supply, recreation, mineral resources and non-fossil energy production. The research challenge is to develop effective ways to harness these benefits while equitably maintaining the resilience and sustainability of the marine environment and its existing services in terms of food supply, biodiversity and human health. We have complex governance arrangements for the open ocean in which to consider new and substantial pressures including mineral extraction (for oil, gas and metals) increasing global shipping and open ocean and deep water fishing. Beyond internationally agreed national jurisdictions, and subject to a fragmented set of environmental and security agreements, the open oceans represent a global, interconnected physical and biological system. Experts in marine science and governance need to work together to develop new and effective ways to allow appropriate exploitation of marine resources while maintaining the sustainability of the entire marine system.
5. **Food supply.** Marine systems provide a major source of global food and in some regions this food is the main source of protein for people. Over recent decades this supply has changed from being dominated by wild food capture to an increasing importance of aquaculture, a trend projected to increase further. This aquaculture currently requires a wild fish harvest and robust coastal natural capital. Fish and shellfish are increasingly traded commodities particularly those with high commercial value, while poorer communities utilise less high value, and potentially less nutritious, marine derived foods. Climate change is projected to cause significant fish migrations and while large scale fishing fleets may move with the fish, local poorer fishing communities cannot. Shellfish production is projected to be impacted by ocean acidification. The logistics of supplying marine foods where they are needed has implications for other issues that Future Earth highlights, such as the sustainability of cities and emissions from transport on land and across the ocean. Patterns of change related to marine food supply are driven overwhelmingly by commercial and consumer pressures. The research challenge is to understand the overall impact of these changes on the marine system over the next few decades. This will allow development of appropriate management strategies for sustainable management of the ocean while at the same time providing food and employment for coastal dependent communities.

Green Cities

This section aims to capture research and policy-relevant challenges for urban areas, especially with respect to the Future Earth initiative, upcoming GCRF calls, and strategies to meet the UN SDGs. To be green, cities must enable the wellbeing and prosperity of citizens, while minimising impact on the outside (e.g. hinterland, coast, rivers). Achieving this requires consideration of numerous biophysical and socioeconomic influences, including air quality, sustainable and free-running transport, energy and food supply, health, changing economic and employment practices induced by technology and IT, demographics and governance. In deriving a set of research questions and in order to identify opportunities for future engagement, the group kept coming back to the following generic points:

- what is the 'research base' in cities and sustainability in the UK?
- who are the relevant stakeholders when it comes to urbanisation – whose identification and inclusion in dialogue and research development are crucial for the purposes of genuine *co-production* and engagement in research and beyond?
- how to conceptualise the 'urban' as a process, recognising the range of urban forms and identities depending on geographical and socio-economic context, the dependencies of cities on rural hinterlands, and the need for comparative analysis,
- how to reveal the "manageability" of governance for major metropolitan complexes in the face of immigration, cultural mixing, and changing nature of vulnerability and resilience to physical and health hazards, both climate related and directly human caused, and
- how to treat normative assumptions about the 'city', to question the objectives for urban intervention and consider who such interventions are designed for. How different would critical engagement, research questions and processes be if we "started from the South" and did not take a Northern city as the 'norm'?

Discussion was wide-ranging, reflecting the many disciplinary and interdisciplinary interests of those present, the emphasis on more and less applied research, combinations of quantitative/qualitative approaches, and interests in cities at different scales in both global South and North. Three clustered themes emerged:

1. **Data for urban design: Co-producing dynamic and sustainable cities**

Questions surrounding data – its forms, integration possibilities and potentials, the extent to which data scarcity constrains or enables urban planning and interventions are a major theme in urbanisation research and application. Data is a key requirement for future city development, enabling better management of complex urban systems, while empowering citizens to change their practices so as to co-design the way cities operate. The explosion of geo-spatial, market, consumer, health and social data is linked to the emergence of Smart Cities initiatives, which offer the prospect of collaborations between researchers business, policymakers and society. There was general consensus that genuine moves to trans- and inter- disciplinary data gathering and integration leading to action were scarce, but necessary. As an example, health issues require economic and experiential data synthesis. There is currently a dearth of systematically-designed research programmes with baselines, monitoring and evaluation pre- and post- interventions in different settings over long time periods. Citizen science and community monitoring are seen to have enormous potential here, particularly as a means for enrolling public support for research and as a mode of co-production. There is real scope for this approach with regard to public health generally but especially public health amongst poor and disadvantaged residents, to pollution incidence and control measures and to devising low carbon infrastructures.

2. **Cities as ‘natural experiments’: Development through a people-based urban agenda**

Cities are systems that evolve and expand even in the absence of purposeful interventions, with identifiable flows and metabolic processes. There is enormous scope to investigate the ways cities change through the preferences, practices and choices of citizens. This is a complementary perspective to the conventional view of cities as systems planned and managed by city authorities. Technology and culture (including the emergence of business models such as Amazon, Uber and Air BnB) are shaping the mobility, economic opportunities and environmental quality experienced by citizens, and the resource, ecological, health and security profile of cities. What can we learn about cities by seeing them as the outcome of an interaction between planning, innovation and emergent practices?

Critical engagement is required with the term ‘co-production’, as it may require holistic engagement with stakeholders combined with non-prescriptive research and intervention formulations. This recognises that research questions will be contextually sensitive to needs and geographies, particularly between cities of the global ‘South’ and ‘North’. It is also vital that people whose wellbeing is not visible because they are not ‘connected’ or online, need different engagement strategies, as they risk being ignored as stakeholders in cities.

3. **Cities at ecological edges**

Coastal cities and others on geographical “edges” are places where infrastructure meets a natural boundary such as the sea: sites where political, economic and ecological processes can be studied at multiple (local to global) scales. Which cities will be most affected by global environmental change? How will this affect trade, investment and commodity chains as well as local environment? In turn, how does the environment beyond the city (e.g. ocean) influence the cultural, social and economic evolution of the city? Urban studies have not to date focused on coastal cities and their unique economic, social, political and environmental position. A starting point would be a cross-disciplinary review of coastal cities.

A second style of ecological edge is that where growth is so fast that it outstrips interventions designed around yesterday’s city. Therefore a second urgent focus for systematic experimental design application was seen to be those urban areas where change (in terms of population numbers, density and environmental impact) will be rapid and high.

Finally, we summarised core themes and ideas. Two questions emerged for future discussion:

1. **What is the evidence required for social and environmental interventions to design equitable cities through co-production?**

To explore this question, the group again focussed on Coastal Cities (to tie in with the Blue Oceans group) and Cities on Ecological Edges, experiencing rapid change. ‘Evidence’ is seen as a promising point of departure for challenging conventional policy-making processes – the group discussed what evidence base is needed for decision-making, not only in Government, but in business and by citizens. How is this evaluated? What qualifies as evidence in different contexts? Who gets to decide? Does evidence re-affirm traditional decision-making pathways or open new ones? Who do decision-makers become when we ‘make’ data unconventionally?

2. **Are cities an appropriate unit of measure to assess progress towards the SDGs?**

SDGs represent a shared framework for setting out sustainability goals and for understanding trade-offs between them. They are also a good point of departure for research and action at the city-scale. At present, the SDGs have been set out as global and national goals and targets, but there is significant benefit to developing ways of translating these to the city and neighbourhood scale.