Gordon McBEAN*

SCIENCE AND TECHNOLOGY FOR A SUSTAINABLE FUTURE EARTH

Abstract: Climate change, disaster risk reduction, poverty eradication, social and economic sustainable development are interconnected issues that must be addressed in the development of policy. In 2015, governments agreed on goals and targets and a key issue is how can science best provide the inputs to these policy processes and more importantly to help governments and people address the issues? The Programme Future Earth: Research for Global Sustainability has as its goal: „To provide the knowledge required for societies in the world to face risks posed by global environmental change and to seize opportunities in a transition to global sustainability". Future Earth and the World Climate Research Programme are linked, through the International Council for Science (ICSU), to the Integrated Research on Disaster Risk and Urban Health and Wellbeing Programmes to collectively address the challenges of bringing together interdisciplinary and transdisciplinary teams of scientists to undertake transformative research leading to outcomes that make a difference for global sustainability.

Key words: *climate change, disaster risk reduction, urban environment, sustainable development, science for policy, Future Earth*

INTRODUCTION

As we look ahead to the future, there are many science, technology and society policy issues that need to be considered. These include: poverty; food, health; security in the broad sense of the word; cities and, in general, urban issues; migration, both voluntary and involuntary; biodiversity; sustainable development on local to global scales and over decades to potentially millennia; disaster risk reduction and climate change. The year 2015 was a crucial year for the international policy agenda with the Third UN World Conference on Disaster Risk Reduction (WCDRR) and the ensuing Sendai Framework on Disaster Risk Reduction [1], United Na-

* President, International Council for Science,
Co-Chair, Governing Council, Future Earth,
Western University, London, Canada

tions Sustainable Development Summit and ensuing Agenda 2030 and Sustainable Development Goals (SDGs) [2], COP-21 of the UN Framework Convention on Climate Change and its Paris Climate Agreement [3] and the International Conference on Financing for Development [4]. To address these issues, there is need for integrated information on these topics and related issues. As we look ahead for the next decades, there is need for recognizing the responsibilities of global science to contribute to post-2015 frameworks, including the Sendai Framework, Agenda 2030, Paris Climate Agreement and the upcoming urban agenda at Habitat III Conference. It is important to note the 17th of the Sustainable Development Goals: *Strengthen the means of implementation and revitalize the global partnership for sustainable development*. To achieve these goals and targets it is important to develop fully global science capacity so that science benefits of all societies and „leaves no scientists behind". Recognizing the theme of this Conference, it is imperative to develop the abilities to project ahead technologies and societal changes to „*see the future*" for Sustainable Development.

SUSTAINABLE DEVELOPMENT

Sustainable Development [5] is defined as: „*Humanity has the ability to make development sustainable — to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*". A principal key part of the sustainable development is the linking of social, economic, technology, science and environmental issues and connecting the future with the present. It essentially leads to science-informed decision making. This clearly relates to the theme of this conference of „*Technology + Society =? Future*". There are major issues of sciences and policy in how to „*see the future*". The fundamental concept of the Science and Technology in Society Forum [6], held annually in Kyoto, Japan, is: „*The explosive progress of science and technology up to the 20th century brought prosperity and enriched the quality of life for much of mankind. However, the advance of science and technology raises important ethical, safety and environmental issues: possible negative applications are threatening mankind's own future. Since progress in science and technology is expected to accelerate and will be necessary for sustainable human development in the 21st century, wisdom must be exercised to keep it under proper control. In that sense, the most pressing problems we face today include harmonizing economic development with global warming; preventing terrorism; controlling infectious diseases; and assessing the potential health benefits and ethical factors relating to cloning technology. International efforts to address these problems are needed now more than ever. This is really what symbolizes the „lights and shadows of science and technology." Opportunities need to be taken, but the risks must also be controlled. Health, meeting energy needs, and many other aspects of human welfare are dependent on continued progress in science and technology.*" The sense of the „*lights and shadows of science and technology*" is very important and an important challenge is identifying in advance both the lights and shadows.

The Global Risks Report 2016 [7] is published by the World Economic Forum, within the framework of The Global Competitiveness and Risks Team and is based

on information obtained from experts around the world. Global risk is an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years. Risks are ranked based on impacts, from low to high, and likelihood, also low to high. The highest likely risk was judged to be „*Large-scale involuntary migration*" with „*Extreme Weather Events*" next. The highest impact risks were: „*Failure of climate change mitigation and adaptation*" with „*Water crises*" next. „*Large-scale involuntary migration*" was the next highest in terms of impact. From the overall point of view of high impact, high likelihood risks, the environmentally related issues of failure of climate change mitigation and adaptation, water crises and extreme weather events are very important risks. Large-scale involuntary migration also links to environmental issues as well as other issues is also very important. The Global Risks Report 2016 draws attention to ways that global risks could evolve and interact in the next decade. The report notes that the year 2016 marks a forceful departure from past findings, because risks that they have been warning of over the past decade are starting to manifest. *Warming climate is likely to raise this year's temperature to 1° Celsius above the pre-industrial era* is one issue among several and the *Report calls for action to build resilience — the „resilience imperative*" — and identifies practical examples of how it could be done.

The roles of science and technology policy and application need to be to reduce the Impacts and the Likelihoods through better „solutions" to the risk issues and, importantly, to examine and activate in a positive way the societal roles. For this, it is necessary for the global communities to better communicate and globally connect.

SEEING THE FUTURE — PREDICTION

Prediction is used across the natural, environmental, social and economic sciences [8]. The Oxford Dictionary defines the verb to predict as to „*foretell, prophesy*". The noun forecast is defined as: „*conjectural estimate of something future, especially, of coming weather*". Conjecture is the „*formation of opinion on incomplete grounds*". We can use the definition [9] „*Prediction is a statement or claim that a particular event will occur in the future. Narrowing the sense of prediction it may be added that the place and time of event are known as well.*"

The sense of estimate, future and incomplete information is certainly consistent with the sense of prediction of natural and human systems. Prediction is the process of looking ahead on the basis of incomplete knowledge of the present and with incomplete understanding of how the system works; the process is not simple. For some natural science issues, such as the tides and related lunar orbits, there are laws of physics that relate the present state to the future state. When we move to weather prediction, the relationships are more complicated with the additional uncertainty in defining the present state. Projecting climate over the next century not only includes the uncertainties in the present state and the natural scientific relationships, but, more importantly actually, the actions that societies will or will not take to reduce their interference with the climate system through emis-

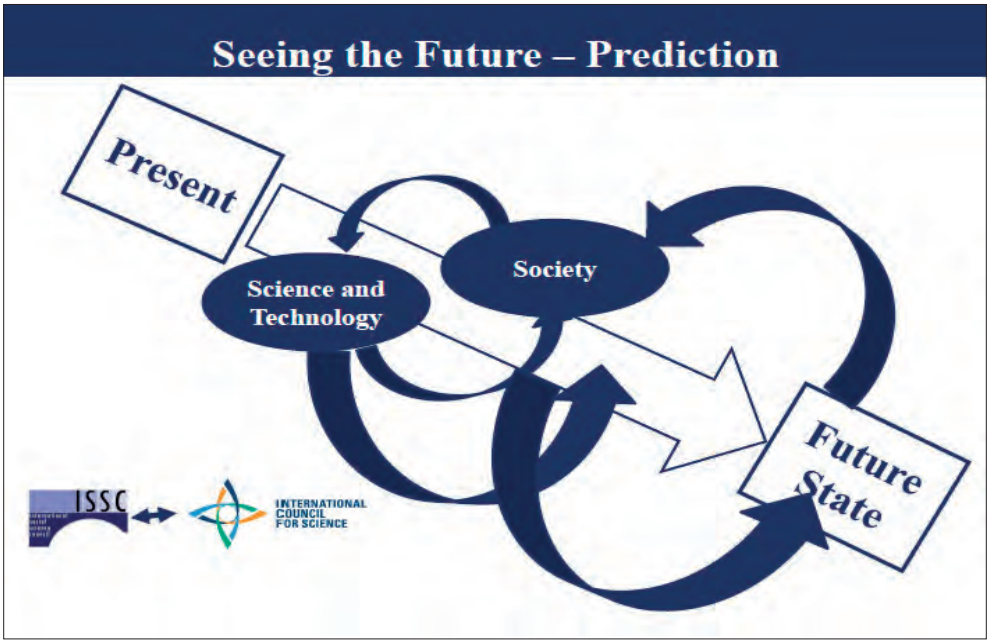

Figure 1: Prediction — „seeing" the future state from the present

sions of greenhouse gases and the changes in the conditions of the planetary surface, as examples.

As schematically shown in Figure 1, projections or predictions of future states require understanding and incorporating the implications of science and technology and society in iterative ways, recognizing that changes in technology result in changes in society and vice versa. Further, as the future state becomes clearer for a specific projection based on the „best" estimates of technological and societal changes, these may „feedback' into the societal response, resulting in the modifications to the prediction of the future state. A fundamental role of the science and technology community is to work closely with the social science community to enable the prediction of future states through an integrated, continuously iterative process of refinement to reduce uncertainty and provide the „best" estimates of futures states as well as clarification of the assumptions inherent in the prediction such that the societal processes can, when possible and appropriate, modify societal changes.

INTERNATIONAL COUNCIL FOR SCIENCE

The International Council for Science (ICSU) [10] is a leading non-governmental science organization that was created in 1931. The Council now has 120 National Members and 31 Unions or Associations of scientists by discipline. The scope of these disciplines include math, physics, chemistry, geology, biology, anthropology, sociology and the philosophy of science. The Mission of the International Council

for Science (ICSU) is „*to strengthen international science for the benefit of society*", for all societies. The vision of the Council is for a world where excellence in science (all sciences) is effectively translated into policy making and socio-economic development, with universal and equitable access to scientific data and information, where all countries have scientific capacity, enabling the generation of new knowledge and nations can establish their own development pathways in a sustainable manner. The Council's key priorities and associated activities are: Science for Policy (and policy for science*);* Universality of Science with the freedom to do science while recognizing the responsibilities of science and scientists; and International Research Collaboration.

INTERNATIONAL RESEARCH COLLABORATION

The International Council for Science (ICSU) is very involved in initiating, organizing and leading international research collaboration, often partnering with other governmental and non-governmental organizations. The International Geophysical Year (IGY) [11] of 1957 is an important early example. During the IGY, Sputnik was launched opening a new mode of „see our planet" and the systematic measurements of carbon dioxide and ozone, as two important atmospheric constituents, were initiated. Without these measurements, society would not now be able to document the changes in the stratospheric ozone layer and the greenhouse effect and project ahead the changes that are now being addressed through the Montreal Protocol [12] and the Climate Convention [13]. Recognizing the increasing societal concerns about the climate system, the International Council for Science (ICSU) and the World Meteorological Organization (WMO) joined in 1980 to create the World Climate Research Programme (WCRP) [14] with the scientific objectives: to determine: *the predictability of climate; and the effect of human activities on climate*. The underlined word, predictability and human activities — societal — link closely to the theme of this Conference. The Intergovernmental Oceanographic Commission of the UN Educational, Scientific and Cultural Organization (UNESCO) became a co-sponsor in 1992, to most effectively connect the global oceanographic community to the WCRP. By the mid-1980's, the level of international concern regarding climate change and broader issues of global environmental change, plus the discussions on sustainable development, led the International Council for Science (ICSU) to initiate the global change program, International Geosphere-Biosphere Programme (IGBP) [15] to: *study earth system science and to help guide society onto a sustainable pathway during rapid global change*. Again note the connections with Conference themes. With the increasing global concern about the climate system and possible human-caused climate change, the Intergovernmental Panel on Climate Change (IPCC) [16] was created in 1988, under the sponsorship of the World Meteorological Organization and the UN Environment Programme (UNEP) in order to: (i) assess available scientific information on climate change, (ii) assess the environmental and socio-economic impacts of climate change, and (iii) formulate response strategies. The First Assessment Report was prepared in 1990 for presentation to the 2 nd World Climate Conference which, in

turn, fed the information into the creation of the UN Framework Convention on Climate Change (1992) at the Earth Summit in Rio in 1992. The 2nd IPCC Assessment Report was completed in 1995 to provide an assessment for the Kyoto Protocol in 1997. Over the years, the scientific programs planned and coordinated by the WCRP and the IGBP have been the major source of scientific results for the IPCC assessments.

In 1992, the International Council for Science (ICSU), with one of its unions, the International Union of Biological Sciences, and the ICSU Scientific Committee on Problems of the Environment, with UNESCO, recognizing the concerns about the state of biodiversity on the planet, created the program DIVERSITAS [17], as an integrative biodiversity science, that links biological, ecological and social disciplines to address the complex scientific questions posed by the loss in biodiversity and ecosystem services and to offer science-based solutions to this crisis. In 2011, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) [18] was created as the intergovernmental body to assess the state of biodiversity and of the ecosystem services it provides to society, in response to requests from decision makers. IPBES is placed under the auspices of four United Nations entities: UNEP, UNESCO, FAO and UNDP and administered by UNEP. DIVERSITAS became one of its major supplier of scientific information. The International Human Dimensions Programme on Global Environmental Change (IHDP) [19] was established in 1996 by its two scientific sponsors, the International Council for Science (ICSU) and the International Social Science Council (ISSC). IHDP was an international, non-governmental, interdisciplinary research programme addressing the coupled human-natural system in the context of global environmental change (GEC). It fostered high quality research aimed at describing, analysing and understanding the human dimensions of GEC. Human dimensions are the ways in which individuals and societies contribute to global environmental change, are influenced by global environmental change and mitigate and adapt to global environmental change.

Recognizing the needs for research capacity enhancement in Africa and Asia, Global Change START [20] was launched in 1992 under the aegis of the International Council for Science (ICSU) and its four international global change science programs as the capacity building arm of the global change programs' work in Africa and Asia-Pacific.

The impacts of natural hazards continue to increase around the world with hundreds of thousands of people killed and millions injured, affected, or displaced each year because of disasters, and the amount of property damage has been doubling about every seven years over the past 40 years. To address the shortfalls in current research on how science is used to shape social and political decision-making in the context of hazards and disasters, the International Council for Science (ICSU) initiated the Integrated Research on Disaster Risk (IRDR) Programme [21]. The IRDR mission is to develop trans-disciplinary, multi-sectorial alliances for in-depth, practical disaster risk reduction research studies, and the implementation of effective evidence-based disaster risk policies and practices. The IRDR Programme objectives are: 1) Characterization of hazards, vulnerability and risk; 2) Under-

standing decision-making in complex and changing risk contexts; and 3) Reducing risk and curbing losses through knowledge-based actions. Attainment of these objectives through successful projects will lead to a better understanding of hazards, vulnerability and risk; an enhanced capacity to model and project risk into the future; better understanding of decision-making choices that lead to risk plus how they may be influenced; and how this knowledge can better guide disaster risk reduction. The IRDR Programme is now co-sponsored by the International Council for Science (ICSU), the International Social Sciences Council (ISSC) [22] and the UN Office for Disaster Risk Reduction (UNISDR, International Strategy on Disaster Reduction) [23].

With the increasing growth of populations in cities and the accompanying health issues, the International Council for Science (ICSU), in partnership with the UNU International Institute for Global Health and the Inter-Academy Medical Panel (IAMP) created the Health and Wellbeing in the Changing Urban Environment: a Systems Analysis Approach Programme [24] to promote systems approaches to understanding health and wellbeing in urban settings by understanding the functioning of the urban system as a whole. The systems approaches involves one or more of the following elements: 1) development of new conceptual models that incorporate dynamic relations; 2) use of systems tools and formal simulation models; and 3) integration of various sources and types of data including spatial, visual, quantitative and qualitative data. The overarching vision for the ICSU-IAMP-UNU Urban Health and Wellbeing Programme is the development of aspired levels of wellbeing for people living in healthy cities.

FUTURE EARTH: RESEARCH FOR GLOBAL SUSTAINABILITY

Future Earth: Research for Global Sustainability [25] is a major international research platform with the Goal: „To provide the knowledge required for societies in the world to face risks posed by global environmental change and to seize opportunities in a transition to global sustainability". Future Earth brings together and, in partnership with existing programmes on global environmental change, coordinated new, interdisciplinary approaches to research on three themes: Dynamic Planet; Global Sustainable Development; and Transformations towards Sustainability. DIVERSITAS, the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP) have been merged into Future Earth and the World Climate Research Programme (WCRP) is a partner. Partnerships with START and other programs are also being undertaken.

Future Earth is a platform for international engagement to ensure that knowledge is generated in partnership with society and users of science and will bring together scientists of all disciplines, natural and social, as well as engineering, the humanities and law. The governance structure of Future Earth embraces the concepts of co-design and co-production of science with relevant stakeholders across a wide range of sectors.

Future Earth is led by a Governing Council and supported by two advisory bodies: a Science Committee and an Engagement Committee. The Governing Coun-

cil of Future Earth is composed of the International Council for Science (ICSU), the International Social Science Council (ISSC), the Belmont Forum of funding agencies, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the United Nations University (UNU), World Meteorological Organization, Sustainable Development Solutions Network (SDSN) [26] and the STS Forum. The Future Earth Engagement Committee is a strategic advisory group, comprising thought-leaders from stakeholder groups including business, policy and civil society. Working together with the Future Earth Science Committee and the Secretariat, its primary purpose is to foster in-depth and innovative interactions between science and society. The Engagement Committee provides leadership and creative thinking on how to bridge the gap between knowledge and solutions for sustainable development. Through their joint actions the research program of Future Earth is developed to co-design the themes, priorities and approaches with the stakeholder community so that the co-produced knowledge, technologies and approaches with better address societal needs.

In the context of this Conference, the combined approach of identification of the technological and societal needs and challenges, with modifications and adjustments in the conduct of the program is to lead to futures for society and technology that better correspond to our science-informed choices. The key question that Future Earth and its partnering programs, including Integrated Research on Disaster Risk and Urban Health and Wellbeing Programme, need to address is: *How can we develop the integrated, equitable, societal, science and technology approaches for the „right" future?*

SCIENCE FOR POLICY AND POLICY FOR SCIENCE

An important area of action for the International Council for Science (ICSU) is Science for Policy, which includes the international research programs described above, and policy for science. In the global policy arena, there are the intersecting issues of climate change, disaster risk reduction and sustainable development and their applications for cities, energy, resilience, health, populations and security. As shown schematically in Figure 2, there is the need to bring the integrated science together for policy so that the issues of technology and society can be addressed for the benefits of future societies. There is also the need to address fully global science capacity so that science benefits of all societies and „*leave no scientists behind*". A related issue is big science and open data, which will be discussed further below.

To enhance the connections between science and policy, the International Council for Science (ICSU) and Professor Sir Peter Gluckman, the Chief Science Advisor to the Prime Minister of New Zealand, created the International Network of Government Sciences Advice (INGSA)[27]. The INGSA provides a forum for policy makers, practitioners, academies, and academics to share experience, build capacity and develop theoretical and practical approaches to the use of scientific evidence in informing policy at all levels of government. INGSA is a collaborative platform for policy exchange, capacity building and research across diverse science advisory organizations and national systems. The network aims to enhance the

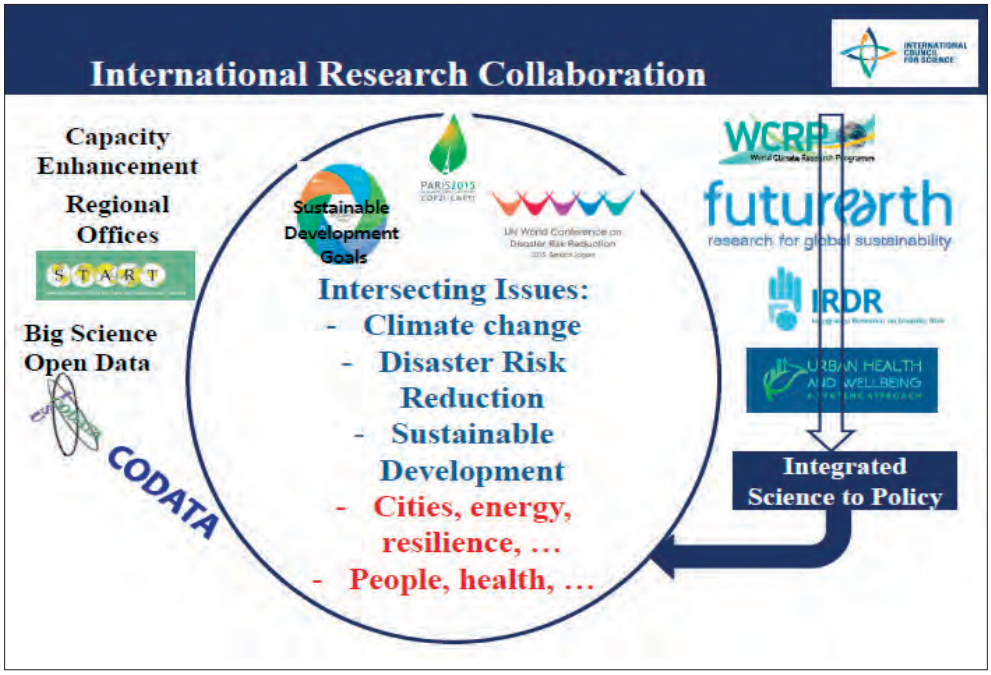

Figure 2: Intersecting issues and the need for integrated science to policy

global science-policy interface and improve the user of evidence based policy formation at both national and transnational levels through workshops and fora. The first meeting was held in Auckland associated with the 2014 General Assembly of ICSU and now involves hundreds of science advisers around the globe. Professor Gluckman is Chair of INGSA. Both major events, at least biannually, and regional events are held.

Another science-policy issue is „big" science and open data. In 2015 the International Council for Science (ICSU) initiated 'Science International' as a new series of action-oriented meetings bringing together major international science bodies: International Council for Science (ICSU); the International Social Science Council (ISSC); The World Academy of Sciences for the advancement of science in developing countries (TWAS) [28]; and the InterAcademy Partnership (IAP) [29]. The initial issue for joint consideration was that of big data and open science. An International Accord, Open Data in a Big Data World [30], was created and has now close to 100 endorsements from academies and other international organisations. The Accord is an example of international science, the global voice of science, addressing issues of policy for science. The Accord presents information on the opportunities and challenges of the data revolution as predominant issues for global science policy and some fundamental principles. It presents the distinctive voice of the scientific community. It was agreed that fundamental pre-requisites are rigour of scientific inquiry and maximising public benefit, in both developed and developing countries. It is important to promote discussion and adoption of princi-

ples like these and have their endorsement by bodies of science at national and international levels.

CONCLUSIONS

This paper has discussed the building on technology and science, including social sciences, to „see society's future" and through collective actions to have the „future we want". It has focussed on the role of the International Council for Science (ICSU) as a key, leading international non-governmental organization that works with many partners to achieve these common goals. We look forward to working together for the benefit of all societies.

ACKNOWLEDGEMENT

Thanks to my colleagues in the International Council for Science (ICSU) and around the world for the initiatives and leadership for international science.

REFERENCES

[1] Sendai Framework for Disaster Risk Reduction 2015–2030 — UNISDR; *www.unisdr.org/we/inform/publications/43291*
[2] Sustainable Development Goals; *https://sustainabledevelopment.un.org/?menu=1300. SDG/Agenda 2030; „Transforming our world: the 2030 Agenda for Sustainable Development „http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E*
[3] Paris Agreement, UNFCCC; *https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf*
[4] Third International Conference on Financing for Development, http://www.un.org/ga/search/view_doc.asp?symbol=A/CONF. 227/20
[5] World Commission on Environment and Development, 1987 *www.un-documents.net/our-common-future.pdf*
[6] Science and Technology in Society Forum http://www.stsforum.org/?lang=en
[7] The Global Risks Report 2016, 11th Edition, World Economic Forum within the framework of The Global Competitiveness and Risks Team. http://wef.ch/risks2016
[8] McBean, Gordon A., 2008: „Role of Prediction in Sustainable Development and Disaster Management", in: Brauch, Hans Günter; Oswald Spring, Úrsula; Mesjasz, Czeslaw; Grin, John; Dunay, Pal; Behera, Navnita Chadha; Chourou, Béchir; Kameri-Mbote, Patricia; Liotta, P. H. (Eds.): *Globalization and Environmental Challenges: Reconceptualizing Security in the 21st Century.* Hexagon Series on Human and Environmental Security and Peace, vol. 3 (Berlin — Heidelberg — New York: Springer-Verlag): 929–938.
[9] Mesjasz, Czeslaw, 2005: „Prediction in Security, Theory and Policy", Paper presented at the First World International Studies Conference at Bilgi University, Istanbul, Turkey, 24- 27 August.
[10] http://www.icsu.org/
[11] http://www.icsu.org/publications/about-icsu/the-international-council-for-science-and-climate-change-2015/the-international-council-for-science-and-climate-change-2015–1
[12] http://ozone.unep.org/en/treaties-and-decisions/montreal-protocol-substances-deplete-ozone-layer
[13] http://unfccc.int/essential_background/convention/items/2627.php

[14] http://www.wcrp-climate.org/
[15] http://www.igbp.net/
[16] http://www.ipcc.ch/
[17] http://www.diversitas-international.org/
[18] http://www.ipbes.net/about-us
[19] http://www.icsu.org/what-we-do/past-interdisciplinary-bodies/hdp
[20] http://start.org/programs
[21] http://www.irdrinternational.org/
[22] http://www.worldsocialscience.org/
[23] https://www.unisdr.org/
[24] http://urbanhealth.cn/
[25] http://www.futureearth.org/
[26] http://unsdsn.org/
[27] http://www.ingsa.org/
[28] http://twas.org/
[29] http://www.interacademies.org/ The InterAcademy Partnership is an umbrella organization that brings together IAP — the global network of science academies, the Inter Academy Medical Panel (IAMP), and the InterAcademy Council (IAC).
[30] http: //www.icsu.org/science-international/accord/accord?searchterm=Big+data