Future Earth - its implication in science and society

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Future Earth program has been initiated not only as an integration and interdisciplinary research of global environmental changes, but also a transdisciplinary research between scientific community and other relevant stakeholders in society. Its research style is, therefore, co-design, co-production and co-delivery of research. This implies that Future Earth is a new scientific movement towards science in society, rather than science for science which has been a fundamental characteristic of the modern science scince the 18th or 19th century. How to implement this new science is a great challenge for both scientists and many stakeholders in society. This paper will focus on this issue, including some proposals for Future Earth implimentation.

Keywords: Future Earth, Earth, Sustainability, globa environmental issues, interdisciplinary and transdisciplinary research

Knowledge for our transformation to a sustainable “Future Earth”

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Unsustainable ways human development over the last decades have generated large environmental footprints and have led to critical degradation of many aspects of our livelihood and wellbeing, including such basics as clear air, water, food and health. The concepts of planetary boundaries and of socially required standards illustrate that a fundamental transformation to global sustainability is required if we want to life and develop within the margins of a safe and just operating space. Scientific assessments, most prominently by the IPCC and IPBES, have been put in place to deliver regular global scientific updates. In addition, international policy targets have been agreed to such aa the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, the Aichi Biodiversity Targets and the Paris Agreement on Climate Change to provide international coordination and guidance on the desired trajectory of transformations. All these complex and interconnected processes require underpinning with research of international excellence, integrated across a wide range of disciplines, and focussed to identify and solve the most crucial questions, issues and problems along the path of our socioeconomic transformation towards sustainability.

The new international research coordination platform Future Earth aims to facilitate this kind of research and to ingrate it with the above mentioned policy processes. The research is carried out in disciplinary Core Projects, short-term Fast-Track Initiatives, and longer-term Knowledge-Action Networks. All of these involve stakeholders of sustainability research in co-designing the research plans and co-producing the output to optimise the use in policy and decision processes. My presentation will feature fist successful examples how research activities are set up and how results are generated that are of relevance to societal and policy processes. Areas that will be covered with examples include science on climate, ecology, marine, urban, health, governance, among others.

Keywords: Future Earth, Sustainability science, Science-policy dialogue

How can IYGU (International Year of Global Understanding) enrich Future Earth?

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Global environmental research is being restructured under the framework of Future Earth, i.e. a grand international initiative for sustainability. Geoscience specializes in physical phenomena and human-nature interaction on the surface of the Earth, including natural disasters. Geoscience as such discipline has a special duty of contributing widely to Future Earth. IYGU (International Year of Global Understanding, 2016), a partner of Future Earth, is a scientific/educational initiative which is intended to contribute to Future Earth through its grass-route bottom-up practices. It offers a unique opportunity to geoscientists who are willing to contribute to Future Earth through its research, education and data programmes, as well as its symposia and publications.
Yuan-Tseh Lee, the former ICSU President, says “sustainable development is a global challenge, but solving it requires transforming the local –the way each of us lives, consumes, and works. While global negotiations on climate attack the sustainability crisis from above, the IYGU complements them beautifully with coordinated solutions from below.”
The paper discusses how the research/education/information programmes of IYGU can enrich Future Earth in the way Yuan-Tseh Lee expresses above from the standpoint of geoscience.

Keywords: IYGU, Future Earth, global environmental research

The Recent Development of Future Earth and the Roles of Its Japan Hub

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Geoscientists can play various important roles in Future Earth, which is a global research platform intended to provide knowledge to solve issues for global sustainability. The paper overviews the recent development of Future earth and the roles played by its Japan Hub, and discusses its expected priority activities both in global and regional contexts, with special reference to the expected involvement of the geoscience community in Future Earth and its possible collaboration with Japan Hub.

Collaboration for the study on environmental change in “Permafrost and Culture”

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Arctic and high-latitude in northern hemisphere is the most susceptible region to global warming. In Northeast Eurasia, multiple impacts of hydrological changes due mainly to precipitation increase are accelerated as well as air-permafrost temperature rising after 1990s. The Arctic climate change has threatened landscape degradation in boreal forest and grassland, corresponding with increasing difficulties for not only indigenous forms of natural resource use but also for social infrastructure in the urbanized area during the recent decades. It means that these unprecedented environmental changes could exceed mitigation and/or adaptation abilities based on their local knowledges.
The RIHN research project No.C-07 entitled "Global Warming and the Human - Nature Dimension in Siberia" (RIHN-Siberia Project) has been carried out from 2007 to 2013FY. The project based on collaboration between natural and social sciences discerned that permafrost-ecosystem-hydrological changes produced frequent occurrence of spring and summer flooding, causing a great deal of damage to hay harvest for animal husbandry using grasslands in alases (grassland landscape in thermokarst depression) in boreal forest and sandbanks along the Lena River and furthermore severe situation that forced people to relocate from their settlement damaged by the perennial floods.
Growing international interest in permafrost degradation in eastern Siberia which was contemporary with RIHN-Siberia Project motivated to organize the Action Group "permafrost and culture (Permafrost and Culture: PaC)" in the International Permafrost Association during 2014 through 2015FY. Multi-disciplinary experts in cooperation with local researchers and stakeholders have promoted stimulate discussion in terms of permafrost degradation and its influence on indigenous people there. The issues are summarized as follows: From the natural science, 1) How did the permafrost ecosystems initially form?, 2) What kind of current changes are there?, and 3) What are the major biological-physical processes currently at work? From a social science, 4) How did the people interact with the permafrost ecosystems?, 5) How do the people use them today?, and 6) Will they be able to continue using them into the future and if so how?
In this presentation, we would like to propose possibility for effective framework based on learning from theses research development to find proper objectives and methods for managing actual environmental change.

Keywords: Permafrost, wet climate, eastern Siberia

New Ocean Paradigm on its Biogeochemistry, Ecosystem and Sustainable Use

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It is an important issue for today's science community to consider how marine ecosystems and their material cycles respond to marine environmental changes taking place on a global scale. Such changes are becoming more apparent, including how the benefits that humans have been receiving from the ocean will change in the future, and how we can enhance the utilization of the ocean in order to promote sustainable development. In 2012, a five-year transdisciplinary project was launched in Japan, called the "New Ocean Paradigm on its Biogeochemistry, Ecosystem and Sustainable Use (NEOPS)". This project aims to explore ways to utilize ecosystem services from the high seas in a sustainable manner. It integrates natural science, which focuses on the open ocean in the central and western Pacific, in particular the high seas where there is limited knowledge about ecosystem mechanisms or material cycle functions, and social science which looks at governance necessary for sustainably utilizing services. As an essential part of the project, we aim to establish new ocean provinces by identifying material cycling and ecosystem functions in each of the provinces as a scientific base for a legal and economic framework to establish governance for sustainable use of the ocean. In the presentation, we will show obtained results from NEOPS and also the plan of a next FUTURE EARTH related project based on the fruits of NEOPS.

Keywords: New Ocean Paradigm, Sustainable Use, FUTURE Earth

Visualizing the inter-sectoral connections of climate risks

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It is now widely recognized that climate change is affecting various sectors of the world. Climate change impacts on one sector may spread out to other sectors including seemingly remote ones [1], a process which we call “interconnections of climate risks”. While a number of climate risks have been identified in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) [2], there has been no attempt to explore the interconnections between them comprehensively [3]. Here we present a first and the most exhaustive visualization of climate risks and their interconnections drawn based on a systematic literature survey. Our risk maps and flowcharts depict that changes in the climate system impact the natural and socio-economic system, influencing ultimately human security, health, and well-being. Our findings point to the need to address the climate risk interconnections in impact and vulnerability studies. Furthermore, our diagrams are useful to educate decision makers, stakeholders, and general public about cascading risks that can be triggered by climate change.

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[2] Birkmann, J., R. et al. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability (2014)
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Keywords: climate change, impact assessment, risk

Japan strategic research agenda and research design for Future Earth

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The Future Earth Unit at Research Institute for Humanity and Nature (RIHN) promotes research on Japan strategic research agenda and research design for Future Earth in Japan and Asia under the program of Promotion of Future Earth Research by Research Institute of Science and Technology for Society (RISTEX) of Japan Science and Technology Agency (JST). Future Earth is a global platform for international scientific collaboration, providing 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. The idea of Future Earth has been discussed since Rio+20 by the International Council of Science Union (ICSU) and others, and is based on the merging of the Global Environmental Change (GEC) Programmes and Sustainable Development Goals (SDGs). Future Earth was officially launched in 2014 when the SRA (Strategic Research Agenda) 2014 was published. In this study, we develop the Japan Strategic Research Agenda (JSRA) with not only researchers of natural/social science and humanities but also with other stakeholders, such as governors, research funders, international cooperation and development aid agencies, industries, citizens, and media, through interviews and questionnaires. We had an expert workshop to prioritize the strategic research agenda. In addition to this, evaluation axes on the research advantage for Japanese scientists and transdisciplinary research have been developed. JSRA and evaluation axes have been developed with stakeholders in co-design, co-production, and co-delivery ways.

Keywords: Future Earth, Strategic Research Agenda, Transdisciplinary

Co-design trial: Case of climate engineering (geoengineering)

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The global sustainability research program, Future Earth, aims to pursue transdisciplinary research, by conducting projects in collaboration with stakeholders and integrate necessary knowledge across disciplines (natural sciences, social sciences, and humanities). Here we report the progress of a feasibility study under the auspices of the Future Earth activities supported by JST RISTEX.

Climate engineering (CE) or geoengineering refers to a set of proposals that are aimed at intervening in the climate system to counteract effects of global warming. It covers a broad range of proposals, which can be categorized into solar radiation management (SRM) and carbon dioxide removal (CDR) (Royal Society 2009; National Research Council 2015). Among many proposals, stratospheric aerosol injection (SAI), an SRM method, is receiving the most attention. It mimics the mechanism of global cooling after a major volcanic eruption and artificially sprays aerosols into the stratosphere, thereby increasing the planetary albedo. The climate science community is paying attention to CE, and the model intercomparison project on CE, GeoMIP6, is one of the endorsed projects under CMIP6, which is underway in preparation for IPCC AR6.

There are many controversies with CE, and it is desirable to reflect interests and concerns of the public and stakeholders in research directions. The transdisciplinary approach is thus essential for CE research, and it should start from the very early stage of research. In other words, responsible innovation is a necessity.

Looking at the past research projects, nevertheless, reveals a problematic situation. Although the literature contains many interdisciplinary projects and public engagement, research questions have been often framed by scientists; stakeholders join projects only after the projects start. To improve this situation, we co-designed a research agenda in collaboration with stakeholders..

Methodologically we adopted the workshop for creating a research agenda developed by Sutherland et al. (2011). We held our workshop on July 26, 2015, at the Hongo Campus of the University of Tokyo. About 20 researchers and approx. 20 stakeholders (policymakers, industry, environmental NGOs, media, etc.) took part in the workshop. This group covers major interests in the climate debate in Japan. We gathered 600 research questions from the participants before the workshop, during which we reduced to 40 questions. The resulting 40 questions can be grouped into the following categories. They include a number of interdisciplinary questions, reflecting diverse interests of stakeholders.

(1) Social and economic assessment: costs, benefits, and non-economic values
(2) (Negative) side effects: risk, uncertainty, and policy response
(3) Prediction, attribution, observation and technological controllability
(4) Policy approaches in broader climate risk management: mitigation, adaptation, and emergency response
(5) Field test and technology development: technical design and socio-political framework
(6) Governance of implementation: legal, political and ethical challenges
(7) Social and political implications: gender, communication, and Japan’s role

Based on some of these questions, we are now conducting Phase 2 of our research project.

Without doubt, the whole process contributed to mutual learning between scientists and stakeholders. Our next step is to reflexively examine the process and explore possibilities and limitations of the workshop method.

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Keywords: Climate engineering, Transdisciplinary research, Co-design

A Study on the Water-Biomass-Livestock-Energy Nexus for the Joint Credit Mechanism (JCM) in Mongolia

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Background/Objectives/Methods

Mongolia's GDP grew 3.8 times and the agricultural production grew 2.4 times from 2001 to 2010. Mongolia also experienced an accelerated urbanization during the last decades. It was found that the rapid increase of energy use due to urbanization and economic development caused the sharp growth of CO2 emissions during last decades in Mongolia. Mongolia and Japan signed a bilateral document for the introduction of the Joint Credit Mechanism (JCM) on January 8th, 2013 (https://www.jcm.go.jp/mn-jp/about). It is urgently required for us to develop MRV (Measurement, Reporting and Verification) methodologies for evaluating effects of GHG emission reductions or removals by applying low carbon technologies, mitigation actions & adaptation strategies.

In this study, we have developed a framework of Water-Biomass-Livestock-Energy Nexus to estimate CO2 emissions from energy use and CO2 sequestration by ecosystem at first, and then, to evaluate effects of CO2 emission reductions or removals by applying low carbon technologies, mitigation actions & adaptation strategies. To achieve those objectives, we have developed a Water-Biomass-Livestock-Energy Nexus framework (Figure 1). For estimating CO2 emissions, we accepted the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. However, for estimating CO2 sequestration, we developed an ecosystem model based on Biome-BGC by using satellite data of AVHRR and MODIS, the local GIS database of DEM, land use and soils, as well as field observations of meteorological and hydrological factors, for which we have established an integrated monitoring system network since 2006.

Results/Conclusions/Suggestions

It was found that the rapid increase of energy use caused the sharp growth of CO2 emissions during last decades in Mongolia. However, we evaluated the vulnerabilities caused by climate change in Mongolia and found that the fragile steppe ecosystems are being affected not only by rapid global warming, but also by increased grazing pressures from livestock husbandry. Our estimation shows that global warming and anthropogenic activities might exacerbate the degradation of permafrost, and cause the water deficit over land surface, and then led a decrease in both biomass productivity and its carrying capacity, which finally caused a decrease of CO2 sequestration by ecosystem (Figure 2).

For the purpose of ensuring the country's sustainable development and reducing or removing the CO2 emissions from energy use, we suggested several adaptation strategies, which include: 1) to educate herds to reduce livestock numbers in accordance with local grassland carrying capacity; 2) to promote sustainable agriculture through enhancement of water allocation and water-saving technologies; and 3) to improve energy use efficiency and develop renewable energy technologies, such as the Film-solar Power System for Gel and Renewable Energy Refrigeration System.

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Keywords: Joint Credit Mechanism (JCM), Water-Biomass-Livestock-Energy Nexus, Adaptation Strategies

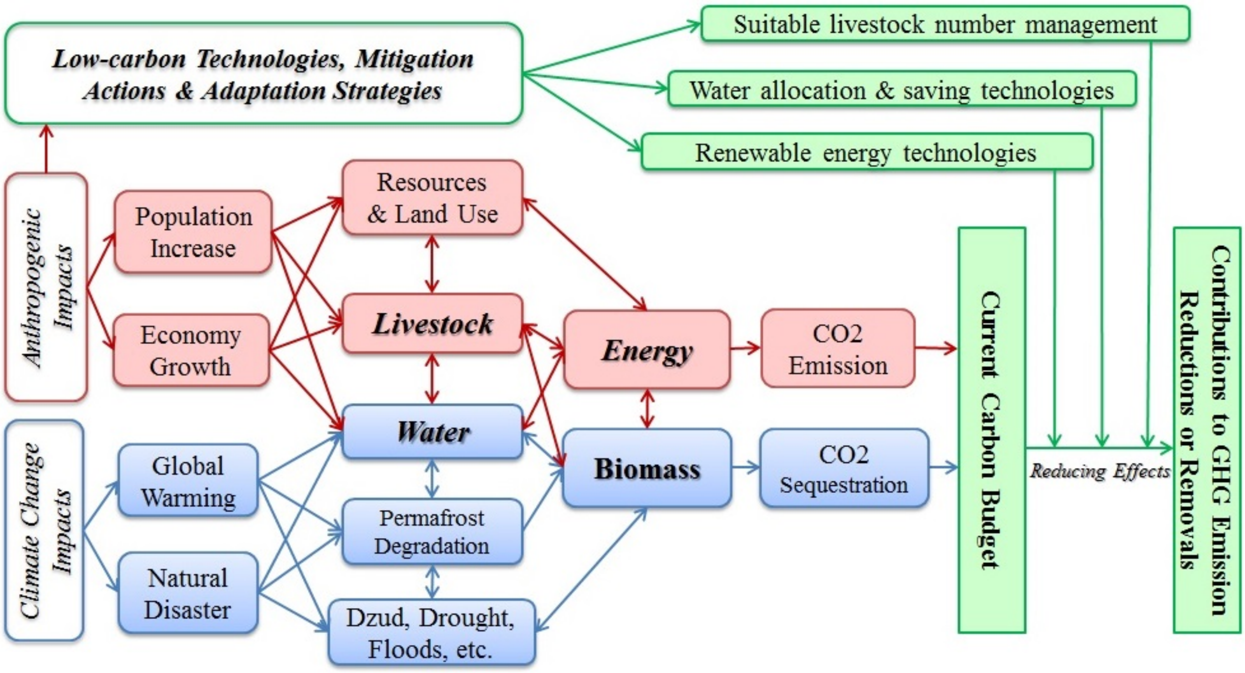

Figure 1 A framework of Water-Biomass-Livestock-Energy Nexus for JCM

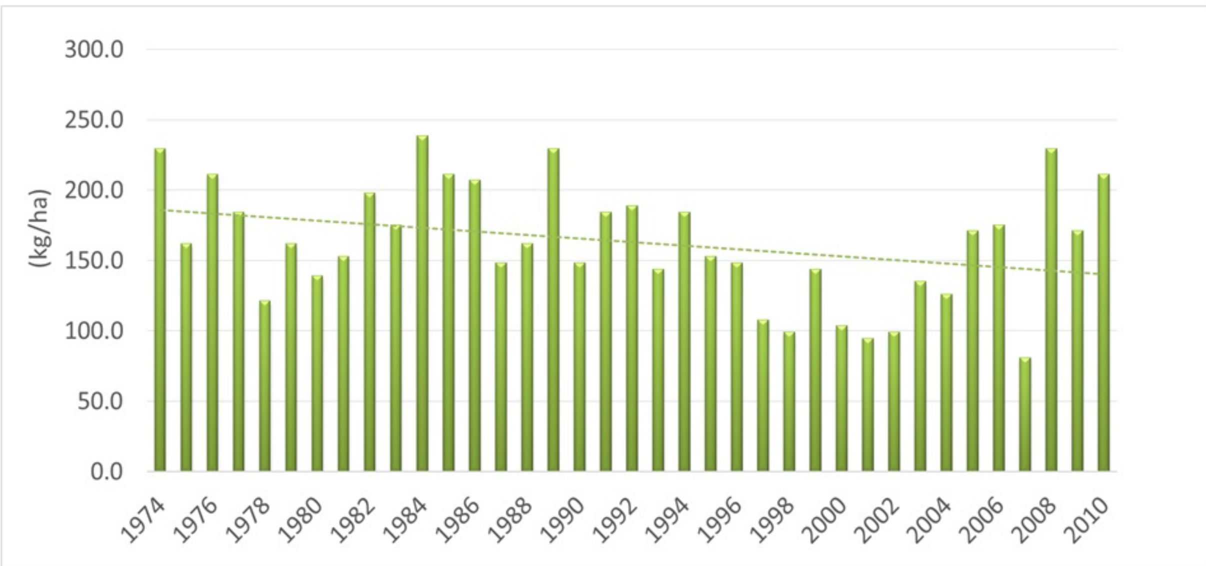

Figure 2 Changes in CO2 sequestration by ecosystem in Mongolia

Earth and Human Society: Sustained strategy of the human society for the continuous state-changes of water-planet Earth

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On continuous process by the changes of material states of the Earth, it's summarized up as follows.
1) Against present water-planet Earth by mutual state-changes of global atmosphere, seawater, rock solids zones, human society cannot stop or change largely and suddenly Earth's activities.
2) This is mainly because extraterrestrial bodies collisions (particularly ocean collision), earthquake and volcano which are activity sources of the strong shock waves in and out of the Earth cannot change these events against any situation of our Earth.
3) Therefore, the thought that the humankind changes water Earth does not flow too much for the present life society and the question for our life future, so that the Earth's activity sources do not change during their successive activity. Humanity society will change not Earth's process, but the local and global effects in limited life circulatory system.
On sustained strategy of the Earth's humankind, it's summarized as follows.
1) The life of humankind with gas, fluid and bone solid , called as the mini-Earth system has been changed actively and mutually. However, the living mini-Earth changes of human life show local and global extinction mainly for each life group, because water Earth keep global activity continuously. How to change is dependent on our environments largely.
2) Even if huge disasters are faced to the human society caused by terrestrial and extraterrestrial origins, the water-planet Earth changes only the outer layer. Therefore, the human society changes by destruction and extinction, might be remained globally within wide planet Earth, because human life is copied mini-Earth group.
3) Therefore, the human is not only each personal front-strategy that only lives long against active Earth, but also the global resolution for humankind under active mini-Earth activity to be continued now and in future. It is expected for human society mainly for less damages for Earth activity of the earthquake and volcano within the water-planet Earth. However, collision caused by the extraterrestrial bodies is only the phenomenon that the human ability will control directly by expected method in future. Ocean impact on water-planet followed earthquake and volcano geologically, which can be controlled by humankind ability, is major global Earth activity (followed the above natural hazards) related deeply in our human-life future.
In summary, the sustained Earth can be known as long-remained water planet globally only to change of local surface against any shocked events. In order to develop successive strategy, human society should make strongly suitable plan for material reuse process and the control of extraterrestrial bodied to be collided to the planet as one of main target in future.

Keywords: Continuous state-changes of Earth, Sustained Strategy of human society , Earth and human society

