UNITED NATIONS UNIVERSITY

UNU-IAS

# GLOBAL CHANGE AND PLANETARY BOUNDARIES

WILLIAM STEIMEL

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  - Dr. Tsuyoshi Fujita
- Intergovernmental Panel Climate Change (IPCC) Fifth Assessment Report (2014)
- UN SDG's
- Rockström et al. A safe operating space for humanity
- Intergovernmental Panel Climate Change (IPCC) Third Assessment Report (2001)

# GLOBAL CHANGE AND PLANETARY BOUNDARIES

- Intensive Course at United Nations University from September 3-28
- English Course with UN Personnel and students from around the world from universities including Tokyo University, United Nations University, and Sophia University
- Today I will discuss my experience and what I've learned.

UNITED NATIONS UNIVERSITY

UNU-IAS


Entrance Ceremony

# COURSE LECTURERS


**Global Environment and Governance**

Lecturer: Prof. Kazuhiko Takemoto, UNU-IAS: Prof. Kensuke Fukushi, the University of Tokyo

**Sustainable Development Goals and Education in Future Earth**

Lecturer: Prof. Yuto Kitamura, the University of Tokyo

**Water Related Disasters and Management**

Prof. Kei Yoshimura, Associate Professor at Institute of Industrial Science, The University of Tokyo

**Health Issues in Urban Areas**

Prof. Kozo Watanabe, Head of Molecular Ecology and Health (MEcoH) Laboratory at Department of Civil and Environmental Engineering, Ehime University, Matsuyama

**Future Earth, Research for Global Sustainability**

Lecturer: Dr. Hein Mallee, Research Institute for Humanity and Nature

**Climate Science and Projection**

Lecturer: Dr. Kiyoshi Takahashi, Center for Social and Environmental Systems Research, National Institute for Environmental Studies (NIES)

**Global Water Issues and SDG's**

Prof. Taikan Oki, Professor, The University of Tokyo; Senior Vice-Rector, UNU; Assistant Secretary-General, United Nations

**Water Sustainability for Peace Under Climate Change**

Lecturer: Dr. Koji Kumamaru, Ministry of the Environment, Japan

**Sanitation & Future Needs in Context of Developing Countries**

Dr. Saroj Kumar Chapagain, Research Fellow, UNU-IAS

**Food Sustainability Under Climate Change Stress**

Lecturer: Dr. Geetha Mohan, UNU-IAS

**Climate Change Mitigation/Low Carbon Cities, Practical Approach in Developing Countries**

Dr. Tsuyoshi Fujita, Director, Center for Social and Environmental Systems Research, National Institute for Environmental Studies (NIES); Visiting Professor, Advanced Energy Systems for Sustainability (AES), Institute of Innovative Research, Tokyo Institute of Technology

# COURSE CONTENT

- Most Important Course Themes
  - Sustainable Development (SDG's)
  - Great Anthropocene
  - Planetary Boundaries
  - Climate Change
  - Impacts of Climate Change
  - Adaptation/Mitigation (Climate Resilience)
  - Transdisciplinarity/Multidisciplinarity

# SUSTAINABLE DEVELOPMENT GOALS

What is Sustainable Development?

- "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987)

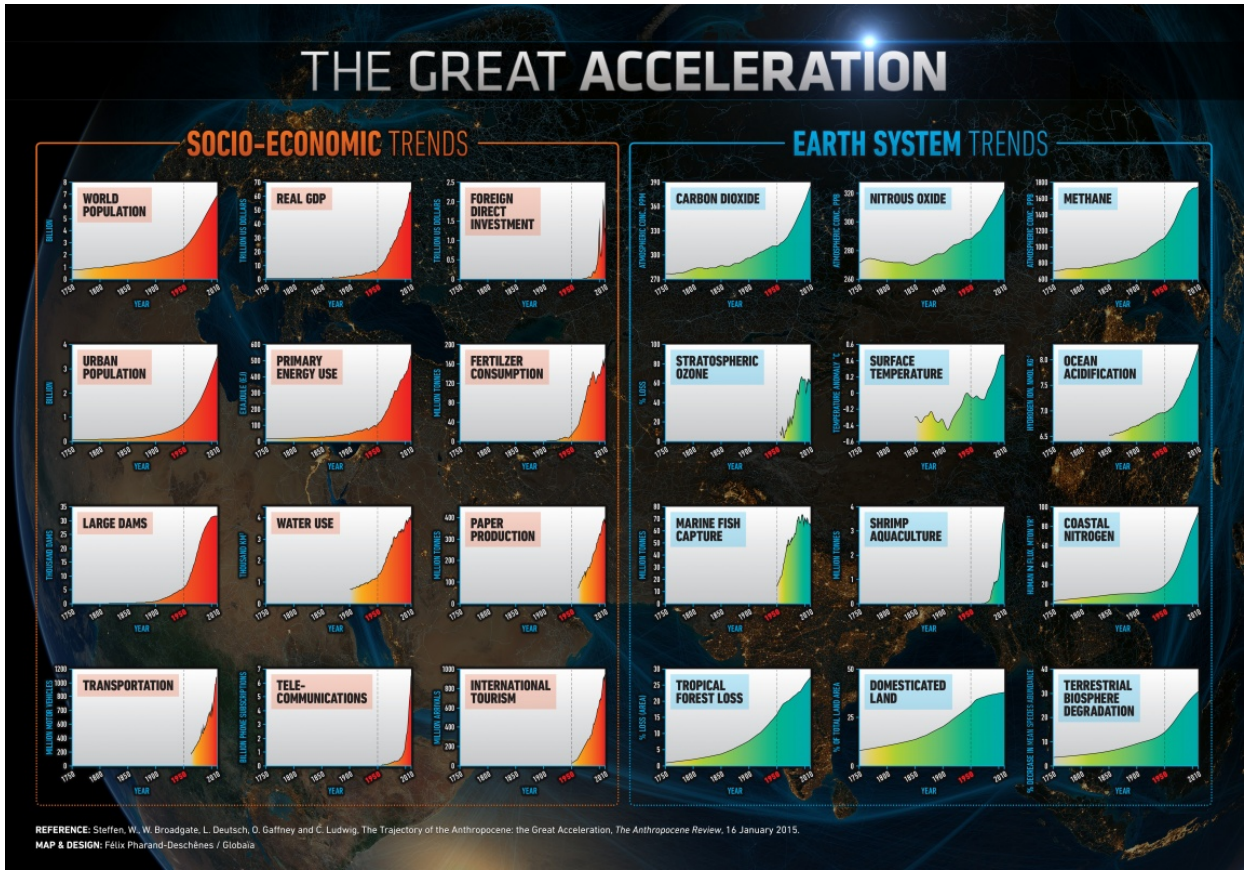
Sustainable Development Goals are 17 goals and 169 targets developed by the United Nations to end poverty and protect the planet

- Global Partnership/Common Pledge for Action
- Integrates economy, society, and environment

Open Data


# GREAT ANTHROPOCENE (GREAT ACCELERATION)

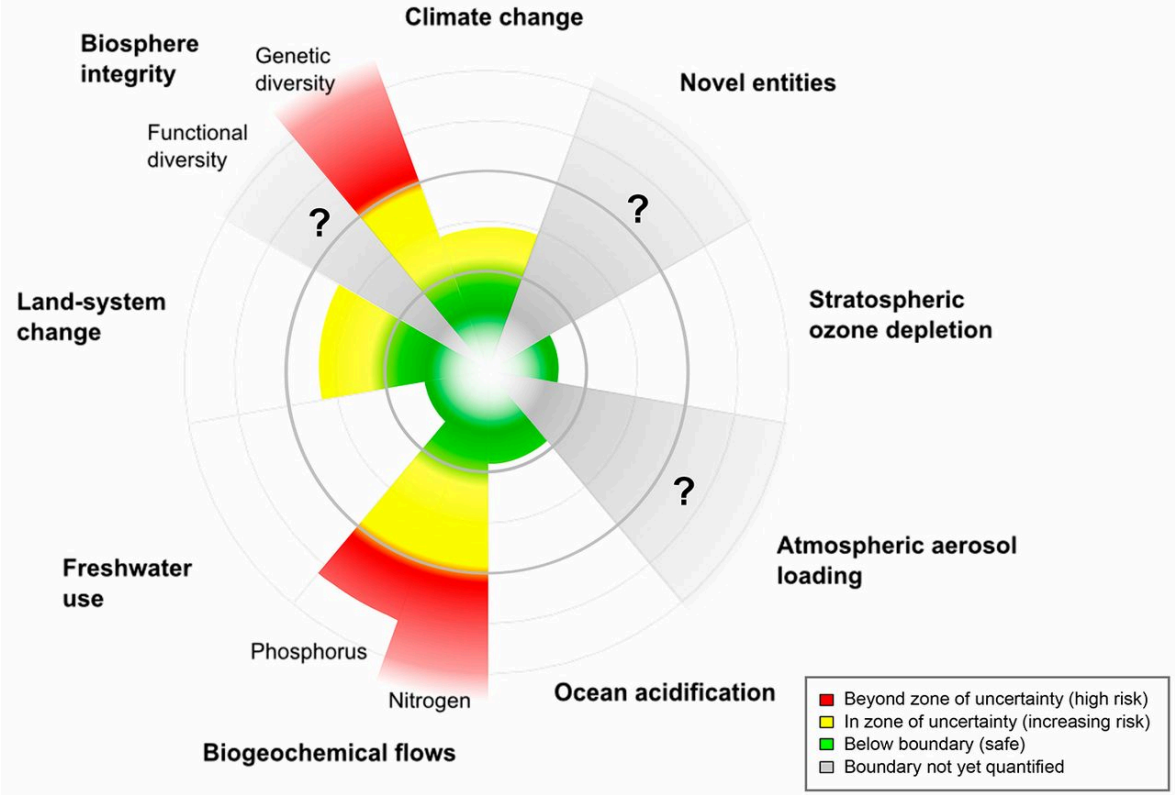
**Human Impact on the Earth is Increasing-** After the 1950's as Socio-Economic Trends and Human Development increased strain on Earth Systems has also increased



# PLANETARY BOUNDARIES

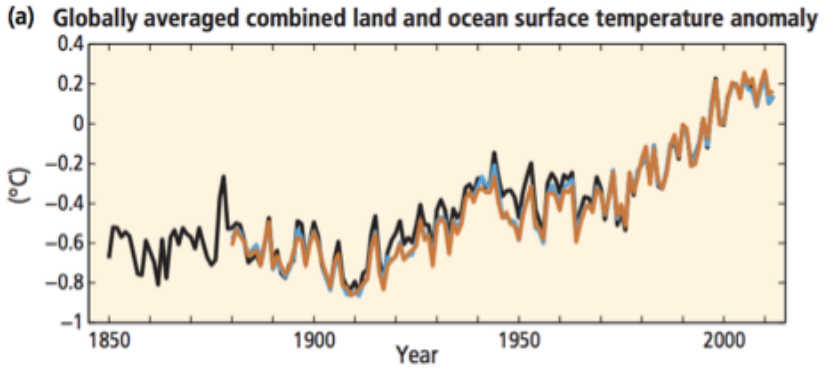
"*The planetary boundaries concept presents a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come*" -Rockström et al. A safe operating space for humanity, *Nature*, 23 September 2009

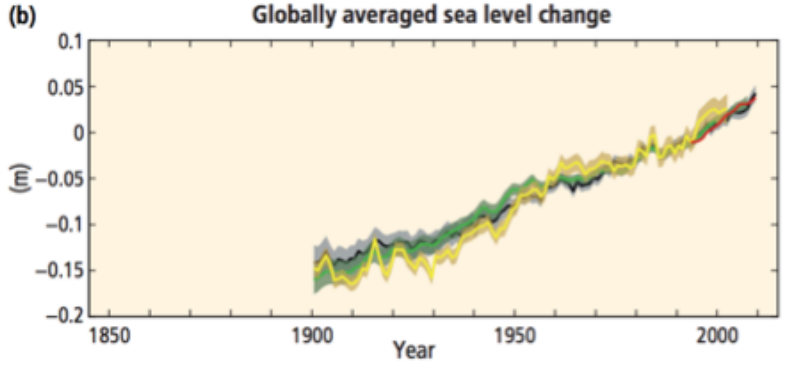
If we continue with our current trends these planetary boundaries will be surpassed and Earth System will shift for the negative.



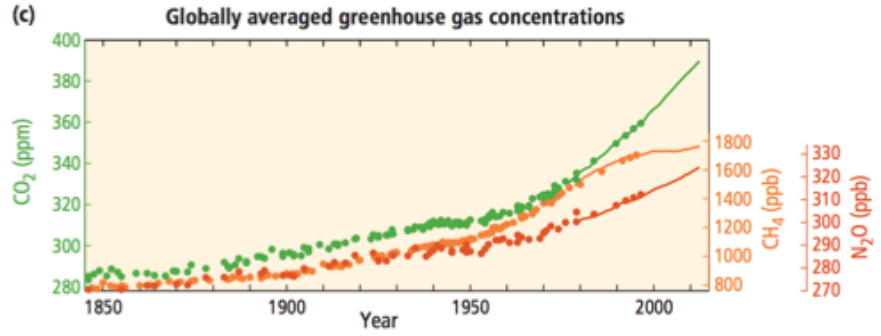
# CLIMATE CHANGE

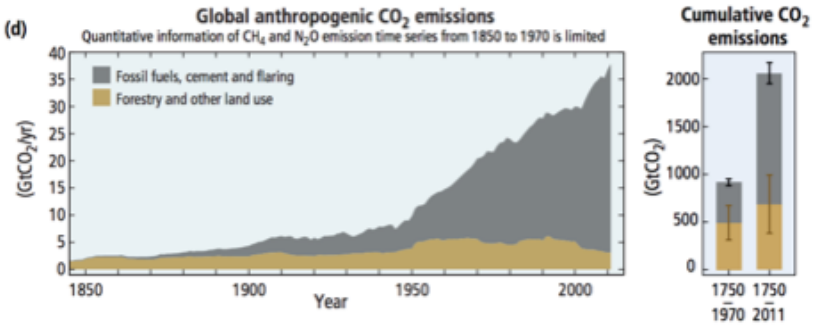
**4 Important Graphs from the IPCC –** Global Temperatures are Rising, Sea level is rising, as well as human emissions



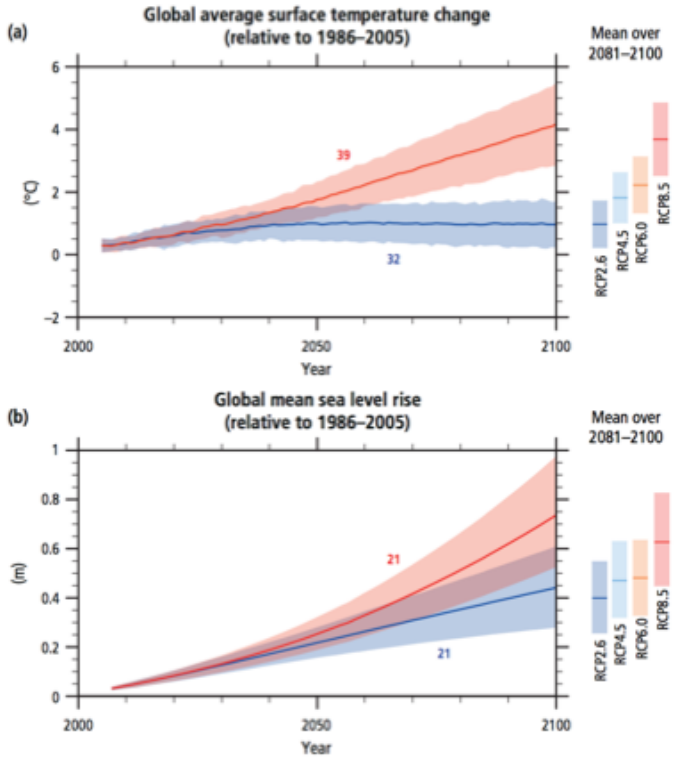

*Colors indicate different datasets

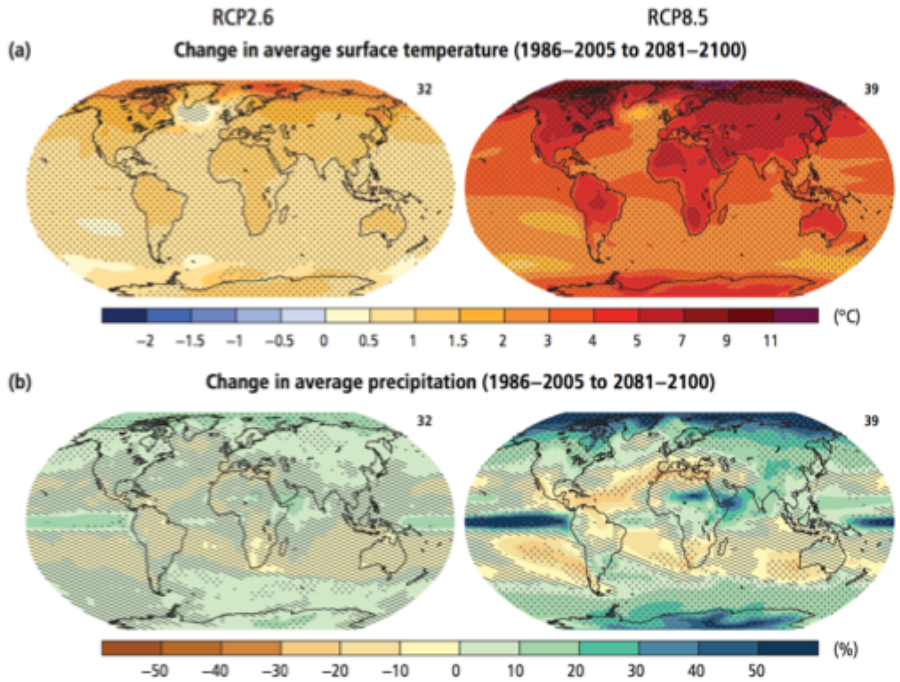


# CLIMATE CHANGE

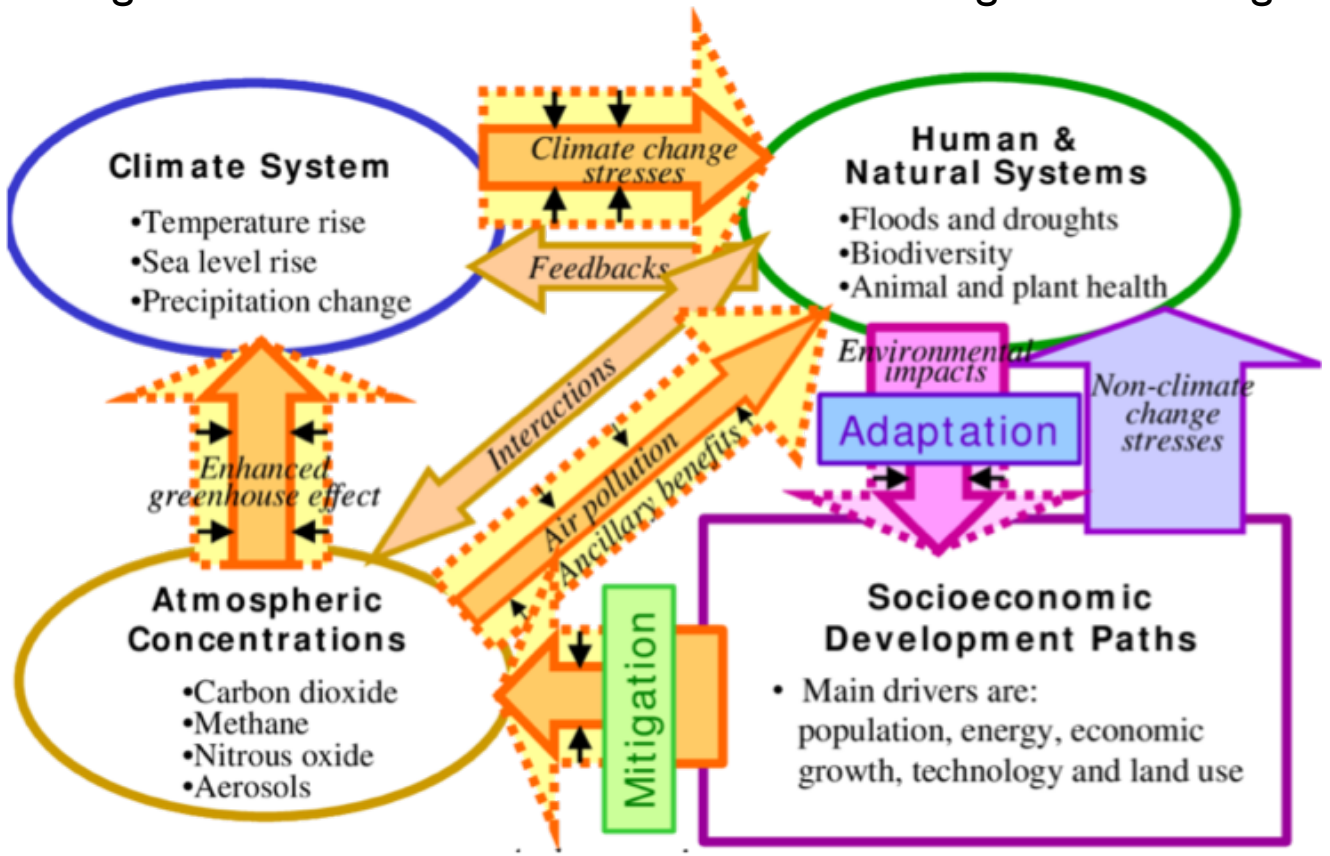
- If we continue on the Earth's current path we will face increasing global temperature, sea level rise, and changes in average precipitation.



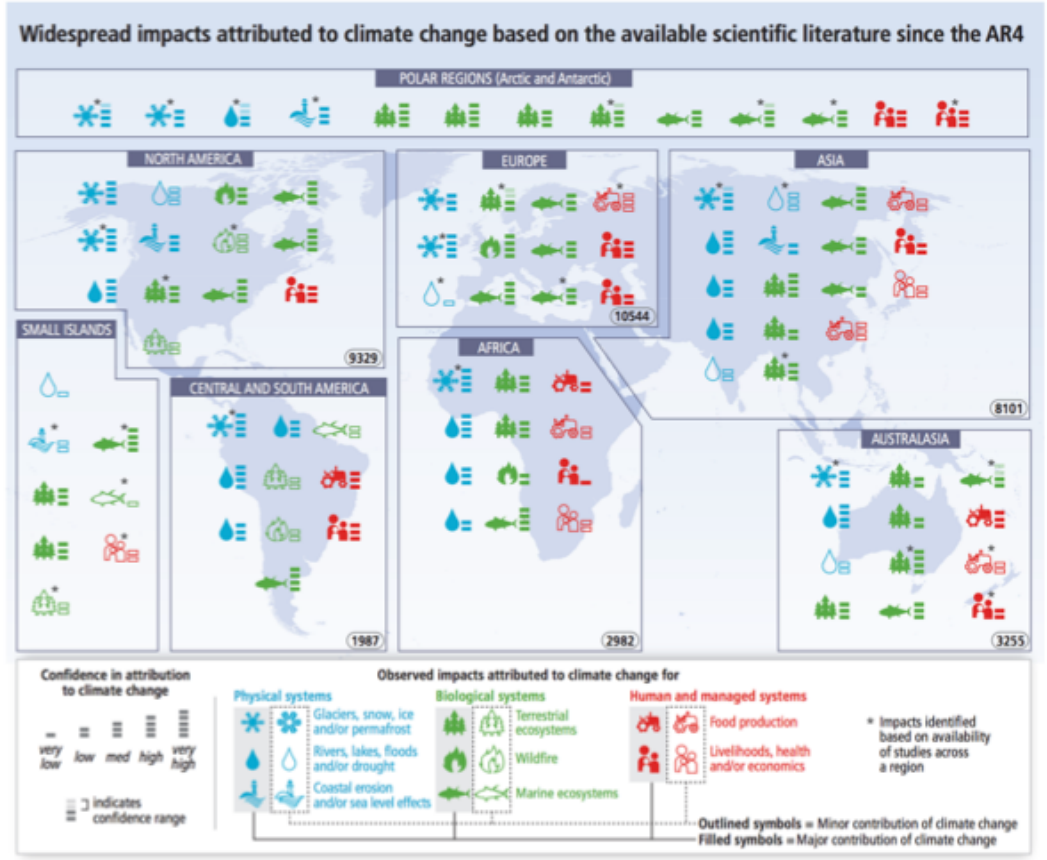
# WHAT CAUSES CLIMATE CHANGE?

An integrated assessment framework for considering climate change




Intergovernmental Panel Climate Change (IPCC), 2001

# IMPACTS OF CLIMATE CHANGE



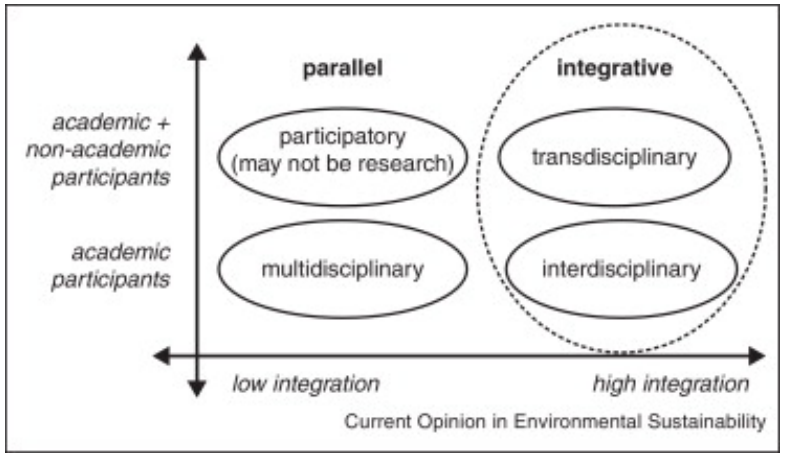

Intergovernmental Panel Climate Change (IPCC), 2014

# ADAPTATION/MITIGATION

- How do we manage the impact of Climate Change?
  - Mitigation– "A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs)." (Before)
    - CO2 Reduction/GHG Emission Reduction – Renewable energy
    - Introduce more Carbon Sinks like Forests
  - Adaptation- "The process of adjustment to actual or expected climate and its effects." – IPCC (After)
    - More efficient use of resources
    - Flood defenses and disaster preparedness for extreme weather events.
- Climate Resilience – The Combination of Adaptation and Mitigation Measures create climate resilient society and reduce risk.
- Various professors in the course were performing research in methods for Climate Change Mitigation and/or adaptation around the world in various sectors (Food, Water, Sanitation, etc.)

# TRANS-DISCIPLINARITY VS MULTI-DISCIPLINARITY

- With Climate Change and Sustainable Development there are a number of complex challenges that need to be faced.
- Transdisciplinarity thinking is needed for solving hard global challenges (Holistic View)
  - Multidisciplinarity – Scientists collaborating with other fields of study/academics
  - Transdisciplinarity – Scientists collaborating with other fields of study(academics)/local people and stakeholders



# INTERESTING RESEARCH – TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT

- Climate Modeling – Dr. Kiyoshi Takahashi
- Flood Prediction – Prof. Kei Yoshimura
- Dengue Disease Modeling – Prof. Kozo Watanabe
- Smart Cities & Infrastructure – Dr. Tsuyoshi Fujita

# CLIMATE MODELING

- Dr. Takahashi specializes in Climate Change Modeling and climate risk assessment and management
- Typical Process for Climate Change Modeling/Impact Assessment
  - Future Societal and Economic Growth
  - Future GHG emissions with these growth circumstances
  - Concentration of GHG in the atmosphere (How much remains in the atmosphere)
  - Climate/Environmental Change due to GHG concentration
  - Impact on Natural Ecosystem and human society (How will our world be impacted?)
- The output from these models are then used to advise policy makers.

**Climate Science and Projection**

Lecturer: Dr. Kiyoshi Takahashi, Center for Social and Environmental Systems Research, National Institute for Environmental Studies (NIES)

# CLIMATE MODELING

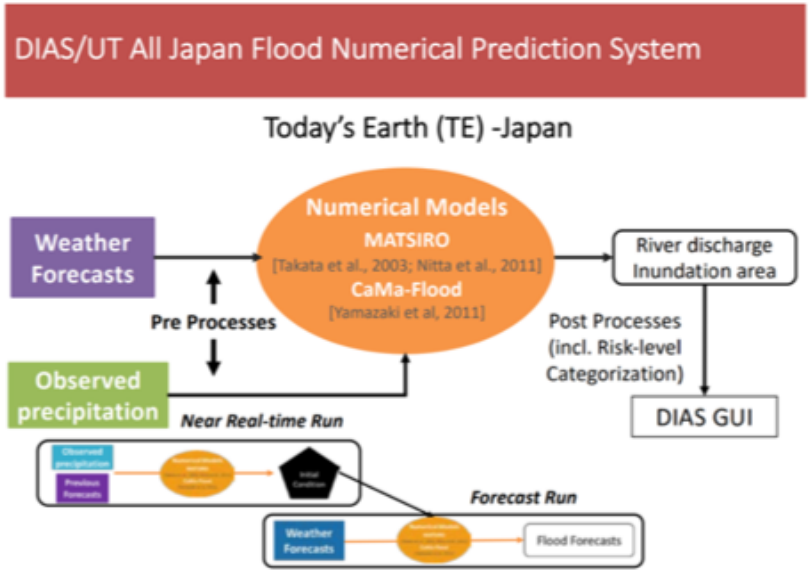
- I was especially impressed with the use of stories for generating various different climate generation scenarios.
- It is clear that if we continue on our path of limited mitigation (RCP 8.5) that our earth will transgress its planetary boundaries leading to unavoidable consequences.
- Data and modeling are important as it gives us a lens to look at the world which promotes a data driven evidenced based approach to solving problems.
- One thing that really struck me with Mr. Takahashi's research was the unintended impacts that can sometimes occur when implementing mitigation measures.
  - Professor Takahashi performed research on Climate Mitigations impact on hunger and found that climate mitigation measures reduce negative effects of crop yields but have large negative impacts on hunger in the developing world.

# FLOOD PREDICTION

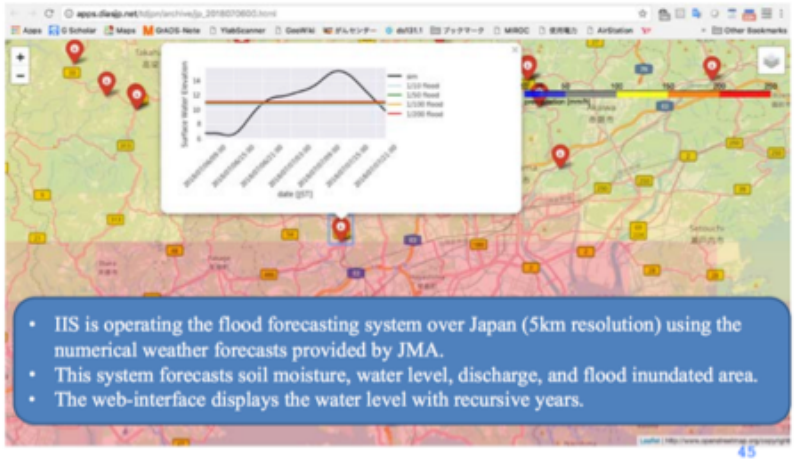
- Professor Yoshimura worked on many flood related natural disasters in Japan
  - Takahashi / Hiji Rivers (July 2018) – Western Japan
  - Kinu-river flood disaster (Sept 2018) - Kanto/Tohoku
- Currently working on a Flood Prediction System with statistical methods

Prof. Kei Yoshimura, Associate Professor at Institute of Industrial Science, The University of Tokyo

**Water Related Disasters and Management**




TE-JPN（5km）：Web-Interface



# DENGUE DISEASE MODELING

- Dengue – Viral infection transmitted by the bite of an infected female Aedes mosquito (WHO, 2012)
- Professor Kozo Watanabe
  - Applied Machine Learning Modeling in the Philippines to predict occurrence of Dengue Outbreak デング
  - Conducting many research projects in the Philippines, Indonesia, and Japan
- Project Goal – "Developing an Early Warning System and Dengue Risk Maps"
  - Interesting application of Machine Learning for Sustainable Development

BMC Infectious Diseases

RESEARCH ARTICLE Open Access

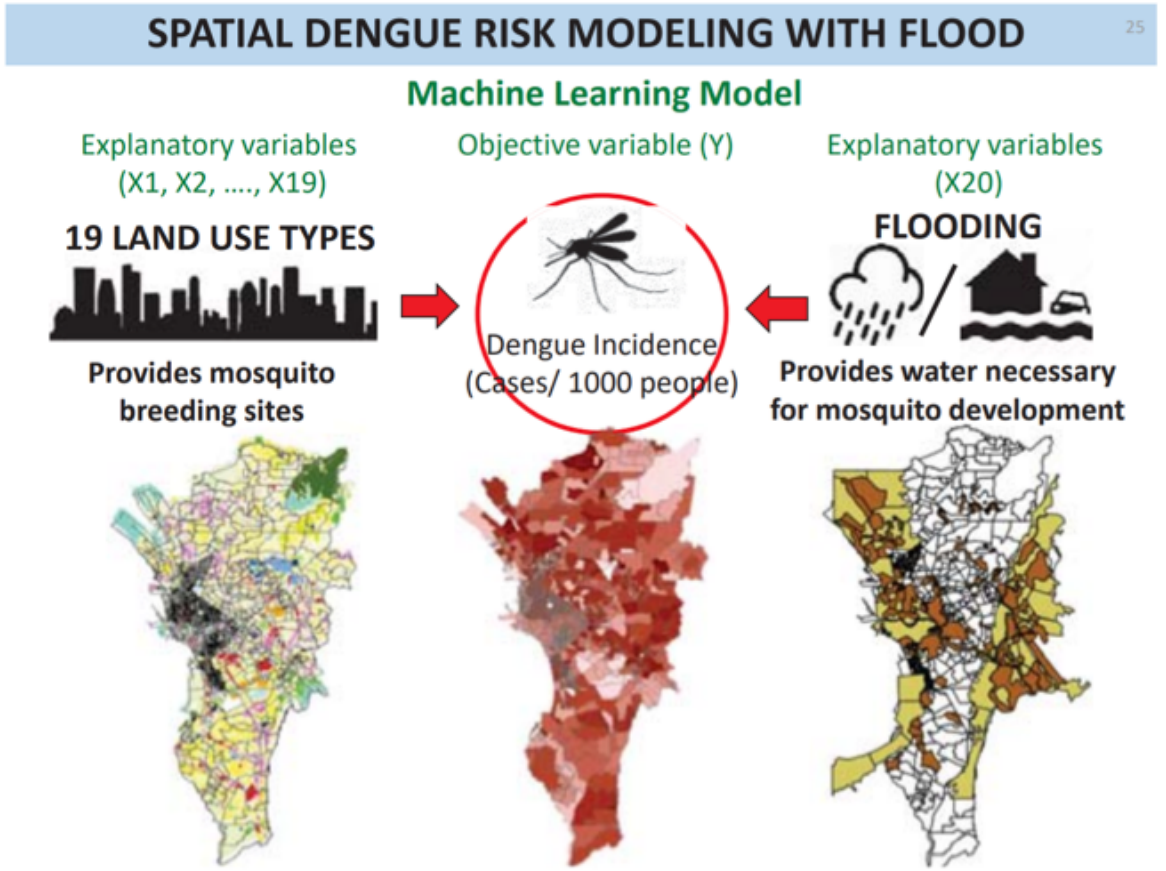
Machine learning methods reveal the temporal pattern of dengue incidence using meteorological factors in metropolitan Manila, Philippines

**Health Issues in Urban Areas**

Prof. Kozo Watanabe, Head of Molecular Ecology and Health (MEcoH) Laboratory at Department of Civil and Environmental Engineering, Ehime University, Matsuyama

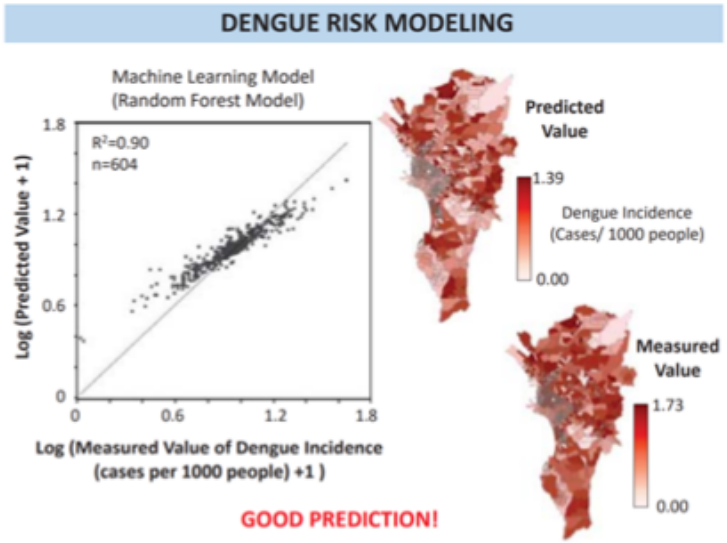
# DENGUE DISEASE MODELING

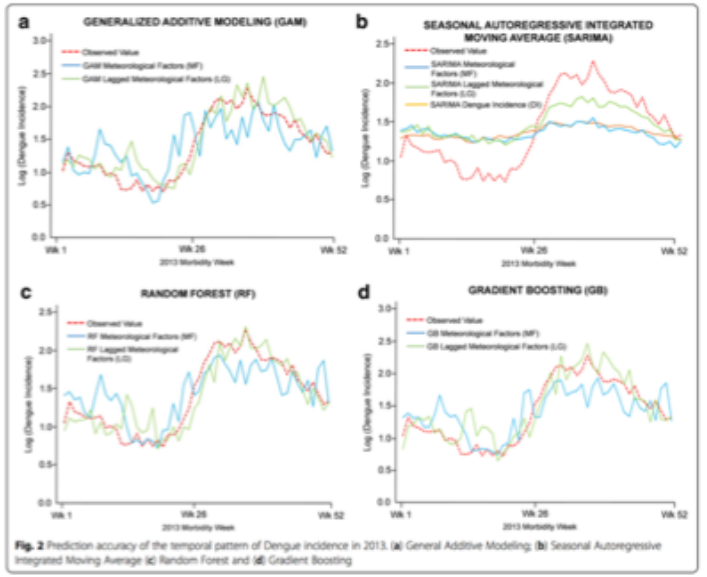
- Methodology
  - 19 Land Use Variables + Flood Variable
  - Random Forest Model
- Data Source-
  - Various Government Sources including :
    - Philippine Department of Health
    - Philippine Atmospheric Geophysical and Astronomical Service Administration
    - Australian Government Bureau of Meteorology



# MACHINE LEARNING FOR DENGUE PREDICTION

- Random Forest Model was used to predict Probability of Dengue Risk in area based on factors like Weather/Flood and Urban Landscape
- Random Forest was also able to determine Variables of importance for Predictions
- Random Forest Outperformed traditional statistical methods like SARIMA and GAM



# MACHINE LEARNING FOR DENGUE PREDICTION

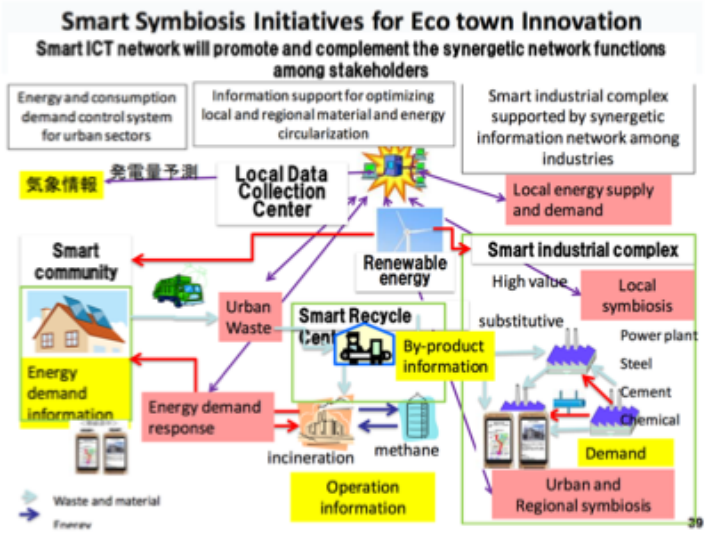
- I admit that I was previously unaware of the sheer number of people impacted by Dengue every year as well as the disproportional impacts it has on the developing world.
- Professor Watanabe's project that really caught my interest was the application of Machine Learning methods for prediction of Dengue outbreaks in the Philippines.
- This relates to my current research in Machine Learning and reminds me of the importance in development of domain knowledge for accurate and effective model building.
  - An example of domain knowledge is an understanding of concepts other than statistical methods like dengue disease dynamics which without this knowledge would make modeling very difficult.
- This model truly seems like it has the potential to reduce impacts of Dengue if deployed in an active production setting.
- In addition, I was curious as to whether the dataset was available open-source as I am interested in further improvement of the model's predictive accuracy with other known machine learning methods.

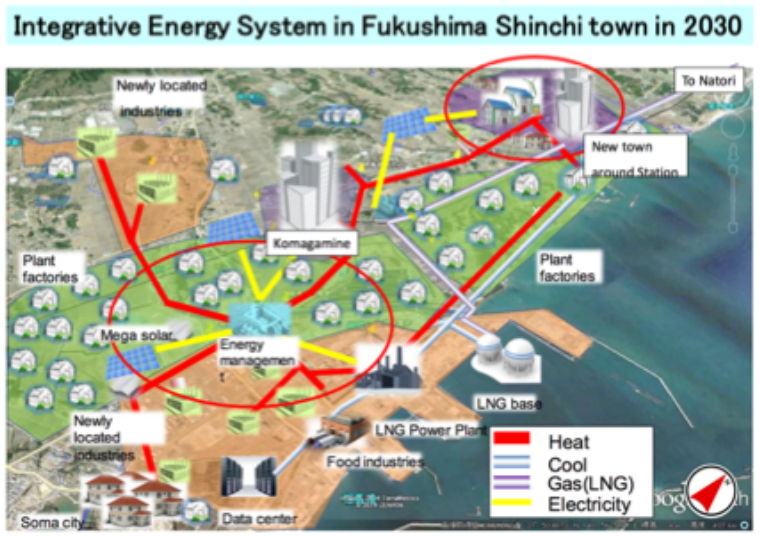
# SMART CITIES/INFRASTRUCTURE

**Climate Change Mitigation/Low Carbon Cities, Practical Approach in Developing Countries**

Dr. Tsuyoshi Fujita, Director, Center for Social and Environmental Systems Research, National Institute for Environmental Studies (NIES); Visiting Professor, Advanced Energy Systems for Sustainability (AES), Institute of Innovative Research, Tokyo Institute of Technology

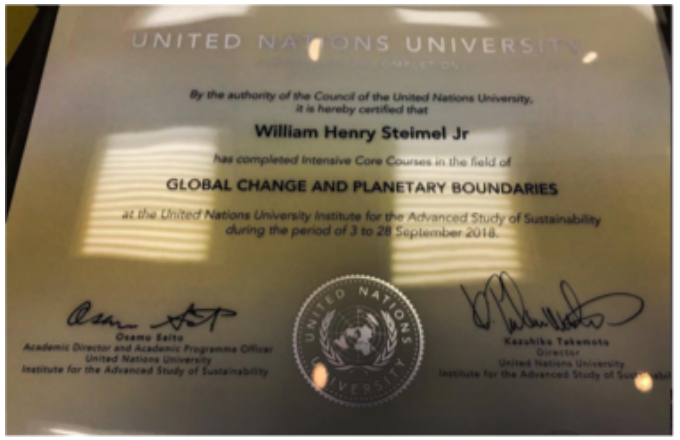
- Dr. Fujita research focused primarily on mitigation through low carbon city development, low carbon city evaluation, and strategic assessment and decision support tools. (Smart Cities)
  - Smart City Yokohama
  - Fukushima Shinchi Town
- Optimization of cities from a low carbon perspective



# CONCLUSION

- Very challenging month but worth it
- It was great that the lectures covered a variety of areas related to sustainability and sustainability science.
  - Especially interesting was machine learning / smart infrastructure applied to sustainable development problems
- As scientists, technologists, or machine learning Engineer's collaboration will be necessary to solve difficult problems trans-discplinary problems in the future.
- Innovation is one of the keys to achieving the new sustainable development goals and technologies like machine learning,  blockchain, and IoT can be utilized to help reach these goals.




# TECHNOLOGY FOR SDG'S

- World Food Programme – Building Blocks
- Utilizes BlockChain to make cash transfers more efficient, transparent, and secure
- Cash Transfers (through vouchers or pre-paid debit cards) are important for providing assistance.
  - 3 million people in 2010
  - 9.3 million in 2015
- "By harnessing the power of the blockchain, WFP aims to reduce payment costs associated with cash transfers, better protect beneficiary data, control financial risks, and set up assistance operations more rapidly in the wake of emergencies."

# PLAN FOR THIS SEMESTER

- Dimensionality Reduction (PCA, Umap, T-SNE)
- Mathematics for Machine Learning- Book
- Deep Learning – Book
- Feature Engineering for Machine Learning – Book

# INTERESTING LINKS FOR SHARING

- Data Science Glossary
- Winning Solutions of Kaggle Competitions