

# 2015-2016 Biennial Report of Center for Sustainability Science, Academia Sinica

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#### **Foreword**

At one time, mankind regarded the Earth as an almost infinite globe with inexhaustible resources, and people could exploit these resources from and do whatever they want to the earth without ever worrying about any adverse impact on human society. In the last few decades, however, it became clear that this is quite an illusion. The earth is finite after all, and human exploitation of earth's resources and environment would one day create negative impact on the human society. By now it is well accepted that many phenomena such as global warming, acid rain and extreme weather are very likely the adverse consequences of impact of human activities on the earth environment.

To solve such problems and to mitigate their adverse impacts, there is a need to understand the origin of the problem, the physical-chemical-biological processes involved and the way human society respond to it. This calls for interdisciplinary studies that involve not only science and technology but also humanity and social studies. The Center for Sustainability Sciences (CSS), Academia Sinica, was created precisely for dealing with such problems. Since its inception in 2012, CSS has been sponsoring research projects that utilize the combined strength of the three divisions in Academia Sinica – Mathematical and Physical Sciences, Life Sciences and Humanities and Social Sciences. This report is a summary of the latest results from these research activities. In addition, CSS has been working with international communities, both global and regional, to engage in sustainable development research. Such activities are also included in this report.

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Pao K. Wang
Director, Center for Sustainability Science
Academia Sinica



#### Introduction

The 2015-2016 biennial report of the center for Sustainability Science provides a summary of activities undertaken by the Center to achieve its mission of conducting boundary-crossing sustainability-related research projects and international programs.

The Earth System (including Geosphere, Hydrosphere and Biosphere) is an integrated system with self-regulatory capacity. Human activities have driven interactions within the system causing complex impacts to the environment, the ecosystem and the climate; affecting the wellbeing of mankind and threatening the sustainable development of the human society.

Great efforts and large amount of resources have been put worldwide into the efforts to find solutions to those problems. Academia Sinica has initiated an interdisciplinary Sustainability Science Program in September 2012 with the establishment of the Center for Sustainability Science. Researchers from the three divisions of the Academy, the

Physical Sciences, Life and Medical Sciences, and Humanity and Social Sciences are encouraged to engage in boundary crossing research projects organized and coordinated by the Center, aimed at solving relevant problems and serving as a think tank for the Government on issues related to sustainable development.

The Integrated Research on Disaster Risk (IRDR)-International Centre of Excellence in Taipei (IRDR-ICoE-Taipei) established at Academia Sinica in 2011 with the support of International Council for Science (ICSU) was incorporated into the Center in 2012 to serve as an international platform for conducting integrated research, establishing a partnership network of interdisciplinary researchers and strengthening international collaborations.

#### **Mission**

The mission of the Center is (1) to organize, coordinate and evaluate boundary crossing sustainability-related research projects to be carried out by researchers from the three

divisions of the Academy, (2) to support capacity building by hosting workshops, training courses, forums, and scientific meetings, (3) to engage and coordinate sustainability and disaster risk reduction research community in Taiwan, (4) to promote international cooperation and scholarly exchange, and (5) to provide independent and objective advice to the Government on matters related to sustainable development.

#### **Organization**

Members of the Center as of October, 2016 Chairman:

Dr. Yu WANG

Director:

Dr. Pao-Kuan WANG

Deputy Executive Secretary:

Dr. Louise L.Y. WEI

Director of International Programs:

Dr. Shih-Chun LUNG

Program managers:

Ms. Yu-Fang HSU

Ms. Yun-Han CHIN

Ms. Li-Wen LEE

Science Officer of International Programs:

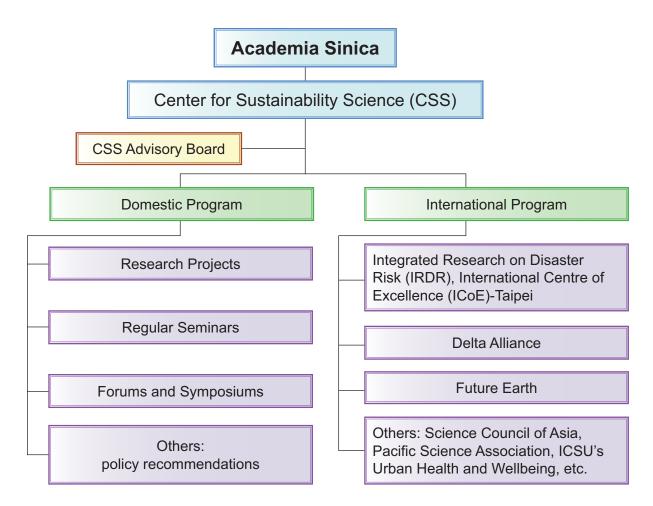
Dr. Chia-Hsing Jeffery LEE

Dr. Ying-Chen LIN

## **Sustainability Science Research Program**

#### Introduction

The Sustainability of Human Society is one of the most challenging issues facing humanity today. Because of its complexity, it is recognized that only through cross-disciplinary research integrating the relevant natural sciences and humanity and social sciences can we hope to develop practical solutions for sustainable development problems.



Center for Sustainability Science Organization Chart

2015-2016 Biennial Report

The Center supports research in six areas:

#### **Earth System Science**

An important pillar of global sustainability is the maintenance of a healthy ecosystem and environment. In the context of climate change, there is a need to better understand the interactions between the different parts of the earth system including the earth's surface, the atmosphere, and the ocean through observation and modeling. At the same time, it is important to study the impact of environmental change on ecosystems and biodiversity, in order to find proper adaptation practices.

### Green Energy related science, technology and policy studies

Energy saving, carbon reduction, and discovering new energy resources are key to achieving global sustainability. Research topics include new sustainable energy sources, energy storage technology and novel materials for energy saving and carbon reduction. Further study on Taiwan's energy policy will also be carried out.

### Natural Disaster including mitigation, adaption and reconstruction

Despite the growth in knowledge and understanding of natural hazards, disaster losses associated with environmental hazards have risen in recent years at a seemingly exponential rate and the frequency of recorded disasters has also been rising rapidly. By participating in the international Integrated Research on Disaster Risk (IRDR) program, researchers in environmental change, socioeconomics, and engineering will work together with scientists from other countries to develop disaster risks reduction technologies and adaptation policies

#### **Food Security and Safetyy**

Because of the impacts from climate changes on food production and the continuing growth of the population, food security and safety become important sustainability research topics. The local agricultural industry in Taiwan has been mainly based on small scale farming practice. How would this affect food security on Taiwan under the impacts of extreme weather events is a crucial issue. Research on the effects of environmental change on rice growth and production in Taiwan is being conducted. The bird flu vaccine using combination of virus-like particle and adjuvant strategies is being developed.

#### **Health-Related Issues**

With increasing average life expectancy and decreasing birth rate, the worldwide population is rapidly aging, leading to the increasing demand for elderly care. In addition, extreme climate conditions aggravate the impact on them both physiologically and psychologically. In-depth health care studies of the elderly will be conducted in the hope to develop more efficient methods of caring and new medicine. Also, effects of climate change on infectious diseases will be studied.

### Human-Dimension of Sustainability Science

Disasters resulting from environmental change and government mitigation policies influence people's livelihood. To formulate appropriate policies, in-depth understandings of the history of long-term environment changes are needed. The economic models that can be used to analyze and predict sustainable development for Taiwan and Asia need to be developed, linking economic development to environmental and ecological factors (including land, water, air quality, etc.), as well as population and health and other social elements. This research area also includes the study of the impact of population aging and globalization on pension, labor policy, and industrial transformation. Urban response to global climate change, and the development of integrated Taiwan sustainable transition model are also investigated.

### 2015-2016 Sustainability Science Research Program

In 2015, the center conducted and supported 22 integrated projects including 118 main projects and sub-projects; In 2016, the center conducted and supported 16 integrated projects including 88 main projects and sub-projects.

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#### **Earth System Science**

Linking ecology to management for sustaining resources of coral reefs facing climate changes **Chen, Chaolun Allen** 



#### **Green Energy**

Thermoelectrics as Alternative Sustainable Energy Source Chen, Kuei-Hsien

Efficient Transformation and Utilization of Solar Energy Tao, Yu-Tai

Development of new-generation solution-processed organic solar cells Wang, Juen-Kai

Biotechnology of Anaerobic Digestion Producing Biogas Energy Wu, Shih-Hsiung



#### **Natural Disaster Reduction and Adaptation**

DRBoaST (Disaster Resilience through Big Open Data and Smart Things) Jan-Ming Ho / Jane W. S. Liu

Study on Climate Change and Urban development/Land Use Hsu, Huang-Hsiung Integrated Multi-source and High-resolution Heat Wave Vulnerability Assessment of Taiwan Lung, Shih-Chun / Wang, Da-Wei



#### **Food Security and Safety**

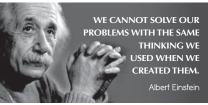
Effects of environmental changes on rice growth and production in Taiwan Shih, Ming-Che



#### **Health-Related Issues**

A Blueprint for Healthy Aging: Determinants and Prevention of Frailty and Depression in Elderly Pan, Wen-Harn / Chang, Hsing-Yi

The Impact of Population Aging and Globalization on Pension . Labor Market and Industrial Transformation Tung, An-Chi



#### **Human-Dimension of Sustainability Science**

Enhanced GEMTEE (General Equilibrium Model for Taiwan Economy and Environment) for IAM Framework-An Integrated Computable General Equilibrium (CGE) Model and Database for Appraising Policies toward Sustainable Development Chang, Ching-Cheng

Sustainable development and democratic governance: aspects of localization and globalization Leng, Tse-Kang

Sustainable Development in Anthropocene: Changing Urban Life in Taiwan Liu, Shao-hua / Huang, Shu-min

Reconstructing East Asian Historical Climate Series using China's Chronological Records in Past Two Millennia (REACHS) **Wang, Pao-Kuan** 

# Linking ecology to management for sustaining resources of coral reefs facing climate changes



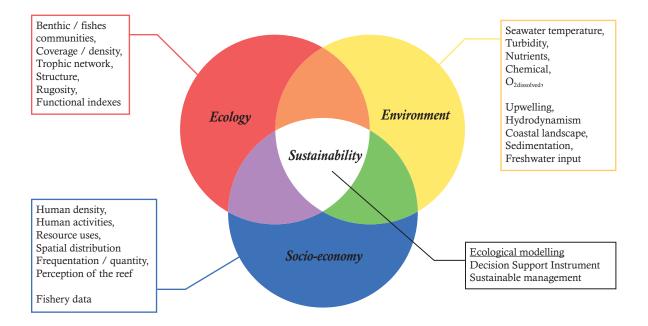
Hosting Institute: BRCAS, Academia Sinica

#### Context and research background

Unsustainable management of coastal development could lead to frequent disturbances that reduce the ability of coral reefs to cope with environmental changes. Located at the Hengchun Peninsula in the southern Taiwan, the Kenting National Park (KNP) was established in 1985 to protect the exceptional biodiversity of this area. In the last 30 years, and despite of marine protected areas were set up to preserve natural resources, negative impacts of human activities have considerably increased, causing a profound degradation of the coral reefs, as well as an decline of the resources available for coastal communities. Combined with recent bleaching events and typhoons in the KNP, this has resulted in a benthic community shift from coral-dominant to sea anemone or macro algae-dominant of many long-term monitoring sites, precipitating the collapse of services provided by coral reef ecosystem of the KNP. With the recent prevision on climate change, there is an urgent need to build a resilient system that could assist coral reefs in the KNP to face the challenge of future environmental modifications. Therefore, integrating the complexity of the ecological, environmental, and social economic expectations on this endeavor should be considered.

#### **Research Objectives**

This project applies a trans-disciplinary approach to preserve coral reef integrity and their associated resources around the KNP. First, environmental settings from the watershed, catchment, and coastal water that affect the modern coral reef ecosystem are assessed (Environmental Subproject). Second, an ecological assessment examines the current conditions of the reefs and their fishery resources around Kenting (Ecological Sub-project). These results are combined with a socio-economic assessment to inventor and quantify their benefits to the coastal communities (Socio-Economic Subproject). Feedback on the biological resources and coral reef health are further evaluated by analyzing impacts of anthropogenic



disturbances on the coral reefs in the region. Historical data from an extensive review of the literature on coral reefs in Kenting are combined with these results and integrated in a framework linking social-ecological assessment in KNP, though System-Dynamic modelling (Modeling Sub-project). Relevant parameters responsible of the reefs degradation are identified, and according to coral reef's responses to catastrophic climatic events such as coral bleaching and typhoons, different scenarios are simulated to analyze the evolution of this ecosystem in an era of changes. Eventually, this project will deliver concrete and valuable recommendations for a sustainable management of the coral reefs and their resources around KNP.

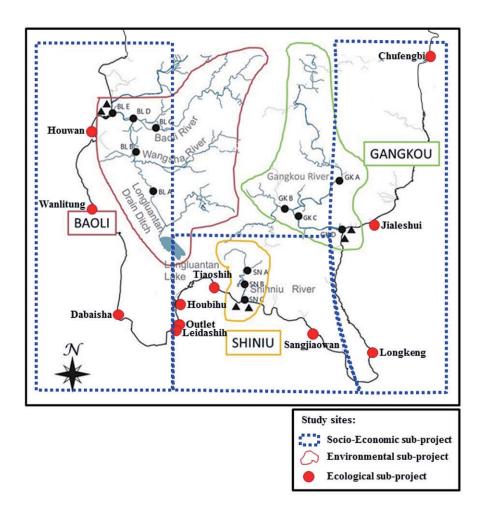
#### Main Results to Date

- The Baoli River is the most polluted river, followed by the Shiniu River. Finally the Gangkou River remains the less polluted river combining a better water quality, a better environmental conditions and a lower urbanization.
- Three different reef ecosystem dynamics, including coral-algal mixed, coral-, and algae-dominant communities, have been identified within the Kenting National Park.

- Due to the strong El Niño event in 2016, some reefs in Kenting close to the Nuclear Power Plant Outlet are currently suffering from a moderate bleaching down to 7m depth.
- Fish communities are highly depopulated. Benthic degraded sites and poor fish communities seem to be highly related.
- Over one thousands Kenting reef' users have been interviewed. Between and within user types important heterogeneity of expectations has been identified.
- Common trends between user groups remain a desire of improvement of Kenting reefs conditions. However, the willingness to pay to improve reef conditions is marginal.
- The structure of the models are currently being built.

#### **Future Research Plan**

- Investigations to relay responsible parameters (natural and anthropogenic) to those different ecosystem dynamics are under process.
- Due to the major role that 3D complexity of the reefs might play in KNP for resilience of fish and benthic components, further analyses on reef rugosity will be performed.



- Collected data from all the sub-projects will be integrated and tested into the model layer by layer. Require adjustments and improvements will be then done before starting the spatial stage.
- Estimating the conservation values under human impact reduction programs, and compare the preferences and attritudes between different stakeholders.
- Estimating the values on coral ecosystem from the conservation policy

#### Sub-Project PI, Co-PI:

Meng, Pei-Jie, NMMBA Chen, Yun-Ju, DAE, NCHU Chang, Yang Chi, DMEE, NSYSU

Other members: Château, Pierre-Alexandre, BRC, AS Chiu, Yuh-Wen, NMMBA

Chen, Chi-Chung, DAE, NCHU

Denis, Vianney, IO, NTU

Lee, Chun-Hung, DNRES, NDHU Wen, Colin Kuo-Chang, DLS, TU

Ribas-Deulofeu, Lauriane, TIGP-biodiv, BRC, AS

# Thermoelectrics as Alternative Sustainable Energy Source



Hosting Institute: IAMS, Academia Sinica

#### **Research Objectives**

- To study the fundamental mechanisms of effective thermoelectric (TE) conversion with respect to nano structuring, alloying, compositing, and new surface transports.
- Rational design of advanced TE materials to enhance the figure of merits (zT) for both p- and n-type thermoelectric materials and to transfer such technologies for feasible applications.
- To investigate the properties of non-toxic and low cost thermoelectric materials for sustainable applications.

The fast-paced development of various technologies that affect our lives have consequently increased our energy consumption that were unheard of decades ago. Such continuous demand for more energy have led us to look for alternative, cheap and sustainable sources. One of the technologies that garnered attention since a century back takes advantage of the thermoelectric effect (TE)—a phenomenon that allows us to create devices that can

generate electricity through temperature gradients. This means that we can harness the waste heat produced from the inefficiency of the current technologies and convert them to useful energy sources such as electricity.

Despite the long history of thermoelectric, the accompanying technological developments haven't been able to play a significant role in helping support our energy needs. One of the key factors that still require attention is the thermoelectric material itself. The thermoelectric project in Academia Sinica, which started since 2011, is formed in order to explore the potential of thermoelectricity as a sustainable energy source. In order to achieve the above mentioned goals, this project has been divided into sub-groups headed by experts in their own respective field of study. As shown in Fig. 1, Thermoelectric Workshop & Exhibition was held in 2015 to promote exchange of ideas and experiences among international and domestic researchers.

#### Main Results to Date

 Attained new understanding about thermal transport in SiGe alloys, which is essential



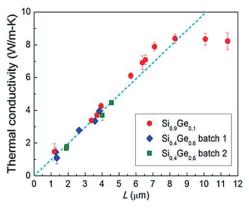
Figure 1. Thermoelectric Workshop & Exhibition was held in 2015 to promote exchange of ideas and experiences among international and domestic researchers.

in thermoelectric properties. As shown in Fig. 2, the results have been published in high impact journals such as Nature Nanotechnology and PRB.

- Demonstrated enhanced TE performance of aerogel TE structures with ultralow thermal conductivity, leading to a new direction in TE materials.
- Achieved high performance up to zT=1.5 for BiSbTe, and zT=1.48 and 1.4 for GeSbTe and Zn4Sb3 respectively. A preliminary data on GeSbTe thin film showed a zT above 3.0 as shown in Fig. 3, which is highly desirable in this field.

 Achieved a good performance up to zT=1.2 for earth-abundant and low cost Mg<sub>2</sub>Sn as TE material.

In the past years, we have established the infrastructure necessary to conduct effective research towards synthesis, development and characterization of thermoelectric materials. Additional support from the Nano Core Facilities in Academia Sinica and high resolution transmission electron microscopy (TEM) facilities in Center for Condensed Matter Sciences (CCMS), National Taiwan University (NTU) provides the cutting edge analytical tools that greatly benefit the characterization aspect of this project.



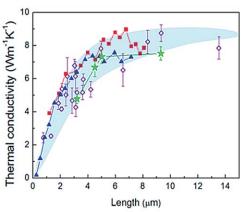


Figure 2. Evidence for ballistic thermal conduction in homogeneously-alloyed nanowire (left) and in heterogeneously-alloyed nanowire (right).

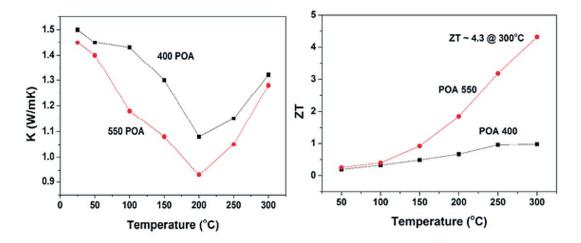


Figure 3. Thermal conductivity and figure-of-merit (zT) of GST thin film with high zT over 3.0.

We have a team of about 30 members composed of 8 post-docs, 7 assistants and 15 students. A monthly meeting to facilitate progress report and exchange of ideas has been held in the past. Workshops and exhibitions to promote international and domestic interaction have also been held.

We have discovered ballistic phonon transport behavior with mean free path above 8µm in SiGe nanowire, a phenomenon that can open up new direction in our goal of achieving better thermoelectric material and understanding of thermoelectric transport properties. In addition, we have also established a novel and much-needed measuring platforms for low-dimensional structure materials (Fig. 2). This would help us study the thermoelectric properties of nanowires, nanosheets and thin films more effectively. The fundamental knowledge obtained from these studies is beneficial in improving our current understanding of thermoelectric materials.

#### **Future Research Plan**

For the future, we will be continuing our work in the synthesis and measurement of TE properties of low-dimensional nanostructures, hetero-composites of multiple components with different TE properties, layered and cage-shape topological insulating



Figure 4. Schematic of the restructured TE Team with PIs and the title of the four sub-projects, respectively.

TE materials, quantum sized TE materials, ballistic phonon transport in alloyed TE materials, and development of non-toxic low-cost TE materials. A newly structured team with defined topics is under construction as schemed in Fig. 4. Specific tasks include:

- Integrate the experimental and theoretical efforts to get better understanding of TE materials.
- Explore the aerogel and nano-composite TE structures and secure the intellectual property right of such discovery.

• Continue to explore different TE materials including nanostructures, alloys, nanocomposites, thin film TE materials including GeSbTe to achieve high performance TE devices.

Meanwhile, development of direct ZT measurement technique such as the Harman method is currently undergoing to cut down the time for traditional ZT measurement.

A three-terminal thermal conductor with nonlocal thermal conduction design will be implemented to test of a new concept. Moreover, we are also collaborating with China Steel Corporation (CSC) and Industrial Technology Research Institute (ITRI) to facilitate technology transfer of our established processes.

#### Sub-Project PI, Co-PI:

Wu, Maw-Kuen, IOP, AS Chou, Fang-Cheng, CCMS, NTU Chen, Yang-Yuan, IOP, AS Chang, Chih-Wei, CCMS, NTU Sankar, Raman, IOP, AS Hsieh, Wen-Pin, IES, AS

# **Efficient Transformation and Utilization** of Solar Energy



Hosting Institute: IC, Academia Sinica

#### **Research Objectives**

This project aims to develop modern technology toward the harnessing of solar energy and to translate the technology to some practical applications. The project contains three components: (1) Development of dyesensitized solar cells through synthesis of novel light-absorbing molecules, development of electrolyte systems, new photoelectrodes; (2) Study of organic/inorganic hybrid solar cells through fabrication of surface nanostructures on electrode, development of suitable charge transporting materials, modulation of electrode work function, control of morphology of perovskite/organic composites; (3) Study of novel solar energybased hydrogen generation/storage systems through development of photocatalytic and electrochemical systems for water splitting, synthesis of hydrogen-absorbing nanoporous systems.



1-1. Sensitizers based on rigidified segment comprising fused electron-rich and

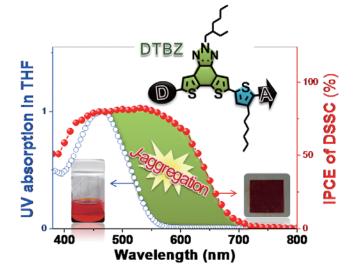


Figure 1. Improved light harvesting due to *J*-aggregation of the dye results in high performance DSSC.

electron-deficient aromatics in the conjugated spacer exhibit broad and intense absorption in the visible region and J-aggregation of the dyes results in high cell efficiency (9.10%), which surpasses that of the standard cell based on N719.

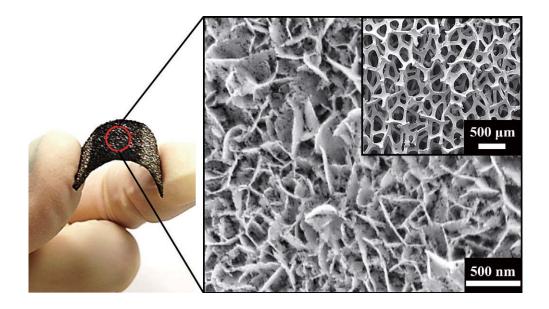


Figure 2. Photograph (left) and SEM image (right) of CoSe<sub>2</sub>/C-NCW on flexible NF.

- 1-2. Organic dye derived from photo-induced cross-linking of a tethered diacetylene monomer effectively suppresses dark current and enhance light harvesting, leading to high cell efficiency (8.27%), surpassing that of monomer dye (7.17%) by 15%.
- 1-3. Pt-free counter electrodes for high performance DSSCs have been developed: CoSe2/C-NCW (nanoclimbing-wall-like) on flexible NF (nickel foam), η: 10.46 (1 sun) and 7.90 (0.2 sun); MoSe2 NS/PEDOT:PSS composite film coated on flexible Ti foil, η: 8.51 (vs. Pt-coated Ti foil CE, 8.20%).
- 2-1. DSSC with a ternary ionic liquid, NMP-2C/TEA-2C/PMII (v/v/v = 28/7/65; NMP = methylpiperidinium, TEA = triethylammonium, PFC = perfluorocarboxylate), gave an efficiency of 6.01% and retained similar efficiency up to 1200 h at 50 °C.
- 2-2. Solution processed cathode buffer layers ZrO<sub>x</sub> and PC<sub>61</sub>BM fullerene derivative, doped (10 mol%) with cetyltrimethylammonium bromide

- (CTAB) were demonstrated to promote power conversion efficiency ( $ZrO_x$ : 6.5%  $\rightarrow$  14.9%;  $PC_{61}BM$ : 2.4%  $\rightarrow$  15.2%) of perovskite-based solar cells.
- 2-3. By replacing PEDOT:PSS with a blend of carbon nano-tubes in a hybrid solar cell, a top layer with higher horizontal conductivity and better hole collection was obtained. The solar cell with CNT top layer gave power conversion efficiency about 14.5%.
- 2-4. Modification of TiO<sub>2</sub> surface with self-assembled monolayer improves the morphology of perovskite film to be more continuous and crystalline.
- 3-1. Several water-soluble and air-stable designed iron nitrosyl complexes were synthesized and applied in hydrogen generation. Both iron-nitrosyl and cobalt porphyrin catalysts revealed good reversibility of the redox processes and stability. The working potential of the iron-nitrosyl complex for catalysis under the basic condition (pH 12) has been decreasing and efforts to further lower the potential is continued.

5. To prepare p-type CH<sub>3</sub>NH<sub>3</sub>Pb(SCN)<sub>2</sub>I<sub>2</sub> solar cells and test its performance with CTAB-doped ZrO<sub>x</sub> cathode buffer layer or CTAB-doped PC<sub>61</sub>BM electron-transporting material.
6. Use of nano-structured TiO<sub>2</sub> electrode for improved dye adsorption and charge

- collection.

  7. Further development of water oxidation catalysts, water reduction catalysts, and photosensitizers to build solar-panel-driven hydrogen generation cells or photo-
- 8. Integrating highly efficient perovskite solar cells or dye-sensitized solar cells with the electrochemical hydrogen generation system for hydrogen production.

catalysts-driven hydrogen generation units.

3-2. A series of high surface area Al-based metal-organic frameworks (MOFs) were synthesized from tetrazing ligand and take up 3.2 wt% of H2 at 77 K and 1 atm. This is the highest value of hydrogen uptake compared with reported data of other materials using MOFs up to date.

#### **Future Research Plan**

- 1. To develop sensitizers with higher voltages (dyes enabling more effective dark current suppression and redox mediators) and higher current (co-sensitized system) for high performance DSSCs and possible indoor applications.
- 2. To develop gel-type redox mediators for DSSCs of high temporal stability.
- 3. To prepare low cost platinum-free counter electrodes for high performance DSSCs.
- 4. To Synthesize high performance nonfullerene, electron-transporting materials for p-type perovskite solar cells.

#### Sub-Project PI, Co-PI:

Lin, Jiann-Tsuen, IC, AS Chen, Chin-Ti, IC, AS Chiang, Ming-Hsi, IC, AS Liaw, Wen-Feng, DC, NTHU Sun, Shih-Sheng, IC, AS Meng, Hsin-Fei, IP, NCTU Lu, Kuang-Lieh, IC, AS Ho, Kuo-Chuan, DCE, NTU Hung, Chen-Hsiung, IC, AS Lin, Jiann-Tuenn, IC, AS

### Development of new-generation solutionprocessed organic solar cells



Hosting Institute: CCMS, NTU

#### **Research Objectives**

The CO2 emission rate of Taiwan increases dramatically in years. A great proportion comes from energy related combustion. If there were no aggressive measures taken to resolve it, Taiwan not only would become one accomplice of deteriorating global warming, but also would be, directly and indirectly, suffered from extreme weather conditions. The development of low-carbon energy has therefore become one main effort to achieve sustainable development and energy security in Taiwan. After the nuclear calamity at Fukushima of Japan in 2011, Taiwan, also being located at the Circum-Pacific Seismic Belt, cannot take nuclear energy as one sustainable energy option and has to develop renewable energies.

In light of Taiwan's renewable energy need, current status of advanced organic photovoltaic technology and this team's research competencies in solar photovoltaics, this project aims to develop new-generation solution processed organic solar cells. The whole program is divided into four subprojects: (1) solution processed low band-gap conjugated polymers hydrogen-bonding with buckminsterfullerene derivatives, (2) highly efficient solution-processed small molecule organic solar cells, (3) in-depth physical studies and device analysis of organic solar cells, and (4) production and testing of large solution-processed organic solar cells.

This project is established on the basis of our current research in solar cells supported by the Nanoscience and Technology Program in Academia Sinica. The first two subprojects are closely linked, for the respectively developed organic materials (polymers and small molecules) and pertinent processing technologies can be benefited each other. The third sub-project focuses on in-depth analysis on the physical properties of the developed materials from the two former sub-projects, and the devices thus fabricated based on these materials to provide crucial advices to the other subprojects. Finally, the fourth sub-project transfers the developed organic photovoltaic technologies into largescale device fabrication, linking the up-stream

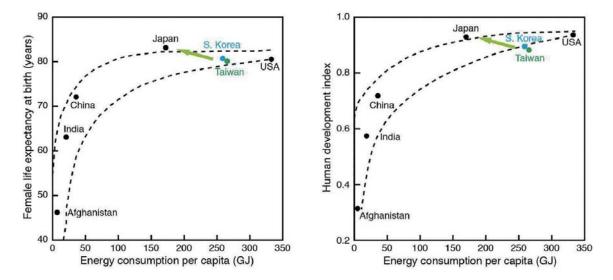


Figure 1. Most of humanity needs to consume a great deal more energy in order to experience reasonably healthy lives and to enjoy at least a modicum of prosperity. Both life expectancy and human development index follow a similar trend with respect to the energy consumption per capita (ECC): When ECC reaches >150 GJ, both indices remain almost constant. Taiwan could lower her ECC while still raise the two indices by engaging higher efficiency in energy usage and deploying more renewable energies (owing to its reduction of primary energy consumption and pollution). These two charts indicate the necessity to research and employ renewable energies in Taiwan.

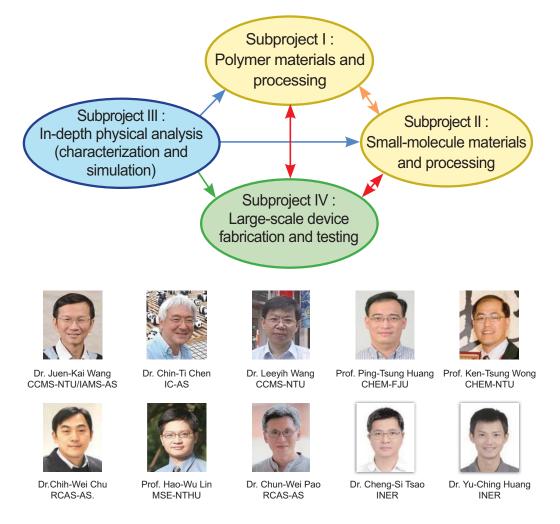


Figure 2. The project is composed of four subprojects: (1) polymer materials and processing, (2) small-molecule materials and processing, (3) in-depth physical analysis (characterization and simulation), and (4) large-scale device fabrication and testing. Ten principal investigators, coming from different institutions, participate in this joint project.

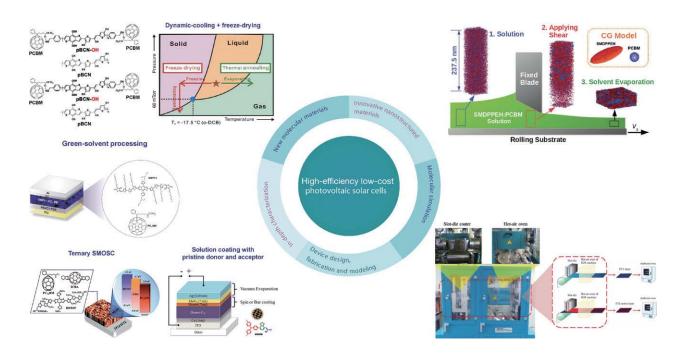


Figure 3. The project is executed with the collaboration of five research efforts: (1) new molecular materials, (2) innovative nanostructured materials, (3) device design, fabrication and modeling, (4) in-depth characterization, (5) molecular simulation. The project is built around a multi-disciplinary platform to enable trans-disciplinary cooperation. The project goal is high-efficiency low-cost photovoltaic solar cells.

researches to the mid-stream technology development and thus establishing a firm ground for potential commercialization.

#### Main Results to Date

After two and a half years of research efforts, we have accomplished the planned deliverables and milestone targets. The achievements of the four subprojects are epitomized below. In Subproject I, the stability of polymer solar cells—one critical issue of their implementation—was strengthened with use of a newly developed end-functionalized compatibilizer (pBCN-COH) and dynamic-cooling and freeze-dry (DCFD) method that stabilize molecular aggregation via H-bond formation and lowtemperature processing. In Subproject II, the bar-coated devices employed small-molecule donors combining with C70 as acceptor showed the best performance with PCE of up to 5.9%. In the effort of developing green fabrication technology, high-efficiency solar cells were successfully fabricated with the

non-halogenated solvents with PCEs that were comparable to and even higher than that with chlorinated solvent, indicating that non-halogenated or green solvents can be excellent alternatives for the roll-to-roll printing of large area modulus. In Subproject III, a coarse-grained molecular dynamics simulation framework was constructed to investigate the organizations of both polymer and small molecule organic solar cells in various solvent solutions, and monitoring the nanomorphology evolution during solvent evaporation processes. Molecular packing during dynamical cooling of P3HT:PCBM blended system during DCFD process was revealed via in-situ characterization of absorption, fluorescence and Raman spectroscopy. In Subproject IV, large-scale fabrication of high-performance solutionprocessed inverted polymer solar cells from cell to module with the roll-to-roll (R2R) process was developed. Halogen-free solvent, o-xylene, was successfully incorporated in the R2R slot-die fabrication of inverted solar cells.





Figure 4. Summer Workshops for Photovoltaics in 2015 and 2016 were held to facilitate scholar exchange between international and domestic researchers.

#### **Future Research Plan**

The project is now working towards the ultimate targets listed below: (1) new polymer and small-molecule materials and their associated processing technologies for high-performance solution-processed organic solar cells, (2) new device structures and fabrication technologies that optimize the photovoltaic performance of these materials,

and (3) new large-area solar cells, based on the technologies developed above, produced by roll-to-rool or sheet-to-sheet manufacturing and the following two deliverables: (1) achieving the power conversion efficiency of 4% for organic solar cells with a device area of  $0.3 \times 1$  cm<sup>2</sup> and (2) achieving the power conversion efficiency of 5% for organic solar cells with a device area of  $1 \times 1$  cm<sup>2</sup>.

#### Sub-Project PI, Co-PI:

Chen, Chin-Ti, IC, AS Wong, Ken-Tsung, CH, NTU Wang, Juen-Kai, IAMS, AS Chu, Ming-Wen, NTU-CCMS, NTU Huang, Yu-Ching, INER, Executive Yuan Wang, Leeyih, CCMS, NTU
Chu, Chih-Wei, RCAS, AS
Pao, Chun-Wei, RCAS, AS
Wu, Chih-I, EE, NTU
Cha, Hou-Chin, INER, Executive Yuan

Huang, Ping-Tsung, CH, FJU Lin, Hao-Wu, MSE,NTHU Tsao, Cheng-Si, INER, Executive Yuan Chen, Char-Ying, INER, Executive Yuan

### Biotechnology of Anaerobic Digestion Producing Biogas Energy



Hosting Institute: IBC, Academia Sinica

#### **Research Objectives**

The most formidable challenges we face on a global scale are associated with how we manage our environment and how we harness and use our energy. Anaerobic digestion, a microbial process converting agricultural, industrial or city wastes into biogas (a mixture of CH4 and CO2) energy, tackles both issues simultaneously. Large scale digesters or biogas plants can generate biogas for heat, for megawatt electricity or for transportation fuel. The workhorse of anaerobic digestion is a mixed culture of various kinds of microorganisms in the digester. They work syntrophically to break down complex molecules into simple CH4 and CO2 (Fig. 1). The knowledge concerning the microbiology, biochemistry and their regulation in the digester is very limited. We propose this project of a mission-oriented basic research, using genomic and proteomic technologies to have a deep look into the "black box". With acquired new information, it is possible that anaerobic digestion can be biologically improved for higher activity and stability.

Four research scientists from Academia Sinica and two faculty members from National Taiwan University will work collaboratively on three sub-projects: 1) laboratory study of anaerobic digestion, 2) metagenomics and bioinformatics, and 3) proteomics and enzyme discovery.

#### Main Results to Date

To improve our understanding of the complex microbial communities that reside in anaerobic digesters, 8 bench-top 3-L CSTRs (completely stirred tank reactors) were installed in the laboratory (Fig. 2). These digesters will serve as the basic platform for systematic studies to search for the optimal operation to maximize biogas production from pig manure. With the long-turn observation of these anaerobic digesters, we found the condition of 8% total solid with 5 days of hydraulic retention time at 55°C showed the highest methane production rate of 2.27 L methane/L/day.

The fermentation products from stabilized anaerobic digesters were the materials for further high-throughput DNA sequencing,

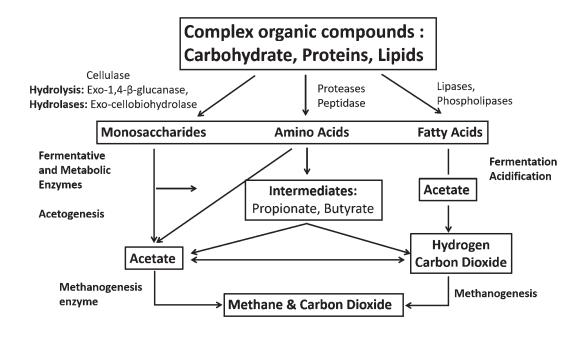


Figure 1. The anaerobic digestion network from complex molecules into simple biogas.

bioinformatics, modeling, proteomics and metabolomic analysis. These results can provide recommendations that increase the efficiency and stability of anaerobic digester operation. During the ongoing project in 2015, we collected the sludge from anaerobic digesters not only from pig manure but also from the steady-state chicken manure anaerobic digesters. We uncovered the microbial community in the anaerobic digesters via metagenomics scale of next-generational sequencing (Fig. 3). Based on bioinformatics approach, we developed network models to help inferring the microbial interactions within anaerobic digesters.

The microbial community involving in anaerobic digestion and methane production in the steady-state anaerobic digester from chicken manure were analyzed via proteomic and metabolomic analysis. According to the total bacterial and archaeal protein database, we can identify each functional protein belonging to which microorganism. The syntrophic networks of microbes which process the anaerobic digestion was uncovered through the identified functional proteins (Fig. 4). We proposed to base on the proteomic peptides database and the metagenomic results, we can determine the dominate species of microbes which involved in the process of



Figure 2. Eight bench-top 3-L completely stirred tank reactors were set-up with condition of 5% or 8% total solids coupled with 37°C or 55°C incubation temperature. Each condition was started-up with duplicate anaerobic digesters for further long-turn observation.

anaerobic digestion and methane production from anaerobic digesters with pig or chicken manure as substrates.

#### **Future Research Plan**

We are currently organizing the metagenomics and proteomics data obtained from steady-state anaerobic digesters with either pig manure or chicken manure. We will further investigate the effects of disturbance events on the composition and function of microbial communities to identify the microbes that are responsible for the stability of anaerobic digester. Base on the integration of metagenomics and metaproteomic data,

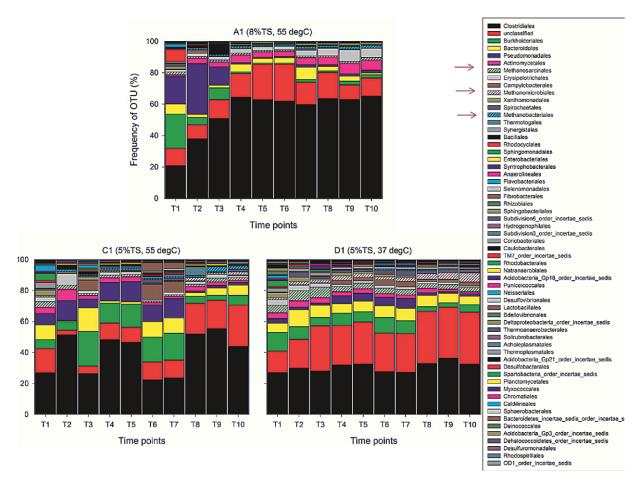


Figure 3. Microbial diversity among anaerobic digesters from pig manure under different fermentation conditions. Time points from T1 to T10 indicated the individual sampling time during steady-state of methane production. Different orders in phylogeny mark in different colors to show the diverse microbial components among anaerobic digesters.

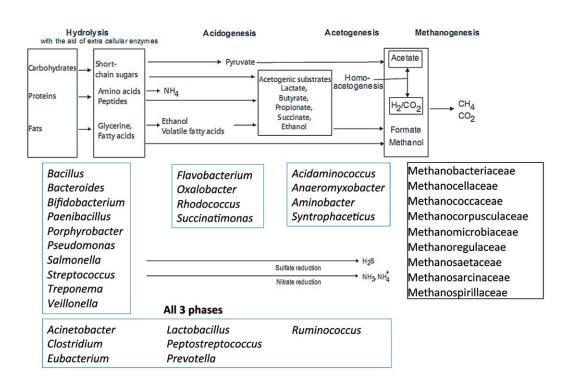


Figure 4. The identified microbes involving in four-phases of anaerobic digestion via proteomic analysis.

we proposed to obtain the comprehensive understanding of the microbial community involved in anaerobic digestion. The inferred microbial interaction network will provide us some information to modify the bacterial community and enhance the biogas yield. We will further choose the key species of

microbes in anaerobic digester to activate/ modulate the steady-state anaerobic digesters we have. Furthermore, we also like to try different materials from poultry, livestock, and other biowastes for co-digestion with manure to enhance the methane production rate.

Sub-Project PI, Co-PI:

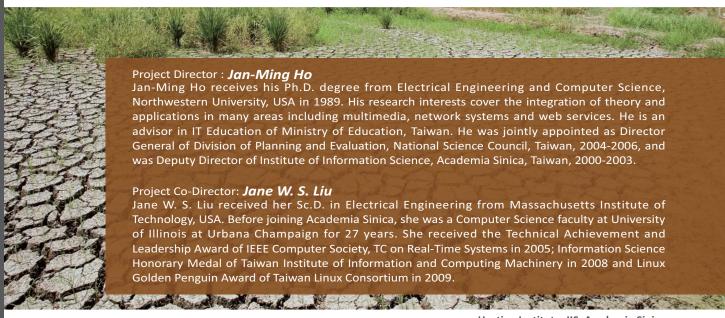
Chou, Chu-Yang, BRC, NTU

Chen, Suming, BRC, NTU

Wang, Daryi, BRC, AS

2015-2016 Biennial Report

# DRBoaST (Disaster Resilience through Big Open Data and Smart Things)



Hosting Institute: IIS, Academia Sinica

#### **Research Objectives**

The three-year Sustainability Science Research project DRBoaST (Disaster Resiliency through Big Open Data and Smart Things) is a continuation of project OpenISDM (Open Information Systems for Disaster Management). The structure of DRBoaST project is shown in Figure 1. While the focus of OpenISDM was on technologies for building open and sustainable information systems for disaster management, project DRBoaST is concerned primarily with the generation and use of data. Its objectives are

- To develop methods and tools for capturing, collection and maintenance of critically needed but missing data for disaster risk reduction, and
- To exploit big and open data and Internet of Things for sake of minimizing personal dangers and reducing property damages when disasters strike.

#### Main Results to Date

In addition to virtual information repositories and tools (e.g., Taiwan Earthquake Science Information System, volunteer GIS platform

and planning domain ontology), which were described in our 2014 Annual Report, results of the project include proof-of-concept prototypes of active emergency response systems (AERS) [1, 2] (shown in Figure 2). Being active, smart devices, applications and subsystems in AERS can automatically process alert messages from authorized senders and building safety systems and take appropriate disaster risk reduction actions. Examples include smart devices and mobile applications that shut gas valves to prevent fire, open doors to ease evacuation, bring elevators to the ground floor, turns off electric appliances, and deliver locationand environment-specific instructions to people upon receiving from Central Weather Bureau an early strong earthquake alert in the international standard CAP (Common Alert Protocol) format. During a disaster, an AERS for a large building can leverage existing surveillance cameras for damage assessment and establish and maintain a temporary network when Internet and phone connections within the building are disrupted.

Results on AERS have demonstrated that diverse configurable and customizable active

Component Names	Principal and Co-Principal Investigators
Main Project	PI: Jan-Ming Ho Co-PIs: Jane W. S. Liu, Der-Tsai Lee, and Chi-Sheng Shih
Sub-project 1: SIDiRC (Strategies and Information for Disaster Resilient Communities )	PI: Feng-Tyan Lin Co-PI's: Han-Liang Lin and Hseuh-Cheng Chou
Sub-Project 2: RTEIC (Real-Time Earthquake Information Cloud for Disaster Preparedness and Response)	PI: Jian-Cheng Lee Co-PI's: Wen-Tzong Liang and Nai-Chi Hsiao
Sub-Project 3: DiSRC ( Disaster Scenario and Record Capture – Authoring Technologies)	PI: Wen-Lian Hsu Co-PI's: Fu-Shih Lin and Hsiang-Chieh Lee
Sub-Project 4: ADiPLE (Active, Disaster Prepared Smart Living Environment)	PI: Tei-Wei Kuo Co-PI's: Edward TH. Chu, Jane W. S. Liu, and Feng-Tyan Lin
Sub-Project 5: CSAI ( Crowdsourcing Situation Awareness Information – Foundation)	PI: John Kar-Kin Zao Co:PI's: Edward TH. Chu and Jane W. S. Liu

Figure 1. Structure and sub-projects of DRBoaST

Specifically, Sub-projects SIDIRC and RTEIC are concerned with, respectively, the generation and maintenance of fine-scale, community-specific information needed to support community-specific disaster risk reduction strategies of disaster-prone communities in Taiwan and delivery of near real-time earthquake related scientific information after each significant earthquake in Taiwan and the use of observational data on geo-hazards caused by the quake to assess new risks of earthquake-triggered compound disasters. Sub-project DiSRC is developing advanced tools for capturing disaster scenarios and generation of machine-readable disaster historical records. Sub-project ADiPLE works to enable the pervasive use of active emergency response devices, applications and systems to enhance disaster preparedness. Sub-project CSAI is concerned with tools for crowdsourcing observational data and the use of the data synergistically with physical sensor data to support situation awareness and decisions of disaster surveillance systems.

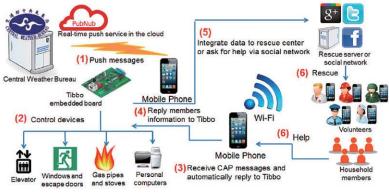


Figure 2. AERS flow chart

components of AERS can indeed be built on a common framework from the same set of reusable components and that CAP alerts can be delivered asynchronously over the Internet to active embedded devices in a timely fashion. In a field trial for evaluating the effectiveness of AERS, the prototype AERS carried out the above mentioned operations in response to a simulated strong earthquake alert. Measured data show that the time for people to carry out these operations can be as long as 15 seconds. By having AERS perform them, people were given sufficient time for get under sturdy furniture, or to evacuate from the third floor to the first floor, or to run more than 100 meters.

Figure 3 shows two mature subsystems of AERS that are ready for technology transfer. The Building/environment Data-

Based Indoor Positioning System (BeDIPS) [3], shown in the top part of Figure 3, is designed to help people in large public buildings to locate themselves within a few meters. In addition to location accuracy, IPS (Indoor Positioning Systems) for large public buildings must stay responsive during orders of magnitude surges in crowd density and location queries; be easy to deploy and systematically maintained; can function without Internet, WiFi and cell phone coverage; and can deliver location information to users via common mobile devices. Typical state-ofthe-art and advanced IPS cannot meet these requirements. BeDIPS meets these requirements by using location beacons that broadcast independently their own 3D coordinates. The design, layout and installation of systems in large buildings are made possible by making innovative use of 3D models provided by the building information models (BIM). The project plans to install BeDIPS in representative large public buildings (e.g., transport hubs and major hospitals) in order to assess its

usability and performance in real-life operating environments.

During emergencies, camera-based surveillance systems are commonly used to support damage assessment, situation awareness and rescue and response operations. Image-Based Disaster Damage Assessment System (IDEAS) [4], shown in the bottom part of Figure 3, is designed to automate image-based damage assessment processes. It does so by comparing images taken by each camera before and after an emergency event. The system was motivated by the fact that in large buildings, hundreds and thousands of images may need to be checked and human's ability to perform the tedious and time consuming tasks of determining manually from images the extents of damage caused by the disaster is limited. In addition to a general IDEAS framework, the project has implemented and evaluated an image-based earthquake damage assessment scheme. Performance data show that IDEAS performs better than existing methods and can achieve an average accuracy of 97.6 % in mapping Mercalli intensity scale. In the future, the project plans to extend IDEAS by adding schemes for image-based assessments of damages inside buildings caused by other types of disasters, including flash floods, typhoons and debris flows/landslides.

Progress has also been made on crowdsourcing observational data for disaster surveillance purposes. Modern disaster surveillance and risk assessment systems, including Taiwan Scientific Earthquake Report

(TSER) system being built by Sub-Project RTEIC (Real-Time Earthquake Information Cloud), may need to make critically important decisions within minutes and hours. Often, crowdsourcing observational data is needed to mend the holes in physical sensor coverage. When crowdsourcing data for this purpose, the system must make effective use of volunteers, guide and monitor them during their explorations and process their reports in real-time to extract decision support information of good and quantifiable quality. Such crowdsourcing processes, as illustrated by Figure 4, are said to be system-driven, as opposed to the crowd-driven approach used for participatory sensing and crowdsourcing crisis information purposes.

CROSS (CROwdsouring Support system for disaster Surveillance) [5] was prototyped to support system-driven crowdsourcing processes [5]. A key component is the volunteer management system (VMS) shown in Figure 5. Typical system-driven crowdsourcing projects, including the TSER project, use registered volunteers. VMS enables people to sign up as volunteers of one or more crowdsourcing projects by registering with the system. In the process, each of them specifies the projects he/she wants to participate and his/her attributes

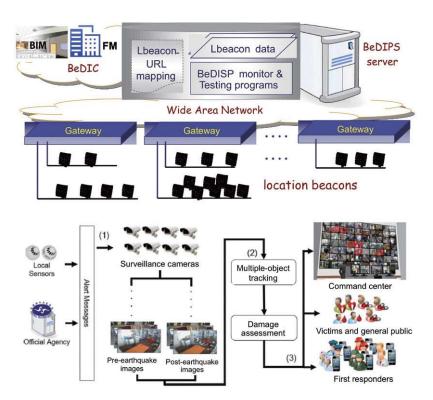


Figure 3. (Top) BeDIPS and (bottom) IDEAS

and credential in general, as well as information needed to assess his/her abilities to participate and constraints associated with his/her participation. Information about each registered volunteered is maintained by the volunteer profile management module. The VMS also provides project managers with support to solicit project-specified information from volunteers during their registration and access to information about volunteers needed to support their selections as participants. The volunteer coordination module contains information on the current commitments of each volunteer. It provides a project manager with real-time information on the current location, activities/ duties, etc. of each volunteer participating in the project's crowdsourcing processes. AAA stands for authentication, authorization and accounting. It enables the system to applied fine-grain, role-based control to access of information maintained by VMS.

VMS was used during the training workshop in July 2016 for registering over 70 volunteers recruited from high school teachers and college students by sub-project RTEIS to participate in crowdsourcing TSER. (Figure 6 shows several photos taken during the workshop). The sub-project has built a crowd-driven crowdsourcing system called DYFI (Do You Feel It) for



Figure 4. System-driven crowdsourcing

creating a shake intensities and damage map after each significant earthquake in Taiwan with the help people who want to share their experiences. TSER is a complementary system: It aims to provide quantitative and qualitative information about natural damages or hazard (e.g., surface rupture, landslide, rock fall, liquefaction, and landslide-triggered dam or lake) induced or triggered by the quake. The July workshop provided volunteers with lectures and field trips designed to educate them of the basics of the science of geological hazards and the way to report the damages of earthquake-induced hazards.

An operational version of CROSS capable of supporting the operations and management of crowdsourcing TSER will be made available within 2016. This version of CROSS is called Ushahidi+. It can be thought of as an extension of Ushahidi, the well-known and commonly platform for crowdsourcing crisis information. In addition to VMS, extensions include the Ushahidi map, which is extended to display for the project manager tours being followed by participants of the on-going crowdsourcing processes of launched by the project. Ushahidi+ also aims to provide tools that make use of popular social-networking services to broadcast of calls for participations to registered volunteers, formulate participant selection

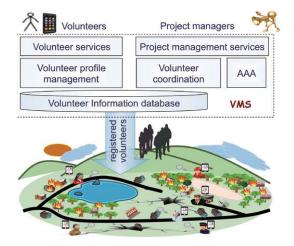


Figure 5. Components of VMS and a use scenario



Figure 6. Photos from TSER volunteer training workshop

problems and submitting the problems to solvers to get selection and assignments of participants, and support the communication between participants and the system (and project manager).

#### Future Research Plan

A high-level goal of the project is to enable pervasive deployment and use of AERS in 5-10 years in Taiwan and abroad.

#### Website:

**Project Home: OpenISDM:** https://openisdm.iis. sinica.edu.tw

**DYFI (Did You Feel It):** http://tesis.earth.sinica.edu.tw/DYFI/

VMS (Volunteer Management Systems):

http://openisdm.github.io/volunteer/#/

**ReDIPS** 

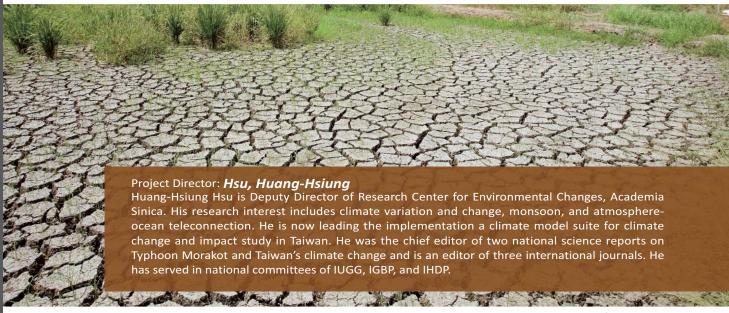
https://github.com/OpenISDM/Lbeacon

#### Sub-Project PI, Co-PI

Jan-Ming Ho, IIS and CITI, AS
Chi-Sheng Shih, CSIE, NTU
Hseuh-Cheng Chou, Geo, NTNU
Nai-Chi Hsiao, Seismological Center, CWB
Hsiang-Chieh Lee, SES, NCDR
John Kar-Kin Zao, CS, NCTU

Jane W. S. Liu, IIS and CITI, AS Feng-Tyan Lin, UP, NCKU Jian-Cheng Lee, IES, AS Wen-Lian Hsu, IIS, AS Tei-Wei Kuo, CSIE, NTU Der-Tsai Lee, IIS, AS Han-Liang Lin, UP, NCKU Wen-Tzong Liang, IES, AS Fu-Shih Lin, IHP, AS Edward T.-H. Chu, CSIE, YunTech

# Study on Climate Change and Urban development/Land Use



Hosting Institute: RCEC, Academia Sinica

#### **Research Objectives**

This project is aimed to develop a dynamical modeling system for downscaling the climate change information obtained from global climate models, which provide data in the order of one-hundred kilometers, to fine local scale (e.g., few-hundred meters to 1 kilometer). This system will be used to understand, assess and project climate change in urban scale. This dynamical system will also be linked with the study of urban development and land use to explore the mutual effects between urbanization, land use and climate change impact. The targeted regions are the Taipei Metropolitan area and the Tseng-wen River basin for the issue on urban development and management of river basin, respectively.

#### Main Results to Date

This study integrates the expertise in climate, hydrological disaster, and urban planning to assess i) the potential threat of future global warming on climate in northern Taiwan and the flood-related disasters and property loss in the Tseng-wen River basin, and ii) the effectiveness of possible adaptation measures in reducing the impacts. Prototypes of cross-

disciplinary assessment systems are developed and used to demonstrate the usefulness of this modeling approach. This system is the first of its kind in Taiwan and can be used for more studies to assess climate change impacts.

This project ended in 2015. Seven research subjects were completed.

- 1. Assessing impacts of global warming on extreme weather and climate near Taiwan using an extremely high-resolution climate model (example in Figure 1);
- 2. Climate variability projection over Taiwan: regional dynamical downscaling and the impact of urban heat island effect (example in Figure 2);
- 3. The flood adaptation analysis under Pseudo Global Warming scenario (example in Figure 3);
- 4. Documentation of urban development in past few decades and design of future urban plan scenario (example in Figure 4);
- 5. Understanding impacts of land cover and land use changes on Taiwan's climate in the past 100 years

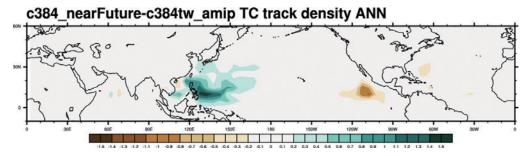


Figure 1. Changes in annual TC tracks by 2030-2050. The results suggest an increase in TC activity.

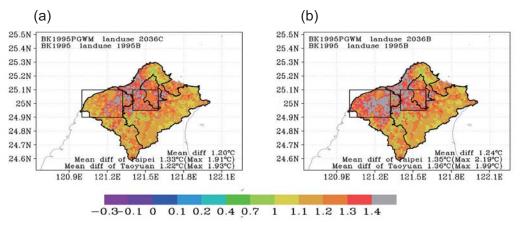


Figure 2. Increases in near-surface air temperature in July and August 2036. The projections were conducted in Pseudo Global Warming simulations by i) superimposing projected global warming on the observed 1995 atmospheric condition, and ii) assuming (a) a compact urban development and (b) a dispersed urban development. Effect of global warming will be worsened by projected future urban development. Urban expansion in compact form will reduce the warming in the dispersed form.

- 6. Trends of regional precipitation and their control mechanisms during 1979–2013
- 7. Accurate estimation of absorbed solar radiation by uneven terrain

Major achievements are summarized as follows.

- Establishment of an Integrated Modeling System for Global-Urban Climate and Land Use Impact Assessment: This system enables us in Taiwan for the first time to assess compounding effects of global warming and urbanization on local climate and provide guidance for sensible urban development in the warming future. The development and implementation of this integrated system, which is rarely seen in the international community, is unique in Taiwan and has high value and potential for both scientific research and practical use.
- Effectiveness evaluation of flood control works based on a combination of pseudo global warming experiment and flood adaptation analysis: Rainfall in the southern plain would increase 40 percent

- if Typhoon Morakot were to occur again in the late 21st century. Our finding reveals the limited effect of engineering approach in loss control. Non-engineering approaches such as evacuation, land use management measures, or flood disaster insurance system must be considered in the future for effective adaptation. This research approach combining climate change projection, flood inundation simulation, and loss assessment system is the first try in Taiwan and provides an excellent example in applying climate information to adaptation guidance.
- Extremely high-resolution global climate change projection: Future climate changes in 2030-2050 and 2076-2100 were projected in 25km resolution. Much fewer but stronger typhoons affecting Taiwan were projected by the end of 21st century under RCP8.5 scenario. Projection of fewer typhoons in warm season and weaker frontal activity in cool season implies the potential reduction in water resource, whereas stronger typhoon may escalate the impact of natural disasters.

#### FLOOD LOSS (USD Billion)

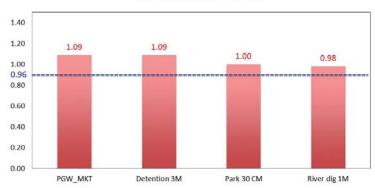


Figure 3. Estimated flood loss in Tsengwen river basin if Typhoon Morakot were to occur again in the end of this century. Typhoon Loss Assessment System was used for the estimation. The flooded area in Tsengwen river basin will increase by 10.4% and loss will increase from 0.96 to 1.09 billion USD. Three flood controls (namely, 3-m detention pool, 30-cm detention park, and 1-m river dredge) considered in the calculation show limited effect (less than 10%) in reducing the loss, not to consider the huge expenses needed for these engineering implementation.

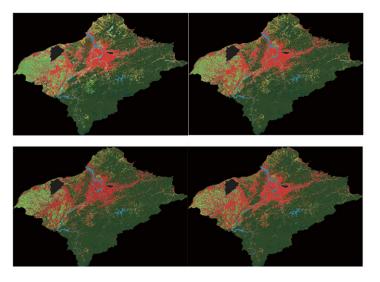


Figure 4. Land use distribution in (upper left) 1996, (upper right) 2006, (lower left) 2036 but in compact form development, and (lower right) 2036 but in dispersed form development. These data were used in projecting the temperature changes shown in Figure 2.

The projected changes provide valuable information for both assessing global warming impacts and planning sensible adaptation measures.

Reconstruction of historical land use and cover data and assessment of land cover and land use change impacts on Taiwan's climate in the past 100 years: This study compiled and digitized the historical land cover and land use data based on the Taiwan historical survey map published in 1904 by colonial Taiwan-Japanese government, and also the land use in 1980, 1996, 2006. Climate simulations assessing the impacts of land use changes in the past 100 years suggest that the urban development had introduced a significant increase in surface air temperature over developed areas and modify diurnal cycle by strengthening land/sea breeze. Precipitation tended to decrease/increase over foothill/ central range area, although less significant.

#### Sub-Project PI, Co-PI

Liu, Shaw-Chen, RCEC, AS Lee, Wei-Liang, RCEC, AS Chen, Liang-Chun, DUPDM, MCU Li, Hsin-Chi, NCDR Chou, Chia, RCEC, AS Lo, Min-Hui, DAS, NTU Cheng, Chao-Tzuen, NCDR Chan, Shih-Liang, GCSS, NTPU Lee, Shi-Yu, RCEC, AS Lin, Chuan-Yao, RCEC, AS Chiang, Shen, NCDR Chen, Yung-Ming, NCDR

# Integrated Multi-source and High-resolution Heat Wave Vulnerability Assessment of Taiwan



Hosting Institute: RCEC, Academia Sinica

#### **Research Objectives**

The overall goal is to evaluate heat vulnerability determinants in order to formulate adaptation strategies in Taiwan. The specific scope is to apply mature and innovative technologies to evaluating three determinants of vulnerability, namely, exposure, sensitivity, and response capacity, for the purpose of minimizing the adverse impacts of heat waves in Taiwan. A multidisciplinary team with experts on environmental, information and social sciences as well as public health is formed so that a holistic approach is taken in this transdisciplinary research.

Figure 1. presents the research framework of this integrated project with four specific targets. The first is to develop, validate, and apply technologies with fine temporal and spatial resolutions to evaluating environmental, socio-demographic, behavioral, community, and physiological factors of vulnerability due to exposure to heat stress and PM2.5 during heat wave and to explore the controllable factors and mechanisms. The second is to establish two systematic methods for generalizing findings obtained through field

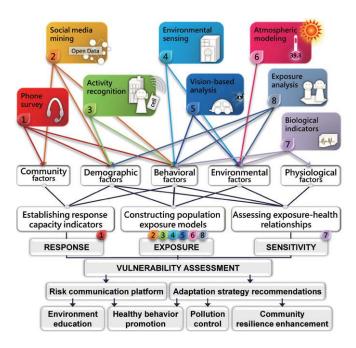


Figure 1. Research framework and data flows

works and surveys conducted in communities to the entire Taiwan island. The third is to comprehensively evaluate heat stress and PM2.5 vulnerability taking into account exposure, sensitivity, and response capacity. Finally, the fourth is to formulate adaptation strategy recommendations and to establish a risk communication platform.

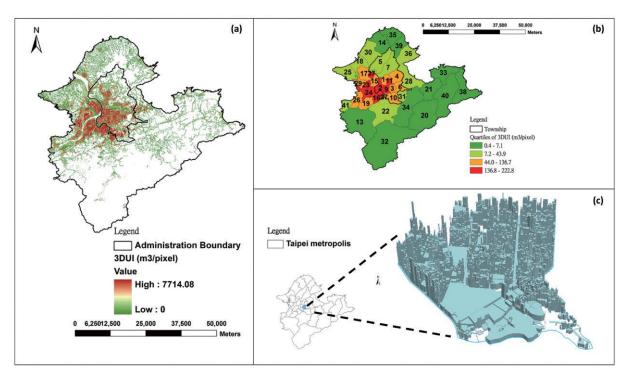


Figure 2. 3-D Urbanization Index (3DUI) Illustration for (a) city, (b) township (mean 3DUI of each township), and (c) community. (Wu and Lung, 2016)

#### Main Results to Date

In terms of exposure characterization, more than 3000 monitoring data at 8 communities in Northern, Central, and Southern Taiwan have verified that the physiological-based heat stress indicator, Wet Bulb Globe Temperature (WBGT), could be accurately estimated by the routine measurements in the Central Weather Bureau (CWB) stations, with correlation up to 0.94 and slope factor 1.0038. Additionally, the forecasted WBGTs based on current

meteorological models, under cloud-free conditions, are very close to the monitored WBGTs (correlation up to 0.94). Thus, it is recommended that CWB adopt this indicator as the basis of heat warning system.

In addition, a quantitative 3-Dimensional urbanization index (3DUI), taking into account the total volume of human constructions (Figure 2.), was developed

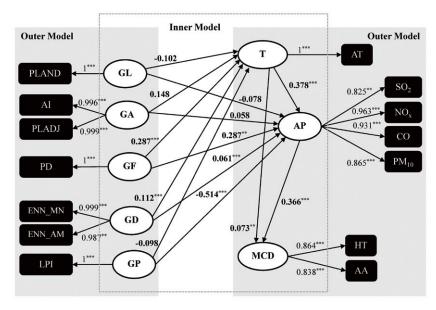


Figure 3. Path diagrams of green structure and atmospheric environment for cardiovascular mortality. \*: p < 0.05, \*\*: p < 0.01, \*\*\*: p < 0.001 (Shen & Lung 2016)

and validated to quantify the urban heat island effects which aggravated heat stress experienced by urban residents (Wu & Lung 2016). Our findings demonstrated not only the strength of 3DUI in representing intraurban temperature variability, but also its great potential for heat stress assessment within cities. This index can be applied in urban planning to reduce heat island effects.

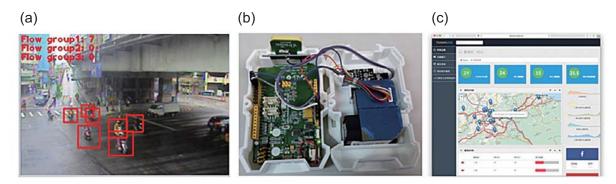


Figure 4. New technologies for (a) vehicle identification; (b) temperature, humidity, and PM2.5 monitoring; and (c) heterogeneous data fusion

In the aspect of sensitivity, we confirmed that cardiovascular mortality of Taiwanese were affected by both temperature and air pollutants. Moreover, cardiovascular mortality could be mediated by green structure. The mediating pathways and effects by green structure characteristics via reducing heat island effect and air pollution levels were quantified (Figure 3.). The two most critical green structure factors are fragmentation and the largest patch; these findings can be applied in greening policy to reduce health risks of heat stress (Shen & Lung 2016).

For response capacity, several waves of survey with telephone, face-to-face, and crowdsourcing were conducted in summertime to assess personal and community response capacities. Demographic characteristics of sub-population with lower responsive capacities were identified. It was found that social support is an essential factor. Intervention program can be developed fostering social interaction and support in local community to increase the well-being of local people during heat waves (Liao, Tu, and Lung, 2016).

Furthermore, innovative information technologies (IT) were developed to facilitate the detection of changes in vulnerability factors, especially environmental and behavior factors (Figure 4.). The numbers of motor vehicle, one of the major sources of heat and air pollution, are quantified as different types with improved vision-based analysis. Reliable, inexpensive, and wireless transmitted sensor prototypes were developed and validated for both indoor and outdoor environments to detect changes in temperature, humidity, and PM2.5. In addition, A location-aware platform with heterogeneous data fusion from multiple sources was also established as the basis of information integration and risk communication.

#### **Future Research Plan**

Three major deliverables are anticipated. The first is the IT tools developed, including social media mining, mobility locating, crowdsensing and vision-based analysis, for collecting data in high temporal and spatial resolutions. The second is a risk communication platform established with comprehensive heat vulnerability database, the synthesized knowledge of the integrated vulnerability assessment, and the advanced IT tools developed. The third one is adaptation strategy recommendations focusing on heat warning system, healthy behavior promotion, pollution control, and community resilience enhancement.

#### Sub-Project PI, Co-PI

Liao, Pei-Shan, CSR, RCHSS, AS Chen, Meng-Chang, IIS, AS Su, Chih-Wen, DICE, CYCU Tang, Chin-Sheng, DPH, FJU Tu, Su-Hao, CSR, RCHSS, AS Chen, Ling-Jyh, IIS, AS Liao, Mark, IIS, AS Chang, Li-Te, DEES, FCU

Chen, Sheng-Wei, IIS, AS Huang, Wen-Liang, IIS, AS Lin, Chuan-Yao, RCEC, AS Wu, Chih-Da, DFNR, NCYU

# Effects of environmental changes on rice growth and production in Taiwan



Hosting Institute: ABRC, Academia Sinica

#### **Research Objectives**

Climate changes could affect agriculture through its effects on environmental conditions, such as drought, extreme temperature and flooding. In Taiwan, there were reports in recent years that environmental changes have resulted in reduction in rice production and grain quality and acceleration in emergence of virulent rice pathogens. Since rice is the most important crop of Taiwan and its production is essential for food safety of our nation, it is an urgent need to come up with a comprehensive plan to cope with the effects of climate changes on rice production. We have assembled a multiple institutional team to study the effects of climate change on rice crop in Taiwan. Three important areas will be investigated: (1) the interactions between rice plants and the pathogen that causes bacterial blight disease, with the aim of controlling this disease and generating new pathogen-resistant rice cultivars; (2) the effects of heat stress on rice production. Results from these studies will be essential for our ability to deal with the impact of global warming; (3) regulation of mineral nutrient utilization in rice. These subjects are essential for development of sustainable rice growing methods. The project will consist of seven subprojects that cover the following topics:

- Identification of virulence factors and biocontrol of rice bacterial blight pathovars in Taiwan.
- Molecular breeding of rice variety resistant to bacterial blight disease.
- Evaluation of the effect of heat stressrelated transgenes on the thermotolerance diversity of rice.
- Improvement of phosphorus use efficiency of rice for sustainable agriculture
- Identification of key transcription factors involved in nitrogen responses in rice
- Biofortification of metal micronutrients in rice
- Generation of rice cultivars with improved nitrogen utilization efficiency

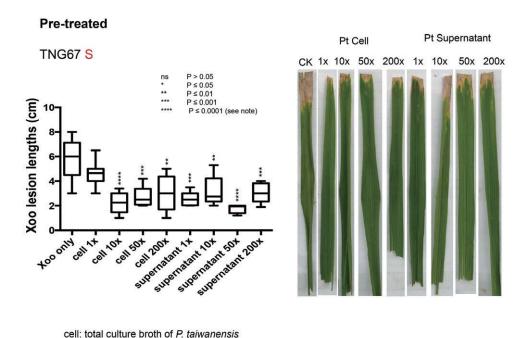


Figure 1. Field experiment with Japonica rice Tainung 67 (TN 67) pre-treated with P. taiwanensis.

supernatant: cell-free supernatant from the total culture broth of P. taiwanensis

### Main Results to Date

For rice bacterial blight disease, XF89b has been reported as one of the most virulent Xanthomonas oryzae pv. oryzae (Xoo) strains in Taiwan. We have completed sequencing of the entire genome of XF89b. A number of major virulent factor encoded genes, TAL genes, were identified. We found that Psudomonas taiwanensis is an effective biocontrol agent against Xoo. Using Tn5 transposon mutagenesis, we have identified a number of genes that are essential for anti-Xoo activity, including genes involved in pyoverdine biosynthesis. In addition, we found that Type 6 secretion system is involved in pyoverdine secretion.

We have isolated a TN67 rice mutant SA0424 that has a stable and broad-spectrum resistance against most of Taiwanese Xoo pathogens. Our analyses showed that SA0424 is resistant to Xoo-XF89b and the resistance of SA0424 might be regulated by the recessive inheritance. In addition, we have completed two crosses SA0424XIR64A and SA0424XTNG77 for improving the bacterial blight resistance of IR64A and TNG77 varieties.

For nutrient utilization projects, we have identified several rice mutants showing increased or decreased P use efficiency (PUE) under phosphate (P<sub>i</sub>)-limited conditions from a sodium azide-mutagenized population. Transcriptomic studies indicated that differential gene expression might be responsible for altered PUE phenotype. One mutant exhibited enhanced PUE and had improved biomass in the field. Analysis of the expression of several P<sub>i</sub> starvation-responsive genes revealed that P<sub>i</sub> starvation responses were strongly repressed in the root of two mutants exhibiting low PUE.

Analysis of microarray data revealed that 24 TF genes were specifically or commonly induced by NH<sub>4</sub>NO<sub>3</sub>, glutamine, or glutamate. We used qRT-PCR analysis to verify that 21 of the 24 TF genes were rapidly induced by NH<sub>4</sub>NO<sub>3</sub>, glutamine, or glutamate. Our results also clarified that some TF genes had specific responses to NH<sub>4</sub>NO<sub>3</sub>, glutamine, or glutamate. We also used microarray analysis to identify at least 120 genes, including some TF genes, which were rapidly induced by nitrogen starvation.

By screening NaN3-mutagenized rice mutant populations (IR64), we identified 26 mutant

## Searching for rice mutants with altered phosphorus use efficiency (PUE)

~3000 sodium azide (NaN3)-mutagenized rice lines (from Taiwan Agricultural Research Institute, TARI)

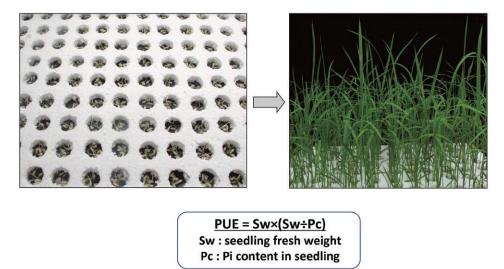


Figure 2. Searching for rice mutants with altered phosphorus use efficiency (PUE).

lines that have higher metal contents and 14 mutant lines had lower Fe contents. The collected mutants will be further grown to the next generation for the confirmation of the phenotype.

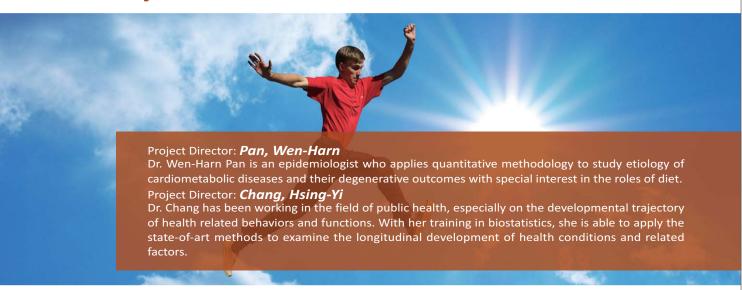
### **Future Research Plan**

In the past three years we have solved the problem of bacterial blight disease by generating new breed of rice that are pathogen-resistant and identify an effective biocontrol agent against bacterial blight disease. In addition, we have made significant findings in the effects of heat stress on rice production and regulation of mineral nutrient utilization in rice. In the future, we will address the problem of another important rice disease, the rice sheath blight disease caused by the fungal pathogen *Rhizoctonia solani*. We will generate new rice varieties and develop strategies to control the rice sheath blight disease caused by the fugal pathogen *Rhizoctonia solani*. In addition, based on our findings in the past three years, we will investigate the molecular mechanisms of heat stress tolerance and nutrient utilization and generate rice breeds that are more efficient in nutrient utilization.

#### Sub-Project PI, Co-PI

Wang, Chang-Sheng, AGRON, NCHU Chiou, Tzyy-Jen, ABRC, AS Tsay, Yi-Fang, IMB, AS Lin, Da-Gin, TARI, COA Hsieh, Ming-Hsiun, IPMB, AS Charng, Yee-Yung, ABRC, AS Yeh, Kuo-Chen, ABRC, AS

# A Blueprint for Healthy Aging: Determinants and Prevention of Frailty and Depression in Elderly



Hosting Institute: IBMS, Academia Sinica

### **Research Objectives**

Frailty is an important intermediate toward disability in the elderly. High prevalence of disability in elderly population will increase the social and medical burden to the society. We intend to contribute to the understanding of frailty pathogenesis and to design and test lifestyle management measures for frailty regression.

The main project of this PPG (Figure 1) will not only carry out the field works, but also ask various questions to clarify frailty definition. Taking advantage of existing cohorts and newly collected data, the specific aims of the main project and 3 subprojects are described as follows:

- (1) In order to clarify frailty definition, to examine whether frailty and depression coexist and whether coexistence would result in greater degree of progression and mortality than each alone;
- (2) For social determinants of frailty, concept of cumulative deficits-an integrated approach is used to evaluate frailty, to examine the dynamic changes of social

- networks with frailty, and to explore the impact of social network determinants on frailty development and mortality;
- (3) to estimate the prevalence of frailty syndrome in Taiwanese communities and to explore the biological and lifestyle risk factors of frailty in an elderly population;
- (4) to carry out a non-pharmacological intervention through improving nutrition and physical activity.
  - ⇒ To develop a feasible home-based intervention for frail and pre-frail community-dwelling elders in Taiwan.
  - ⇒ To improve comprehensive geriatric assessment reliability and feasibility in clinical environment.
  - ⇒ To investigate the effect of nutritional and/or physical intervention for frail elderly at 1 month, 3 month, and 6 month (3 month post intervention).
  - ⇒ To analyze the cost-effectiveness of nutritional and/or physical intervention for frailty elderly.

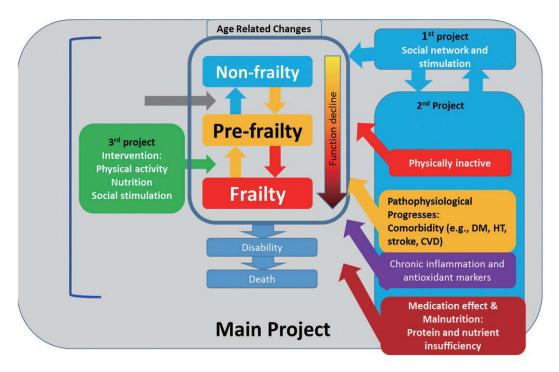


Figure 1. Integrations among projects of frailty

Major Project include the data core for integrating the existed data and for collecting the new data.

### Main Results to Date

### Coexistence of frailty and depression

There were 3352 (1916 males and 1436 females) elders with complete longitudinal information. The results confirmed our hypotheses on the coexistence of frailty and depression.

- After controlling for baseline age, previous depression score significantly predicted frailty defined by accumulation deficits (beta=0.680, s.e.=0.032).
- ⇒ On the other hand, previous number of frailty-associated deficits also significantly predicted the future depression scores (beta= 0.114, s.e.=0.004).

#### Social determinants

- ⇒ Social integration (i.e. activity participation) and perceived social support could significantly slow down the progression of frailty.
- ⇒ The elderly having either more activity participation or higher social support had better survivorships than the counterpart.
- ⇒ Frailty is an important mediator in the causal pathway between social network determinants and mortality.

### Prevalence and risk and lifestyle factors

- ⇒ The prevalence of frailty and pre-frailty was 49.8% in Taiwan and the fatigue was the most common component of the frailty syndrome.
- ⇒ Poor sleep quality was associated with the pre-frailty/frailty syndrome.
- ⇒ Sarcopenia, a contributor to frailty, was associated with higher risk of mortality.
- ⇒ High blood pressure was positively and significantly associated with frailty, and antihypertensive medication, especially CCBs, had a protective effect against frailty, suggesting that the type of antihypertensive medication should be considered in the frailty management.
- ⇒ The higher the number of abnormal blood biomarker values for nutrition and inflammation, the greater the odds to be frail in a joint analysis of NTU and NAHSIT elderly cohorts.

### Non-pharmacological intervention

⇒ We have established a feasible home-based exercise and/or nutritional intervention for pre-frail/frail community-dwelling older adults in Taiwan.

- ⇒ We have recruited 271 number of elders into the intervention trial by September 2016. It is near the target number of 300.
- ➡ With data at 1-month follow-up, the elders in the dietary intervention groups showed significant increase in the consumption of dairy, fruits, and nuts. In addition, total protein and total protein per Kg body weight have significantly increased in the groups with dietary intervention ("diet alone" group or "diet + physical training" group).
- ⇒ After 3 months of home-based exercise training, frail elderly improved their physical performance, such as grip strength, gait speed, upper and lower extremity flexibility, and lower limb strength.
- ⇒ Expenses associated with the intervention have been documented.
- A pilot study on dietary approach had been carried out in 2014-early2015 and analyzed and written into manuscript in 2015-2016. Our study indicated that a prudent diet to optimize the distribution of 6 food groups showed effects to improve not only frailty score but also the geriatric depression score.

### **Future Research Plan**

- ⇒ To develop the proper indicator of social frailty among the Taiwanese elderly
- ⇒ To model the trajectories of social, mental, cognitive and physical frailties
- ⇒ To investigate the impacts of multidimensional frailties on the mortality and social burden
- ⇒ To follow participants and to investigate the progression/transition of frailty syndrome.
- ⇒ To investigate the association between frailty syndrome, dementia, and mortality risk.
- ⇒ To investigate the long-term effects of nutritional and/or physical intervention at the end of intervention and at 3 months post intervention.
- ⇒ To analyze the cost-effectiveness of nutritional and/or physical intervention for frailty elderly.
- ⇒ To establish proper intervention protocols for frailty management in clinical settings in order to assist the enforcement of the Long-term Care Services Act 2.0.

# The Impact of Population Aging and Globalization on Pension Labor Market and Industrial Transformation



Dr. Tung received her Ph.D. in Economics from the University of California at Berkeley in 1988. She has worked as an Associate Research Fellow at the Institute of Economics, Academia Sinica since 1989. Her main research interests include industrial policies, economic demography and economic development. Currently, she focuses on studying the impacts of population aging and globalization on Taiwan's industrial development.

Hosting Institute: IE, Academia Sinica

### **Research Objectives**

Two major trends have marked Taiwan's economic growth since the start of the new millennium, namely, population aging and globalization. All problems that currently plague the economy, such as industrial hollowing out with firms moving offshore, domestic wage stagnation with high unemployment, income inequality, and pension crisis, have roots in these new trends.

To be specific, while Taiwan has come a long way from a traditional agricultural society into a major player in the high-tech world, job creation takes place mostly offshore, not on the island. Furthermore, while economic development typically invites more intensive social protection, new social programs encounter severe fiscal pressure due to rapid population aging and economic slowdown. In turn, the financial insolvency of social insurance programs has negative impacts on fertility rate, willingness to work, industrial development and macroeconomic growth.

The experience of Japan has confirmed the undesirable linkages described above.

This project gathers experts in demography, industrial economics, public finance, and social welfare, to study inter-related issues on population structure, industrial transformation and public pension. It aims to advance a multi-dimensional but well-integrated research report, with policy proposals to the government for a sustainable growth.

### Main Results to Date

The current progress of the project matches the original schedule. Each of the three subprojects are summarized briefly as follows.

### Project 1:

There are three theoretical perspectives that can be used to explain the relationships among morbidity, disability, and mortality: compression of morbidity, expansion of morbidity, and dynamic equilibrium. They all focus on the quality and quantity of life. This project wants to answer two questions. First, are the elderly being healthier as life expectancy increases? Second, what should we do to improve the quality of life among the elderly and prepare for an aging society? We analyzed the data from a survey of Taiwan Longitudinal Study on Aging(TLSA)conducted by the Health Promotion Administration, Ministry of Health and Welfare. Using the interpolated Markov chain approach, we estimated the total life expectancy, consisted of active and inactive life expectancy. Comparing two representative groups of people above age 60, with sample size 4,015 in the year 1989 and sample size 3,518 in 1999, we investigated active/ inactive life expectancy difference between sex, education, and urban/rural residence.

Our analysis indicated that inactive life expectancy was an important part of increasing life expectancy during 1989 to 1999. The incidence of disability remained unchanged (Fig 1), but the rate of recovering from disability declined (Fig 2). The elderly suffered from disability longer owing to the decreasing rate of dying from disabled. The rising disabled prevalence of women accounted for an increase in inactive life expectancy (Fig 3). People with lower education were less likely to recover from disability and experienced lower mortality risks while being disabled. The difference in the disability rates and mortality in the disabled between those living in rural or urban areas was not significant. However, the rate of recovering from disability was lower in the elderly living in rural areas; mortality in the disabled decreased in the elderly living in urban areas. The active life expectancy of the elderly with fewer vulnerable characteristics, e.g. men, the more highly educated, and those living in urban areas, did not increase between 1989 and 1999. We conclude that long-term care should be emphasized, as inactive life expectancy increases in the future.

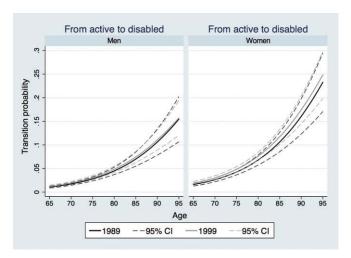


Figure 1. Transition probability from active to disabled, by gender, 1989 and 1999

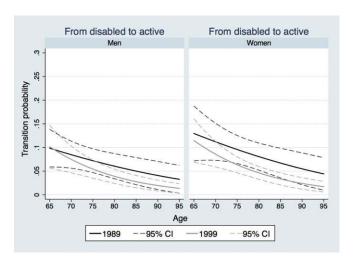


Figure 2. Transition probability from disabled to active, by gender, 1989 and 1999

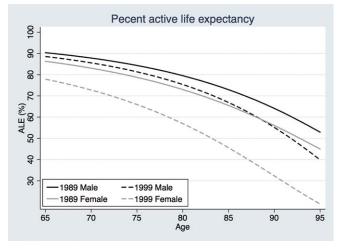


Figure 3. Percent of active life expectancy, by gender, 1989 and 1999

### **Project 2:**

Too little contributions, too much benefits and too early to retire were the major reasons for the financial crises of all the pension systems in Taiwan. Raising contributions, lowering benefits and extending the retirement age are therefore the necessary steps to take to solve the problems. The reform proposals rendered by the Executive Yuan for the Labor Insurance include 5 items: raising contributions, two ways to lower benefits, returns on investment should be 4% or more, and put "government takes on the final financial responsibility" into the Act.

The reform of the GEI has many facets. For the newcomers, a new system will be designed. For the current employees, a full-scaled reform will be applied: extending the retirement age, switching the sum of the age and years of service from 85 to 90; uplifting the limit of contribution rate from 12% to 18% and contribution share from 35% to 40%; changing the pension base from the last pay to the previous 10 years average, and gradually extend to previous 15 years average; lowering the guaranteed interest rate for the sump-sum benefits from 18% to 9%. For those who were retired, only pension base and interest rate change would apply.

The studies that evaluate the reform proposal of the Labor Insurance reveal that lowering the benefits can only save 2% of the payments per annum; however, the reform proposals can improve the income distribution.

As to the experiences of the foreign countries: US pension benefits depend on the PIA amount, which is the sum of three segments of the average indexed monthly earnings, averaging for the top 35 years; and the corresponding payment rates for the three segments are 0.9, 0.32, and 0.15. This strategy has an embedded income redistribution feature. German's pension benefits depend on the individual earnings points (individual's earnings relative to the average earnings for all employees in the system) and earning-point value. The

benefits are linearly-correlated with seniority and earnings. Japan's pension benefits are determined by the seniority and average earnings, therefore no income distribution is presented as well.

### **Project 3:**

The project measures the changes of industrial production and employment of the manufacturing industry under population aging. First, the industrial structure has continually shifted from traditional manufacturing to technology-intensive industries, especially the ICT industries (Fig. 3). World-class enterprises start to emerge, and offshore production has become a norm for many enterprises, large or small.

Second, those employed in technologyintensive industries are the youngest in age, highest in education and highest in wage, while it is the opposite with those employed in traditional manufacturing industries.

Third, with continued low fertility and population aging, the technology-intensive industries suffer more than other industries in the future, as they require the largest number of young workers.

Fourth, the government should continue to encourage technology upgrading and human resource upgrading, especially when traditional industrial and population policies may fail to answer to rapid globalization and swift population aging. For example, innovative policies to encourage R&D investment, to attract quality immigration, to reform high education, and so on, are badly needed.

### **Future Research Plan**

### Project 1:

- 1. reviews literature on international migration and collects data on Taiwan's migration and household registration
- 2. estimates net migration of Taiwan, based on global and Asian experiences
- 3. proposes policies on fertility, mortality, migration and sustainable demographic development

### **Project 2:**

- 1. reviews the reform proposals and histories on public pension programs, and analyzes their financial impacts and income distributional effects, in Taiwan, as well as in Germany, Japan and USA
- 2. studies the appropriateness of replacement rate and compares various benefit designs
- 3. redesigns pension programs, based on the experiences of advanced economies

### **Project 3:**

- 1. reviews the literature and histories of globalization across countries of various development level
- 2. compares between traditional and high-tech industries and studies the changes under globalization in Taiwan
- 3. draws implications for Taiwan, based on a study of past and future trends in world economic development

Enhanced GEMTEE (General Equilibrium Model for Taiwan Economy and Environment) for IAM Framework-An Integrated Computable General Equilibrium (CGE) Model and Database for Appraising Policies toward Sustainable Development

Project Director: Chang, Ching-Cheng
Dr. Ching-Cheng Chang is a Research Fellow in the Institute of Economics at Academia Sinica and is a Professor in the Department of Agricultural Economics at National Taiwan University where she teaches linear programming, agricultural sector modeling, and modeling applications. She is also the Director of the Socioeconomic Department of the APEC Research Center of Typhoon and

Society. She has participated in several international projects on food and human security related issues, including a five-year APEC project on "Strengthening Public-Private Partnership to Reduce

Food Losses in the Supply Chain (2013~2018)", and an EU HORIZON 2020 project on "SUSFANS: Metrics, Models and Foresight for European SUStainable Food And Nutrition Security (2015-2018)".

Hosting Institute: Ins Econ, Academia Sinica

### **Research Objectives**

Albert Einstein

In the project from 2012 to 2014, we construct a dynamic computable general equilibrium model and its database to address important issues related to social-economic aspects of Taiwan's sustainable development. With collaboration from research team from ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences), we established a new CGE model called GEMTEE (General Equilibrium Model for <u>Taiwanese Economy and Environment</u>). GEMTEE is an MONASH-type CGE model with innovative population module and new dynamic mechanism. Important social-economic issues include resource (e.g., water, land, energy, and human resource) management, environmental quality, social equity, aging population, green tax reform, social security and food security will be incorporated into GEMTEE using the modular approach.

Facing the intensified challenges from climate change, urbanization, and rapid ageing population, achieving sustainable societies in Taiwan will require an understanding of the life-supporting nature of water, energy, and food systems and how to maintain the balance among them. This project will extend GEMTEE into Regional Dynamic Model and combine with GCM downscaling predictions to simulate socio-economic impact of future climate change. With these research results, we can construct an IAM and database for IPCC AR5 assessment. The system can analyze the interactive and feedback linkages between socio-economic system and climate change as the basis to develop long-tern sustainable

development pathways. Research objectives of this study include: (1) Constructing an Enhanced GEMTEE and Database for Population Projections and Policies Appraisal toward Sustainable Development; (2) Evaluating the Impacts of Climate Change on Agricultural Productivity and Food Security in Taiwan; (3) Evaluating the Impact of Climate Change on Regional Water Demand Management and Regional Economy in Taiwan; (4) Evaluating the Impact of Environmental Fiscal Reform in Taiwan with Consideration of Household Energy Demand Structural Change.

#### Main Results to Date

- 1. We construct a 4-region (north, central, south, and east) GEMTEE model and database containing age, sex, female fertility rate, life expectancy, mortality information. The regional GEMTEE was used to project regional population up to 2060, and compared with the projections by the National Development Council (Fig. 1 and Fig. 2). And Fig. 3 shows Taiwan's population pyramids for all ages in 2013 and 2061. We apply the regional GEMTEE model by exploring the productive workforce loss from heat-induced cardiovascular diseases. The simulation results suggest that the labor productivity loss will result in a decrease of 0.53 to 0.6% of GDP, while household consumption decreases by 0.17 to 0.18%, total exports by 3.55% to 3.65%, and total imports by 0.61% to 0.63%.
- 2. We use panel data model to estimate the effects of future climate change on sixty major crops in Taiwan and the damage loss function of typhoon on rice production. Data sets including

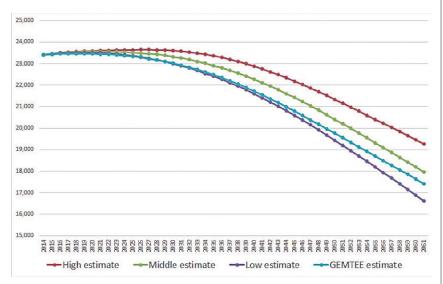


Figure 1. Regional GEMTEE population projection compared with high, middle, and low projections by National Development Council, R.O.C. (unit: 1000 persons)

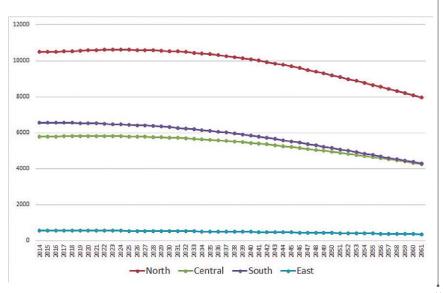


Figure 2. Population forecast for four regions in Taiwan using GEMTEE regional population modules (unit: 1000 persons)

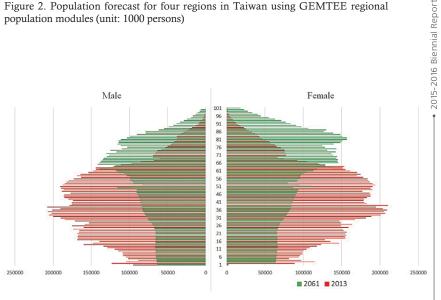


Figure 3. Population pyramids for all ages in 2013 and 2061 (unit: 1000 persons)

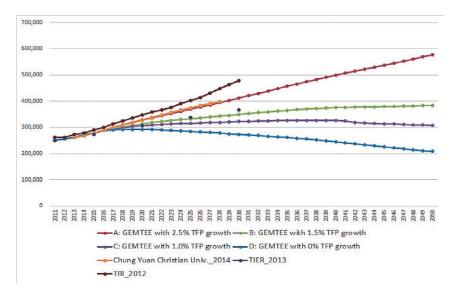


Figure 4. Carbon dioxide emission baseline forecasting using GEMTEE with different assumptions on TFP growth rates (unit: 1000 M.t.)

crop yields, temperature, precipitation, etc. from years 1977 to 2013 for each county are collected. Applying the estimation outcomes with GENTEE model and the future climate change scenarios including RCP2.6, RCP4.5, RCP6.0, and RCP8.5 for 2040s, 2060s, and 2080s, the simulation results suggest that climate change have both positive and negative impacts on crop yields and are ranged 1% to 10% for 2040s. The empirical results also show that when the cumulative rainfall increases by 1%, the economic damage on rice is 0.356%; while 1% increase in the maximum wind speed will increase the loss by 1.644%.

3. We review the literature that dealt with the water scarcity issues for various countries, for example, China, South Africa, and Australia as the basis for our specification of water demand and supply for manufacturing, services and household sectors in our GEMTEE model. For the demand side, water is incorporated as a primary factor, which is used in proportion to the sectoral output. Simulation results suggests that raising water price will be desirable to attain water efficiency and

- get water users prepared ahead of time to brace for and to adapt to likely water stress under looming climate change.
- 4. We integrate the social accounting matrix (SAM) database into GEMTEE to provide a baseline projection on fiscal balance and to investigate the options for accommodating increased public investment in infrastructure while safeguarding macroeconomic stability and debt sustainability. We also build an energy sub-module to generate a 2012-2050 carbon dioxide emissions baseline projection with different assumptions on TFP growth rates (Fig. 4). The baseline projection will serve as the foundation for economic assessment of climate mitigation strategies and related fiscal reform policies.

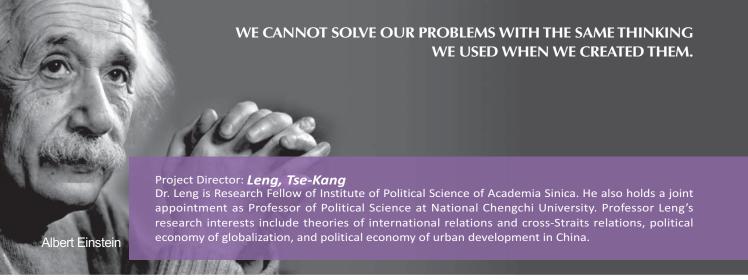
### **Future Research Plan**

Model validations and policy simulations will be explored using different modules of regional GEMTEE to analyze the interactive and feedback linkages between socioeconomic system and climate change as the basis to develop long-tern sustainable development pathways.

### Sub-Project PI, Co-PI:

Lin, Hsing-Chun, Dept. App. Econ., NCYU Lee, Huey-Lin, Dept. Econ, NCCU Hsu, Shih-Hsun, Dept. Agri. Econ., NTU Chen, Chi-Chung, Dept. App Econ, NCHU Su, Ming-Daw, Dept. of BSE, NTU Wu, Chia-Hsuan, CIER Yang, Jiann-Cherng, Ins Econ, AS

# Sustainable development and democratic governance: aspects of localization and globalization



Hosting Institute: IPS, Academia Sinica

### **Research Objectives**

The general project argues that in order to achieve the goal of sustainable development, new types of governance must be developed to incorporate environmental protection, economic development, and social justice. Different from the traditional command and control methods, the new type of governance focuses on the collaborative governance and coexistence between the state and society. In the era of globalization, sustainable development will include cross-national actors such as international non-governmental organizations, local governments, and international regimes. This project will integrate the analytical frameworks of "global governance" and "new types of governance" to discuss the implications of democratic governance. Major focuses of comparative studies will be concentrated in mainland China, South Korea, Japan and Taiwan.

Under the umbrella of general project, four subprojects will be conducted to reflect different aspects of sustainable development:

 Sustainable Development and Philosophic Values: Comparative Analysis of the Case of Nuclear Power Plant

- 2. The New Governance for Sustainable Agricultural Development
- 3. New Types of Governance and Corporate Social Responsibility
- 4. Global Governance and Sustainable Development

### Main Results to Date

### Sub Project 1: Sustainable Development and Philosophic Value: Comparative Analysis of the Case of Nuclear Power Plant

During the last two years, we committed to publish our research findings and conducting fieldworks in Japan and Korea. We submitted our papers at workshops host by Yonsei University in Korea and Institutes of Economics of Academia Sinica in Taipei. A research article titled "Anti-Nuclear Movement in Taiwan: the Past, the Present and the Way Forward" will be published as a book chapter as soon.

The program in 2016, Professor Huang will conduct fieldwork to interview scholars in Japan and Korea on nuclear policy and antinuclear movement in September and submit his paper at Joint East Asian Studies Conference (JEAS) in London. Dr. Rung Yi Chen had

also been invited to visit Nankai University, Tianjin to make a speech at October, 2016.

Furthermore, a workshop entitled "Post-Fukushima Debate over Nuclear Power and Sustainable Development in East Asia" will be hold on 2nd December, 2016 in Academia Sinica.

This workshop, organized by the research team, brings together a group of distinguished scholars in environmental sociology, energy politics, and public policy to provide an insightful analysis on the repercussions of the 311 disaster and how it is shaping politics, state-society relations, and energy policy in Taiwan, Japan and South Korea. We shall attempt to provide policy recommendations on nuclear power for Taiwan government and to resolute the dispute over the 4th Nuclear Power Plant in Taiwan.

## Sub Project 2: The New Governance for Sustainable Agricultural Development

For a long period, the civil society concept of South Korean rural area reflects to some extent the deep embedment in the state mechanism because the development of South Korean rural area is influenced by the government policy, and the rural lifestyle is led by the agriculture association. Although South Korean farmer autonomy organization and movement have been in full operation since entering the new era, the generated effect is not sufficient to compete with the state mechanism that still inherits the solid social control. Lacking in the attention to agriculture from the society, plus the cognition of general public educated by the state is that the trade liberalization is the only and correct policy choice to let South Korean be ranked among the world's great economy entities, it seems difficult for the framer organization to overcome the globalization straitjacket.

On the other side, the object of the CAP in European Union is to distinguish the measures which both developed countries and developing countries undertake respectively to response to the competition pressure coming from the global agri-food market during the globalization process of the farmers market. While promoting the alternative agro-food networks, one of the important



Figure 1. Workshop of Sustainable Development in Asia at Yonsei University

reasons of agriculture transformation is the popularity of the social thought and action that implicate certain degree of institutional heritage. The difference between agriculture and industry has to be distinguished, and the relative weakness of the agriculture needs to be highlighted when emphasizing the farmer autonomy and the preservation of the rural characteristic culture. However, the intention is not to resort to declare the confrontation between state and local, or between agriculture localization and economy globalization, but to find a common method to maintain the sustainable goal.

### Sub Project 3: New Types of Governance and Corporate Social Responsibilities

The research had been further illustrated the relationship between the government and enterprises and how these two actors interact in order to achieve the goal of sustainable development by comparing supportive and restrictive policies. Korean government has paid attention to CSR since the Asian financial crises in 1997. When the economic system collapsed, the government and enterprises started to consider the importance of sustainable development and social responsibility. The Korean government encourages the enterprises to implement CSR in two aspects. The Korean government announced "Social Enterprise Promotion Act" to encourage the enterprises to take CSR in 2007. The Korean enterprises provide job opportunities and assist middle- and smallscale enterprises. On the other hand, the state encourages the enterprises to apply for ISO26000. The enterprises can get more market share and elevate corporate image while implementing CSR.



Figure 2. Prof. Miranda Schreurs sharing the research results of globalization and sustainable governance

The case studies include Samsung, Hyungdai, and the labor union of LG.

## Sub Project 4: Global Governance and Sustainable Development

Based on the research findings of the previous year, team members continue to research on the global aspect of sustainable governance in the second year. The focus of this year is on the global aspects sustainable development of the Arctic circle.

Through critical literature review, field researches, and interaction with international experts, the scope and boundary of this subproject has become clear. The research team figures out that the Arctic issue is much more complex than expected. It involves concerns on environmental protection, energy security, geo-politics, major power politics, and governance on aboriginal people. Team members try to broaden the research horizon, and integrate various research approaches including environmental development, international politics, and international law. With these integrated approaches in mind, the team members expect the major breakthrough for the third year of research.

Major focuses of this year is to establish international research links. Under such considerations, the research team pay visits to South Korea to attend seminars and conduct interviews. Team members visited major universities including Hanyang University, Hankuk University of Foreign Studies, and Yonsei University. A report titled "Major Power politics and the Arctic Policy" was presented at Yonsei University. The research team also attended lectures and conducted interviews of Korean National Assembly. Furthermore, the visit of Prof. Miranda Schreurs and Jo Inga Bekkevold to Academia Sinica help clarify major research arguments and broaden the depth of research. With the conclusion of the second year, the research focuses have been put on impacts of climate change on the Arctic, energy security, and the implications on geopolitics.

To sum up, the director of Project 4 presented three papers in this year, established research networks, and hosted visiting scholars from overseas.

#### **Future Research Plan**

The goal of past two years to deepen and reorient research focuses has been achieved. The research team had also established fruitful academic relationship with major research institutions in South Korea, Japan, and Norway. The project director will pay a visit to Oslo, Norway to presentation research findings and interview experts of sustainable development in October, 2016. Furthermore, a workshop entitled "Post-Fukushima Debate over Nuclear Power and Sustainable Development in East Asia" host by IPSAS will be hold on 2nd December, 2016 in Academia Sinica.

Looking toward the future, the research results of the first two years, along with follow-up research findings, will be presented in seminars and workshops in 2016. Based on the works of the second year, the research team will establish more academic links with other East Asian and Nordic countries and build up the Taiwanese aspects of sustainable development of the Arctic region.

## Sustainable Development in Anthropocene: Changing Urban Life in Taiwan

### WE CANNOT SOLVE OUR PROBLEMS WITH THE SAME THINKING WE USED WHEN WE CREATED THEM.

Project Director: Liu, Shao-hua

Dr. Liu is an associate research fellow at the Institute of Ethnology, Academia Sinica, Taiwan. Her main research field sites are in China and Taiwan. Her first book *Passage to Manhood: Youth Migration, Heroin, and AIDS in Southwest China* was published by Stanford University Press in 2011, which has won several awards, including Taipei Book Exhibition Award for Book of the Year in 2014 and Shenzhen Book Month Festival for "The Best Ten Books" of 2015.

Project Director: **Huang, Shu-min** 

Professor Huang taught for 30 years in the Department of Anthropology, Iowa State University in the US. He returned to Taiwan in 2006 to assume the position of Distinguished Research Fellow and Director of the Institute of Ethnology, Academia Sinica. He was elected Academician of Academia Sinica in 2010, and received Taiwan's Presidential Science Prize in 2015. He has played a crucial role in promoting and resuscitating the discipline of anthropology in Taiwan, China and East Asia.

Hosting Institute: IoE, Academia Sinica

### **Research Objectives**

Albert Einstein

This thematic research project takes 'anthropocene' as its vintage point to analyze how Taiwan, under the impact of globalization, has adjusted to environmental change through urbanization and related lifestyle changes and change in interpersonal relationships in order to achieve the goals of sustainable development. Our research foci include: the history of urban development in Taiwan; the reciprocal impact between urban development and environmental change; changing temple space and practices in Taipei Basin; changing urban family and interpersonal relationships; and changing water resource management and distribution in Taipei Basin.

#### Main Results to Date

### Subproject 1 The forming and transformation of urbanization in East Asia

The project aims to explore the environmental impact of urbanization in East Asia during the early period of post-WWII. The PIs focus on data collection in the first year while putting effort to generate small papers

in the next year. Several major resources have been done for analysis. They are the estimation of urban population in Taiwan, Korea, and Japan during the 1950s-1960s, electricity generation and consumption in the region, and changes of major causes of death. Further analysis has also been done to reveal the possible relationship between urban population and diseases, and age structure of urban population.

## Subproject 2 Consequences of interactions between global environmental change and urbanization

It is assumed that urban carbon emission is dominated by urban development, which can be generalized by urban intensity and density and public transportation. In this study, carbon emission is transformed from energy consumption of electricity and gasoline. The indicator of urban intensity and density is calculated by residential and commercial activities while indicator of public transportation is calculated by the accessibility ratio of public transportation. The relationship between carbon emission



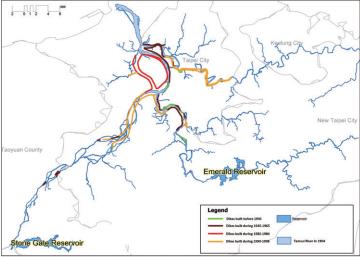


Figure 1. Regulation of Tamsui River (from Qing dynasty to today)

Figure 2. Map of Possible Flood Inundated Area in Tamsui River Basin (1920-1932)

and urban development is analyzed by spatialtemporal analysis of villages (里) and Taipei city as a whole respectively.

## Subproject 3 A research on the urbanized variation of sacred space: Comparative study of Mazhu temples and Earth-God temples in some settlements in Tamsui river basin

In the first year, we successfully fulfilled the planned goal that includes data collection and filed works of Mazhu and Earth-God temples. By considering the connection between temple and nature environment, we find many interesting issues during temple urbanized process. This year, we concentrate on the analysis of urbanized phenomenon of Earth-God temple. The influence of "Urban Sprawl" is very specific and obvious. The following results were obtained: (1) New Earth-God temples appeared. (2) Main god changed after temples reconstructed. (3) Temple sites marginalized. (4) Furrow in fields replaced by roads. (5) Nearby public facility modernized.

### Subproject 4 The mutual shaping between family and social relationship and the context of urban development in Taiwan: positive psychological capital as the dynamic basis for sustainable urban life

During the second year of the project, we have written a conference paper entitled "Sustainable development in Anthropocene:

Psychological strength as the dynamic basis for sustainable urban life" that is based on the preliminary findings from the first year project and has been presented in "the 9th holistic education conference: The common good society and sustainable future" held by Fu Jen Catholic University on May 14th 2016.

### Subproject 5 The waterworld of Taipei megacity

We have collated a great volume of literature and visual data, including pre- and post- war official documents, national congress and local representative assembly records, river maps (originally stored in Water Resource Agency, Ministry of Economic Affairs) and reservoir plans, memoirs and publications by hydraulic engineers, and the media reports regarding the regulation of Tamsui River. Through these data, we are reconstructing the evolution of Tamsui River's 'waterscape' since the early Japanese colonial period until recently. In addition, we are tracing the paradigm shift of river regulation under different political regimes and socio-economic contexts in the development of the Taipei Metropolis.

#### **Future Research Plan**

### Subproject 1 The forming and transformation of urbanization in East Asia

An article on epidemic impact by urbanization in post-WWII East Asia is been prepared to be submitted to a conference on Research of Ecological History at Renmin University in China. Meanwhile, a conference paper is also under consideration for the 4th Annual Meeting (2017) of the Association for East Asian Environmental History from the discovery of the project.

## Subproject 2 Consequences of interactions between global environmental change and urbanization

This research focuses on how urban response to global environmental change (GEC) and how GEC affects urban development. We have done the former issue and will continue to work on the latter. The effects of GEC will be evaluated in terms of natural disasters. Spatial-temporal analysis of urban heat islands and flooding will be analyzed. Finally, consequences of interactions within urban systems on global environmental change will be explored.

## Subproject 3 A research on the urbanized variation of sacred space: Comparative study of Mazhu temples and Earth-God temples in some settlements in Tamsui river basin

Compared with the Earth-God temples, the question which we must consider next is their difference from Mazhu temples. More noteworthy is whether any other interesting possible issues could be found. Meanwhile, some articles are under consideration for publication. These papers will be submitted to related conferences or periodicals.

### Subproject 4 The mutual shaping between family and social relationship and the context of urban development in Taiwan: positive psychological capital as the dynamic basis for sustainable urban life

The project is collecting data from major cities of the island for testing the proposed hypotheses, and now the data of three areas (Taipei city, Taoyuan city and Yilan country) has been completed and is going to be analyzed first. The others are continuously collected.

## Subproject 5 The waterworld of Taipei megacity

Most of the post-war river regulation methods followed the strategies developed in the Japanese colonial period. Our preliminary studies have shown that these methods were either adopted from western thinking models, or reflected the opinions of the local citizens. Future work will focus on investigating this local-global entanglement: how different approaches were selected and integrated into the river regulation policy and impacted the urban development of Taipei City. As the Taipei Metropolis has been growing into a mini megacity since the 1990s, the water supply and its allocation has become a contentious issue among all stakeholders. We will keep investigating how the water supply management has been shaped and changed along with the metropolitan development and Taiwan's social change at large.

Sub-Project PI, Co-PI:

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# Reconstructing East Asian Historical Climate Series using China's Chronological Records in Past Two Millennia (REACHS)



### **Research Objectives**

The Earth system has continued to respond to various external forcing such as solar variability, volcanic eruption, earth orbital perturbation, and changes in atmospheric composition. Climate reconstruction and climate numerical modeling provide important information about the rate and pattern of the responses. Paleoclimatology especially can facilitate a more holistic understanding of the longer-term Earth system feedbacks. One of the most challenging research work of paleoclimatology, as indicated in the IPCC fourth and fifth reports, is to gather sufficient proxy data in the continuously temporal and spatial chains for understanding a full range of global and regional climate fluctuation, anomaly, and variability at different temporal scales. There are still many gaps in the proxy data. To fill these gaps, historical weather records that were systematically recorded in local chronicles through thousands of years in human history can be extremely useful. More importantly, however, is that historical climate data sets, if properly established, often offer much higher time-resolution than environmental proxy data and can provide better constraint for validating climate models and theories.

The main objective of the REACHS project is to build a comprehensive historical climate database in East Asia in which each historical record is systematically coded, attributed, and loaded with precise time (e.g. hour, date, week, month, season, or year) and space (e.g. city, county or province) information with longitudes and latitudes and representative elevation (meter). Researchers can use this database for a great variety of studies, for example, reconstructing historical climate series at fine spatial and temporal resolution, examining general climate fluctuations over different historical periods, their regional expressions and variabilities. Such studies can be extended to perform research to investigate possible relationships among climate, disaster and human society. Furthermore, the reconstructed climate series will be extremely useful for cross-comparison with other welldeveloped reconstructed databases such as those of 2K Network of the Past Global Changes (PAGES) project of Future Earth

Program. This project is now also a member of the PAGES 2K Network.

### Main Results to Date

The project REACHS involves a high degree of interdisciplinary collaboration, comprising knowledge infusion from climatology, environmental history, geography, historical linguistics, and meteorology (Fig. 1). Our initial data source is derived from The Compendium of Chinese Meteorological Records for the Last 3,000 Years (edited by Prof. De'er Zhang and the colleagues at the Academy of Meteorological Science, Beijing, China) that compiles meteorological, socioeconomic and phonological records that are associated with climate from 8,000+ governmental documents from Xia to Qing dynasties (2100 BCE-1911 AD). All records are digitized and restructured based on the Relational Database Management System (RDMS)

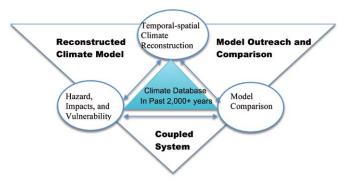


Figure 1. REACHS research structure

scheme, labeling independently while closely linked five subsystems for data management (Fig. 2). So far we have digitized the climate records for part of Qing dynasty for the period of 1644-1795 AD. We have also performed doubly reexamination with the final accuracy rate at  $\sim 86\%$ .

The total number of effective cities/counties included in the digitized records

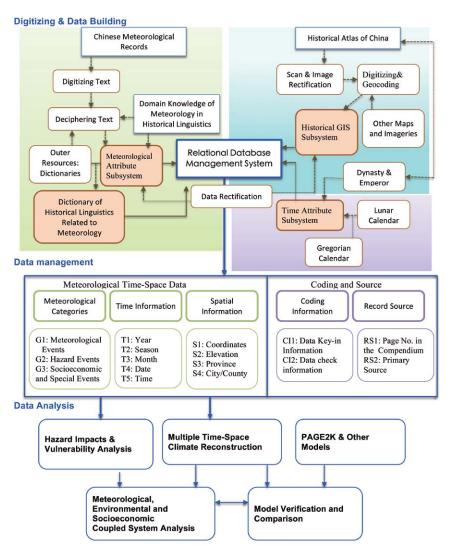


Figure 2. REACHS research methodology

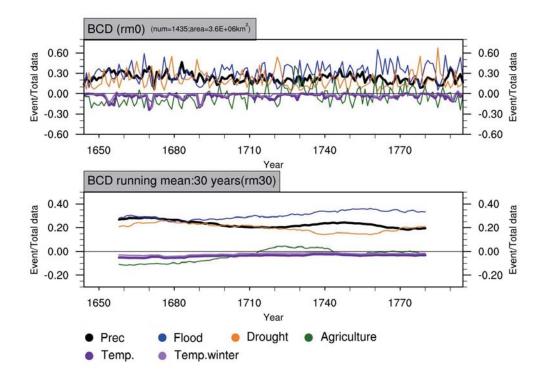


Figure 3. Reconstructed climate trend in East China

The diagram shows changing pattern of historical climate in Northeast (B), Central-east (C) and Southeast (D) China during 1644-1795AD. Temperature in last half of 17th century is bumpier than in 18th century, with a clear warming trend. Precipitation fluctuates but the 30 years running mean shows a wave pattern with declining trend between 1690-1730 AD and then in 1770 AD. The relationships among drought, flood, precipitation and crop seem not consistent and clear throughout the observation period.

of this period is 1,476 with the majority of them concentrated in the traditional China Proper (Northeast, Central-east and Southeast), exhibiting highly spatial unevenness. The total number of records in the period digitized is 34,139. We have also begun using these digitized records to reconstruct various climate data series such as temperature and precipitation time series. We have also conducted statistical analyses including decadal and multi-decadal running mean analysis, spectral analysis and wavelet analysis (Fig. 3-4) on the reconstructed time series. In addition, we have also performed spatial analyses such as frequency analysis, hotspot analysis, and Kernel density analysis to calculate spatial cluster, dispersion and diversion patterns of the climatic indices throughout the years and in different time intervals (Fig. 5). These reconstructed climate data series are cross-compared with other reconstructed climate series and climate models to test the dataset's reliability. robustness and comprehensiveness.

### **Future Research Plan**

In the year of 2016-2017, we expect to achieve some substantial progress for the three main parts of the REACHS project (Fig. 1).

For data building, we expect to accomplish digitizing the records for the rest of Qing dynasty and getting into Ming dynasty by late 2017. Currently all of the built data is preserved and managed only in our local

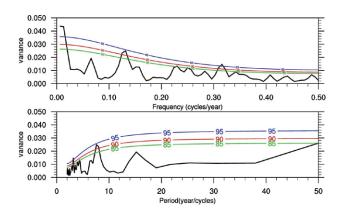
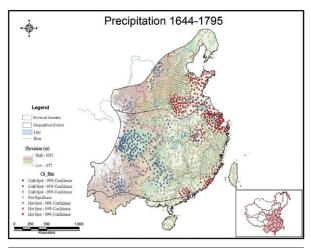
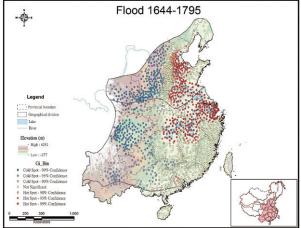


Figure 4. Spectral analyses for temporal precipitation pattern in East China





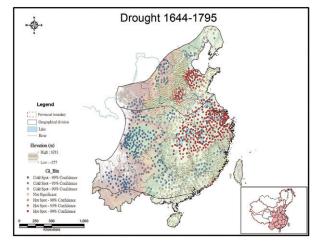


Figure 5. Hotspot analyses displaying spatial distribution pattern of precipitation, flood and drought in East China

Hotspot analysis (Getis-Ord Gi\* statistic) calculates an event's spatial characterization and identifies statistically significant cluster in space. Red dots show clusters of high frequency (hot spots) and blue dots show clusters of low frequency (cold spots). Yellow dots represent higher spatial heterogeneity, meaning that spots of high and low frequency are mixed in the area.

devices, but the management system will be upgraded and a separate system will be established to support publicizing the data on the Internet. Besides, more comprehensive examinations will be executed to improve data's accuracy and preciseness, such as grading method, aggregating and normalizing, rasterizing data, and building monthly or seasonal data for detecting variance. In addition, we will host an international workshop in 2017 to gather distinguished scholars of the field to enhance knowledge exchange and interaction. We also expect to have more interdisciplinary collaboration on a diversity of research topics including monsoon climate and climate-disaster-society studies.

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### **Technology Transfer**

### **Seminars**

Center for Sustainability Science holds more than 13 seminars and 6 conferences as a domestic platform for conducting integrated research. All the research groups in the Sustainability Science Research Program and researchers / experts of different fields were invited to join for establishing the partnership network in strengthening collaborations capacity.

The Center seminars for those research projects completed to share the research outcomes and results. Representatives from governmental departments, universities and industry will be invited to participate and to provide their suggestions that are useful to strengthen the capacity in more comprehensive application of the research results in the near future.





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## Center for Sustainability Science International Programs



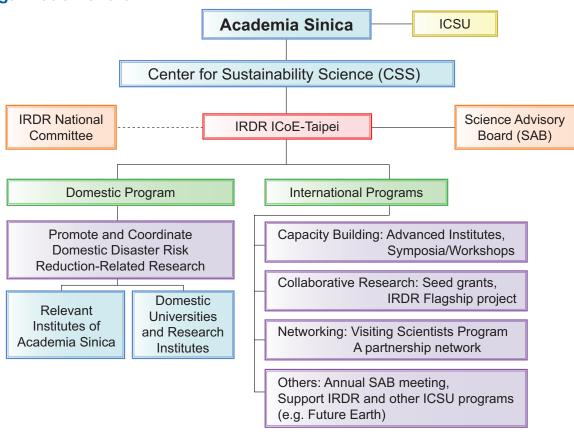


### Introduction

Integrated Research on Disaster Risk (IRDR) is a decade-long, interdisciplinary research program sponsored by the International Council for Science (ICSU) in partnership with the International Social Science Council (ISSC), and the United Nations International Strategy for Disaster Reduction (UN-ISDR). It is a global initiative seeking to address the challenges brought by natural disasters, mitigate their impacts, and improve related policy-making mechanisms.

IRDR International Centre of Excellence (ICoE), Taipei, Taiwan has been established since November 2010 at Academia Sinica (AS) in Taipei and become the 1st ICoE established. The IRDR ICoE serves as an international platform for conducting integrated research on disaster risk from both the natural and social science perspectives and builds a partnership network of disaster reduction research in Taiwan.

### **Organization Chart**



Organization of IRDR ICoE-Taipei

The 2015 Advanced Institute on Disaster Risk Reduction and Loss Mitigation on April 19-25, 2015



### 2015~ Activities

## 2015 Advanced Institute on Disaster Risk Reduction and Loss Mitigation (AI-DRRLM)

This AI was held at Academia Sinica, Taipei, Taiwan on April 19-25, 2015. The 6-day, intensive training event was hosted in partnership with START (www.start.org), the International Council for Science (www.icsu. org) and IRDR ICoE-Taipei. There were 90 international applications for this Advanced Institute (AI-DRRLM). Finally, 18 young to middle-career researchers and practitioners from 10 countries in Southeast Asia were selected who were trained to have enhanced understanding, skills, and practical knowledge in order to reduce disaster risk and mitigate disaster losses in their own countries. The sessions included lectures by eminent scholars and practitioners in disaster risk reduction and management, hands-on interactive exercises, trainee panels, and field visits. In addition, all participants conceptualized individual or collaborative projects which were presented in a plenary session at the conclusion of the Advanced Institute and were submitted for competitive funding to support follow-up research activities in 2016.

After the AI-DRRLM, the Seed Grants awarded to four pilot projects out of eight proposals. The Seed Grants projects are shown below:

- 1. Strengthening community Resilience: The case of Coastal and Island Communities in the Philippines. (Ven Paolo Valenzuela (PI), Kristoffer Berse, Eldin Lumanog and Joan Talubo)
- 2. Web-Based Decision Support System for Hazard Mitigation, Coastal Planning under Storm Surge in Ho Chi Minh & Chennai Cities. (Nguyen Hong Quan (PI), Pradeep Chandra Bose)
- 3. Socio-Ecological Resilience as a Sustainable Development Strategy under the context of Emerging Disaster Risks for Rural Settlements in Different Geo-Climatic Zones of India. (Sameer M. Deshkar (PI))
- 4. Strengthening Community Resilience on the Coastal and Isolated Islands of Indonesia: A case study in the Mentawai Islands West Sumatera. (Agnes Patongloan (PI) Rahmat Pratomo, Anna Napieralska, Ven Paolo Valenzuela)

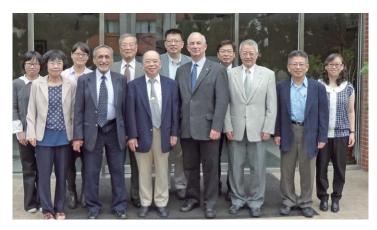
### 2015 Training Workshop on Systems Approach to Management of Disasters

The training workshop was held in Taipei, Taiwan on April 20-22, 2015. This workshop was organized by IRDR ICoE-Taipei, National Taiwan University (NTU), and National Science and Technology Center for Disaster Reduction (NCDR). There were 20 Taiwanese participants. The main

instructor was Dr. Sloboden P. Simonovic, of University of Western Ontario, Canada, a visiting scientist of IRDR ICoE-Taipei in April 2014. The main focuses of this workshop were (i) sharing research experience in the area of systems approach to management of disasters; (ii) discussing modeling of impacts that climate change has on management of water resources and natural disasters; (iii) introducing quantitative resilience as a new way of modeling risk from climate-related natural disasters; (iv) developing decision support tools for the implementation of systems approach in management of disasters; and (v) providing training on the development and use of the systems tools for management of disasters.

### 4<sup>th</sup> International Workshop on Psychological Intervention After Disasters (PIAD)

This workshop was held at Academia Sinica in Taipei, Taiwan on November 9-12, 2015, which represented a further step in a series of workshops dealing with psychological research and practice concerning disasters and how people and communities dealing with disasters with potential impacts on their psychological well-being. The workshop was organized by the International Union of Psychological Science (IUPsyS) and its partners, including IRDR ICoE-Taipei. The workshop aimed at a combination of basic, applied, and translational research, ranging from new insights into epigenetic effects as pathways in the emergence of disaster consequences for human behaviour and development, over cutting edge research in relevant contexts such as family and communities, to particular manifestations of strain such as bereavement and PTSD, and finally to various means of evidencebased interventions. A prime emphasis is the cultural awareness needed when generalizing scientific approaches, on roots of individual and collective differences in response to disasters, such as personality and resilience, with a focus



The 2015 Annual Meeting of IRDR ICoE-Taipei International Advisory Board on Nov 21, 2015

on methodological rigor as a common denominator of all science. In this workshop, lectures by 7 faculty members, break-out sessions, poster presentation, and a field trip to NCDR were arranged. Professor Sue-Huei Chen of the National Taiwan University shared her experiences in psychological intervention after Chi-Chi earthquake and Morakot typhoon during the workshop.

## **2015 Annual Meeting of IRDR ICoE- Taipei International Advisory Board**

This annual meeting of IRDR ICoE-Taipei International Science Advisory Board (SAB) was held at Academia Sinica in Taipei, Taiwan on November 21, 2015. SAB members Prof. Gordon McBean (Chair), Prof. Liang-Chun Chen, Prof. Chao-Han Liu, Prof. Ching-Hua Lo, Prof. Kuniyoshi Takeuchi and Dr. Hassan Virji attended this meeting. Dr. Wei-Sen Li from NCDR also participated as a guest. The IRDR ICoE-Taipei activities, budget, and future plan were presented by the IRDR ICoE-Taipei staff. The SAB members gave their comments and advising, discussed future planning, and approved IRDR ICoE-Taipei's budget for next year.

### **IRDR IPO Visit**

Executive Director of IRDR ICoE-Taipei, Dr. Shih Chun Candice Lung, visited IRDR IPO at Chinese Academy of Science in Beijing, China on August 19, 2016. She discussed IRDR related issues with IRDR IPO Director, Prof. Rajib Shaw, and other IRDR IPO

2015 Training Workshop on Systems Approach to Management of Disasters on Apr 20-22, 2015



The 4<sup>th</sup> International Workshop on Psychological Intervention After Disasters on Nov 9-12, 2015



officers and consulted with them regarding future IRDR ICoE-Taipei's activities, especially for future planning on Advanced Institutes. Both Dr. Shaw and Dr. Lung agreed that future planning of IRDR IPO and IRDR ICoE-Taipei complement to each other. Both will promote integrated research on disaster risk reduction along with the general direction of Sendai framework.

### 1<sup>st</sup> Workshop to Strengthen Scientific Advisory Capacities for Disaster Risk Reduction

This workshop was held in Bangkok, Thailand on August 25-26, 2016. The year of 2015 is a milestone in the history of disaster risk reduction with the adoption of a global framework for action – the Sendai Framework for Disaster Risk Reduction 2015-2030, which calls for a stronger mobilization and application of science in decision-making

and practice and for increased international scientific cooperation. This workshop aimed at strengthening scientific advisory capacities on disaster risk management within each country, sharing experiences among different cultures and supporting the interface between IRDR and policy platforms in charge of disaster risk reduction.

This workshop was co-organized by Integrated Research on Disaster Risk (IRDR) International Program Office (IPO), National Research Council of Thailand (NRCT), and International Council for Science (ICSU) Regional Office for Asia and the Pacific (ROAP) with the collaboration of IRDR ICoE-Taipei. As the representatives of IRDR ICoE-Taipei, Prof. Shih-Chun Candice Lung, and Dr. Chia-Hsing Jeffery Lee attended this workshop with more than 40 experts and government officers from a total of 16 countries who shared their knowledge, experiences, and ideas. There was a consensus

that the communication between science and policy to strengthen science-policy linkage is critical, scientific advisory capacity is needed, and a key person who is willing to and is able to improve the science-policy linkage needs to be found or assigned for each country. A long-term framework of science-policy linkage should be established. In addition, the organizing team of the Workshop decided that the next workshop will be hosted in Taipei, Taiwan in middle of January 2017.

### Networking: A Partnership Network Pan-Asia Risk Reduction (PARR) Fellowships Program

The PARR fellowship program offers unique research, training, and educational opportunities to Asian scientists, practitioners, and policy-makers to enhance their capabilities for advancing and applying knowledge on the critical issues of vulnerability and disaster risks in the Asia-Pacific regions. IRDR ICoE-Taipei is one of the PARR Core Partners. Other core partners include START, Oscar M. Lopez Center (Manila), Kyoto University, and others. The Pilot Program was from July -December 2014 with the initial focus on urban disaster risk and vulnerability under global environmental change. NCDR was one of the host institutes and hosted 4 PARR Fellows in October 2014 for a month-long training in NCDR. Prof. Tony Liu attended PARR Round 1 Culmination and Synthesis Meeting and Alliance Meeting in Bangkok on March 24-26, 2015. Prof. Candice Shih-Chun LUNG and Dr. Ying-Chen LIN participated in the 2016 PARR Fellowship Program Inception Meeting in Manila, the Philippines on Sep 7, 2016.

The PARR Fellowship program is a good model for supporting scientists in developing countries for capacity building in the area of disaster risk reduction. In addition, the New Southward Policy has been initiated by Taiwan government in 2016, which is mainly focused on promoting the exchange, cooperation, and collaboration between Taiwan and Association of Southeast Asian Nations (ASEAN). Based on the think tank resources and technology of disaster reduction



Visit of Dr. Shih Chun Candice Lung to the IRDR IPO office on Aug  $19,\,2016$ 



The International Training Workshop on Natural Disaster Reduction-Natural Disaster Risk Modeling and Applications on Sep 26-30, 2016

and management in Taiwan, such as NCDR, it may be a new possibility for IRDR ICoE-Taipei to develop a fellowship program of disaster reduction for young researchers and professionals in Southeast Asia.

### International Training Workshop on Natural Disaster Reduction -Natural Disaster Risk Modeling and Applications

IRDR ICoE-Taipei Co-organized the "International Training Workshop on Natural Disaster Reduction -- Natural Disaster Risk Modeling and Applications" with NCDR which was held on September 26-30, 2016 in Taipei, Taiwan. The workshop focused on the natural disaster risk modeling and provided a platform for sharing geological, hydrological and climate disaster evaluation models and related experiences among the invited countries. The tenacity of infrastructure and the conception of disaster insurance were also

→ 2015-2016 Biennial Report

 The 1<sup>st</sup> Workshop to Strengthen Scientific Advisory Capacities for Disaster Risk Reduction on Aug 25-26, 2016



• The 2016 PARR Fellowship Program Inception Meeting on Sep 7, 2016



The 13<sup>th</sup> IRDR SC meetings on June 1-3, 2015



discussed. Prof. Shih-Chun Candice Lung was invited to give a lecture speech. Dr. Chia-Hsing Jeffery Lee and Dr. Ying-Chen Lin also participated in this workshop.

## Networking: Participated in IRDR Science Committee (SC) meeting

On behalf of IRDR ICoE-Taipei, Prof. Shih-Chun Candice Lung participated in the 13th IRDR SC meetings in Qingdao, China, on June 1-3, 2015, and presented the activity report. IRDR Flagship project was reported by Dr. Wei-sen Li of NCDR. Representing IRDR ICoE-Taipei, Dr. Candice Lung also participated in the 15th IRDR SC meetings in Paris, France, on May 5-6, 2016, and presented the activity report which was highly appreciated. In addition, The 16th IRDR SC meeting will be held in Sanya, China on November 28-30, 2016. Prof. Shih-Chun Candice Lung and Dr. Chia-Hsing Jeffery Lee will participate in this meeting as representatives of IRDR ICoE-Taipei.

## Networking : Visiting Scientist Program

**Prof. Shen-En Chen** (University of North Carolina, Charlotte)

Prof. Shen-En Chen visited Academia Sinica in November-December in 2015, working with Director P.K. Wang in the Research Center for Environmental Changes, Academia Sinica. Prof. Shen-En Chen conducted the project entitled "Taiwan Carbon Capture and Storage Potential Assessment Including Classical and Innovative CCS Techniques".

## **Dr. Michelle Yung-Feng Huang** (University of Washington)

Prof. Michelle Yung-Feng Huang visited Academia Sinica from January to December 2016, working with Director P.K. Wang in the Research Center for Environmental Changes, Academia Sinica. Dr. Michelle Yung-Feng Huang conducted the project entitled "Hillslope erosion tendency in the storm event series".

#### **Other Activities**

### **Publication in UNISDR/STAG website**

Prof. Tony C. Liu (IRDR ICoE-Taipei, Academia Sinica, Taiwan) and Dr. Wei-Sen Li (NCDR) published a case study entitled "Improved Evacuation Procedures Save Lives in Taiwan from Severe Flood and Debris Flow" online in the UNISDR/Prevention Web STAG page in March 2015.

### Participation in workshop/conference

Prof. Tony C. Liu participated in the Workshop on Practice on Disaster Reduction in Asia Pacific Regions on March 18, 2015, in Sendai, Japan.

Dr. Shu-Li Cheng participated in the UNISDR Science and Technology Conference on the Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 on January 27-29, 2016 in Geneva, Switzerland.

### **Future Earth**



### Introduction

Future Earth is the global research platform providing the knowledge and support to accelerate our transformations to a sustainable world. Bringing together and in partnership with existing program on global environmental change, such as DIVERSITAS, the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP), Future Earth is an international hub to coordinate new, interdisciplinary approaches to research on three themes: Dynamic Planet, Global Sustainable Development and Transformations towards Sustainability. It is also a platform for international engagement to ensure that knowledge is generated in partnership with society and users of science. It is open to scientists of all disciplines, natural and social, as well as engineering, the humanities, and law.

It is sponsored by the Science and Technology Alliance for Global Sustainability comprising the International Council for Science (ICSU), the International Social Science Council (ISSC), the Belmont Forum of funding agencies, the Sustainable Development Solutions Network (SDSN), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the United Nations University (UNU), and the World Meteorological Organization.

### 2015~ Activities

### 2015 Symposium on Pathway to Deep Decarbonization

This Symposium was held at Academia Sinica in Taipei, Taiwan on September 15, 2015. The Deep Decarbonization Pathways Project (DDPP) is a global collaboration of energy research teams charting practical pathways to deeply reducing greenhouse gas emissions in their own countries. It is predicated on taking seriously what is needed to limit global warming to 2°C or less. The DDPP framework has been developed and utilized by a consortium led by the Institute for Sustainable Development and International Relations (IDDRI) and the Sustainable Development Solutions Network (SDSN). It currently consists of scientific research teams from leading research institutions in sixteen of the world's largest greenhouse gas emitting countries. The initial results of this collaboration are reflected in reports on deep decarbonization pathways for Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan Mexico, Russia, South Africa, South Korea, United Kingdom and the United States. In addition, the consortium developed cross-cutting analyses. The invited international speakers of this symposium included: Hans Joachim (John) Schellnhuber, Daniel Ronald Klingenfeld, Frank Jotzo, Fredrich Kahrl, and Leena Srivastava. They introduced DDPP and also discussed with Taiwanese scientists of how to conduct DDPP in Taiwan. These international guests also offered to assist if Taiwan decides to start a DDPP.

## Science and Technology Alliance for Global Sustainability



## International Symposium on Codesign for Urbanization in China and Asia-Pacific Region

This workshop was held by Future Earth - China in Xiamen, China on October 20-23, 2015. Prof. Shih-Chun Candice Lung participated in this workshop with more than 80 scholars and experts from 10 countries. The major themes included state of knowledge on climate change, landscapes of our common future, responding to climate change challenges, and collective action and transformative solutions. Prof. Lung was invited to give a presentation entitled "Community-Based Heat-Stress Vulnerability Assessment with Monitoring, Social Survey, and Crowdsourcing Technology for Health Adaptation" to share Taiwan's experiences on co-designing sustainability research with stakeholders. The workshop summary stated that climate change is a fact that human beings cannot avoid which need the collaboration of scientists from different disciplines and various stakeholders not only on research but also on taking effective actions to tackle the challenge. This workshop also proposed a priority list of scientific topics in the Asia-Pacific Region.

## Regional Advisory Committee for Future Earth in Asia: Inaugural Meeting

Prof. Shih-Chun Candice Lung was invited to be a member of the Regional Advisory Committee (RAC) of Future Earth in Asia. Prof. Lung participated the inaugural meeting of RAC held in Kyoto, Japan on November 20, 2015. The follow-up actions, the role and operations, the funding and the agenda of future works were discussed in this meeting.

## Gro Brundtland Week – Women in Sustainable Development

The Center for Sustainability Science coorganized the Gro Brundtland Week with the Department of Environmental and

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Occupational Health, National Cheng Kung University. Gro Brundtland Week was held in Tainan, Hualien, and Taipei in Taiwan on February 20-26, 2016. This activity aimed to bring up young female researchers who made efforts in the research and practices sustainable development in the developing countries. The 2016 Gro Brundtland Award recipients include five early-career female researchers from China, Japan, Australia and Bangladesh.

### Future Earth Asian Perspective Symposium on Air Pollution: Transdisciplinary Collaboration

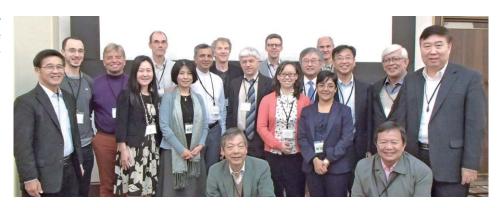
This Symposium was held at Academia Sinica in Taipei, Taiwan on February 29- March 1, 2016. Future Earth is a major international research platform providing the knowledge and support to accelerate transformations to a sustainable world. Launched in 2015, Future Earth



2015 Symposium on Pathway to Deep Decarbonization on September 15, 2015

is a 10-year initiative to advance Global Sustainability Science, build capacity in this rapidly expanding area of research and provide an international research agenda to guide natural and social scientists working around the world. But it is also a platform for international engagement to ensure that knowledge is generated in partnership with society and users of science.

The Inaugural Meeting of Regional Advisory Committee for Future Earth in Asia on November 20, 2015



The Future Earth Asian Perspective Symposium on Air Pollution: Transdisciplinary Collaboration on February 29-March 1, 2016



The Future Earth Asian Perspective Symposium on Air Pollution: Transdisciplinary Collaboration was successful held, with the sponsor by Ministry of Science and Technology, Executive Yuan, in Taipei. The major theme of this symposium is air pollution transdisciplinary collaboration and the objective is to introduce ICSU's Future Earth activity in general and to establish air pollution transdisciplinary collaboration under the framework of Future Earth in Asia for sustainable development. There were 29 speakers from 12 Asian Countries and a total of 106 participants in this symposium.

### 2<sup>nd</sup> Meeting of the Regional Advisory Committee (RAC) for Future Earth in Asia

Prof. Shih-Chun Candice Lung attended the 2nd meeting of the RAC of Future Earth in Asia as an RAC member on April 26, 2016, in Seoul, Korea. The RAC discussed the matters arising from the 1st meeting, updates and follow-up projects, additional RAC members, funding frameworks, and development of implementation strategy for the Regional Center. Prof. Lung introduced the Center for sustainability Science (CSS) of Academia Sinica, presented the activities of CSS and potential contribution from Future Earth in Taiwan.

### 16<sup>th</sup> SCA Management Board Meeting and Conference

The Science Council of Asia (SCA) held the 16th SCA Management Board Meeting and Conference in Colombo, Sri Lanka on May 31-June 1 2016. Prof. Shih-Chun Candice Lung was appointed as the representative of Academia Sinica (one of the Management Board

Members) to participate the Management Meeting and General Assembly. In addition, she was invited to give a presentation regarding Future Earth-related activities held in Taipei, Taiwan. As one of the conclusions, SCA will collaborate with Future Earth to promote sustainability science in this region.

### **CWB-APCC Workshop on Climate Service for Health**

The CWB-APCC Workshop on Climate Service for Health was held by the Central Weather Bureau (CWB) in Taipei, Taiwan on October 12-13, 2016, co-organized by the Center for Sustainability Science, Academia Sinica. The aims of the workshop were to learn from domestic and international experts and scholars on potential climate services for health and to integrate observation, analysis and forecasting techniques of CWB with health service system for enhancing the response capabilities to reduce the health impact of climate change. Prof. Shih-Chun Candice Lung was invited to give a presentation on heat warning system for reducing health risks. Dr. Chia-Hsing Jeffery Lee and Dr. Ying-Chen Lin also participated in this workshop. An invited keynote speaker, Prof. Indira Nath from Indian National Science Academy, India, along with other international guests of this workshop,



The 16th SCA Management Board Meeting and Conference on May 31-June 1, 2016

visited Academia Sinica on October 14 for a discussion meeting which aimed at promoting international collaboration of scientists in Academia Sinica, working on climate change and health-related projects, and international participants of this workshop.

### **Invited Scholar**

Prof. Naomi Oreskes (The Department of the History of Science at Harvard University, USA) was invited for giving a seminar on "On Pope Francis' Encyclical on Climate Change and Inequality: Is technology to blame for climate change?" on September 7, 2015.

Prof. John D. Spengler (The Department of Environmental Health at Harvard University, USA), was invited for giving a seminar on "Promoting Health and Wellness: Programs of the Center for Health and Global Environment at the Harvard T.H. Chan School of Public Health" in Academia Sinica on February 19, 2016.

## The Workshop on Climate Change and Health Adaptation

Prof. Shih-Chun Candice Lung was invited to give a speech in the Workshop on Climate Change and Health Adaptation held in Academia Sinica on September 9, 2016. Prof. Lung introduced the Future Earth Program and key issues on urban health. Dr. Chia-Hsing Jeffery Lee and Dr. Ying-Chen Lin also participated in this workshop and had fruitful discussions with scientists from multi-disciplines during the brainstorming sessions.



Prof. Naomi Oreskes's visit to Academia Sinica on September 7, 2015.



Prof. Shih-Chun Candice Lung's speech in the Workshop on Climate Change and Health Adaptation on September 9, 2016



Prof. John D. Spengler's visit to Academia Sinica on February 20-26, 2016

### **Delta Alliance**





### Introduction

Delta Alliance is an international knowledgedriven network organization with the mission of improving the resilience of the world's deltas. With increasing pressure from population growth, industrialization and a changing climate, it is more important than ever that these valuable and vulnerable locations increase their resilience to changing conditions. Delta Alliance brings people together who live and work in deltas. They can benefit from each other's experience and expertise and as such contribute to an increased resilience of their delta region.

On behalf of Taiwan, the Academy signed a collaboration agreement with the Foundation Delta Alliance International on September 23, 2014, and officially became a member of the Alliance. Taiwan Wing is hosted by the Center for Sustainability Science, Academia Sinica, in collaboration with National Taiwan University, National Cheng Kung University, National Ilan University, National Pingtung University of Science and Technology, and Tunghai University for four major deltas in Taiwan, including the Taipei, Chuoshui River, Pingtung, and Langyang deltas. The Center is responsible for the staff works. The research areas include natural disaster mitigation, adaptation and rehabilitation, food security and health and disease of aging people caused by climate change, etc.

Delta Alliance now has 16 network wings (nation/river or delta region):

- Argentina / Parana
- · Brazil / Pantanal
- Bangladesh / Ganges-Brahmaputra

- China / Yangtze
- Egypt / Nile
- · Ghana / Volta
- Indonesia / Ciliwung and Mahakam
- Kenya / Tana
- Mozambique / Zambezi
- Myanmar / Ayeyarwady
- Spain / Ebro
- Taiwan / Tamsui River, Lanyang deltas,
   Choshuichi River and Pingtung
- The Netherlands / Rhine-Meuse
- USA / California Bay
- USA / Mississippi
- Vietnam / Mekong

#### 2015~ Activities

## The 2015 Workshop on Resilience and Sustainable Development of Watershed

This workshop held in Taipei, Taiwan on April 10, 2015, was the first activity of Delta Alliance-Taiwan Wing. The workshop focused on the exchange and collaboration between Taiwan's research groups which made efforts on the researches on resilience and sustainable development of watershed. The major themes of this workshop included resilience, sustainability, ecology, disaster risk reduction, and humanity settlement. Research groups from Academia Sinica, National Taiwan University, Tunghai University, National Cheng Kung University, National Ilan University, National Dong Hwa University, and National Pingtung University of Science and Technology were invited and gave presentations.

## Visit of Deputy Director of the Delta Alliance to Academia Sinica

The Deputy Director of the Delta Alliance, Dr. Ivo Demmers, visited Academia Sinica on March 9, 2016. Since 2000, Ivo has been working in various functions in the private and not-for-profit sector on integrating spatial development, water, environment, policy and operational management principles in Deltas and river basins worldwide. Currently, he is working at Alterra, part of Wageningen University and Research Centre on strengthening its position in the international water sector. Ivo visited the Agricultural Biotechnology Research Center and the Biodiversity Research Center, and Center for Sustainability Science. After presentations made by scientists in Academia Sinica, three research areas of common interests between Delta Alliance and Delta-Taiwan Wing were identified, namely, wetland research, food security (Rice study), and vulnerability assessment of ecosystem.

## **Delta Alliance Advisory Committee Meeting**

Prof. Shih-Chun Candice Lung attended Delta Alliance Advisory Committee Meeting on May 10-13, 2016 in Rotterdam, the Kingdom of Netherlands. Activities of each wing of the Delta Alliance were reported by representatives from each wing. Prof. Lung reported on the activities of Taiwan Wing and also invited attendees to participate in 2016 International Wetland Convention held in Taiwan.

### 2016 International Wetland Convention

Prof. Shih-Chun Candice Lung, Dr. Chia-Hsing Jeffery Lee, and Dr. Ying-Chen Lin participated in the 2016 International Wetland Convention in Taipei, Taiwan on September 13-14, 2016. The convention is a follow-up of a series of events, which began with the "2007 Taiwan National Parks and Green Network Conference" with 75



Dr. Ivo Demmers' visit in Academia Sinica on March 9, 2016



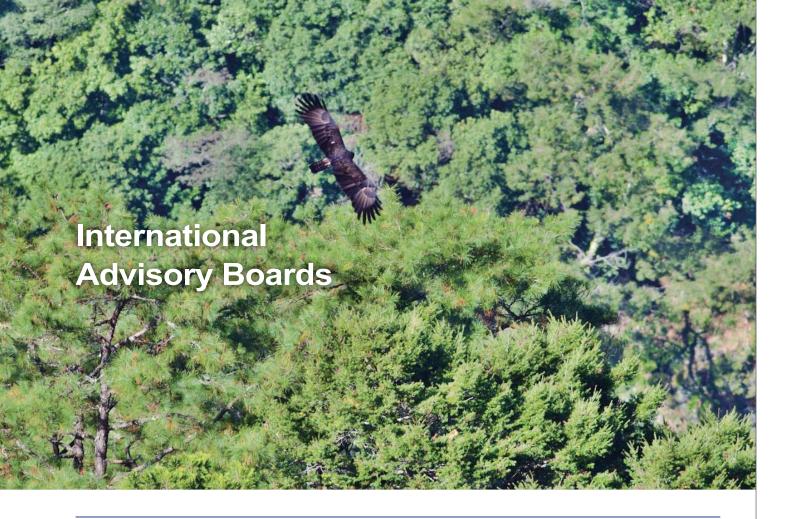
The 2016 International Wetland Convention on September 13-14, 2016

wetlands of national importance officially recognized and a signing of "Taiwan Wetlands Conservation Declaration". A year later, the "First Society of Wetland Scientists (SWS) Asia Chapter's Asian Wetland Convention and Workshop" was held that initiated a sixyear partnership with SWS. Wetland is one of the major components in a delta area. Therefore, wetland conservation is highly connected to the sustainable development of delta areas. This convention features 15 representatives from nine internationally renowned wetland conservation groups for keynote speeches and discussions to strengthen the possibility of international cooperation. During the convention, representatives from Taiwan signed an "Intersectoral Conservation Cooperation Agreement 2016-2021 on a Regional Strategic Program of Action (RSPA)" with SWS and World Wide Fund for Nature (WWF) Hong Kong. The main themes of this convention included: 1) Positioning and Management of Wetlands in National Land Use Planning; 2) Flood Prevention Management for Rivers,

Oceans, and Wetlands; 3) Satoyama Initiative and the Rebirth of Wetland Services; 4) Ensuring Sustainability of Artificial Wetlands and Wetlands Environmental Education; and 5) The Role and Practices of Wetland NGOs and NPOs.

### Participation in an interview survey of Delta-Alliance

Delta Alliance conducted an interview survey in July 2016. The aim of the interview is to assess a list of indicators selected to monitor the resilience of ecosystem services in deltas. The survey was conducted mainly with NGOs, institutions and researchers involved in the management of the California Bay and other Delta Alliance Wings. Taiwan Wing is highly interested in activities of Delta-Alliance and therefore, Prof. Shih-Chun Candice Lung, Dr. Chia-Hsing Jeffery Lee, and Dr. Ying-Chen Lin participated in this survey through replying a questionnaire from Delta Alliance. Although the questions of the survey are expert-specific and involve disciplinary ideas, Prof. Lung, Dr. Lee and Dr. Lin completed this survey after several times of deep discussions.



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