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Would science serve decision-making to adapt the impact of climate change? Introduction to Climate Change Adaptation - scientific evidence, assessment framework and decision-making

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1. INTRODUCTION

We live in challenging times with a heightened sense of uncertainty and unpredictability. Climate change, with its impact on disruptive events as well as gradual trends, has been addressed in scientific studies and become increasingly important in policymaking. This rises up a great need on scientific integration and knowledge transformation. The *Taiwan Integrated Research Programme on Climate Change Adaptation Technology* (TaiCCAT) is formed under this concern. Directing by the Ministry of Science and Technology (MOST), it carries a strong intention to explore and to conduct adequate knowledge of climate change and adaptation strategies for decision-making supports. The TaiCCAT highly recommends the approach of cross-disciplinary collaboration from environmental studies to adaptation governance. The result can therefore be more contributive to reflect the complexity of the changing world.

As the introduction paper, we take a prior focus on framing understanding to the periodic results presented in the selected papers. An overview of the research programme is essential for the readers to get into the context and the content of the studies. The paper is divided in three parts. It firstly introduces the scope of the studies under the national research framework of climate change. The approach in practices is presented. This brings to the summary of the selected papers and the discussions for as the concluding remarks.

2. THE SCOPE UNDER THE NATIONAL RESEARCH FRAMEWORK OF CLIMATE CHANGE

Studying the issue of climate change is rather new. Tsai et al. (2006) has been examined the robustness of hydraulic infrastructure for flood prevention. Coastal levees and reservoirs, according to the assessment, are mostly vulnerable in construction and might cause severe disasters if damaged. In the field of environmental studies, Chou et al. (2008) studied the impact of climate change on biodiversity, forestry, agriculture, fishery, and public health. The result recognised the difficulties, or even the impossibility, to manage the impact by a single profession. Cross-disciplinary collaboration was recommended as a prior concern.

From the perspective of policymaking, however, the results would be mostly theoretical and lacked of a practical pathway for integration. Applicable knowledge of climate extremity was hardly translated to become supportive in policymaking. Collaboration was highlighted without a clear direction to accomplish. In a real situation, policymakers remained focusing on previous experiences of disasters, such as urban floods, storm surges, and landslides, as references. Scientific projections of trends and future threats were seldom considered in decision-making.

Leading by the MOST, the national research framework of climate change was initiated in the early 2010s with an aim to produce applicable knowledge as decision-making supports. It was divided in three programmes: the Consortium for Climate Change Study (CCliCS) focused on developing atmospheric scenarios of the environment. The Taiwan Climate Change Information Platform (TCCIP) was responsible to represent knowledge of trends and future threats. The TaiCCAT played a consulting role for knowledge transformation in policymaking. The vertical collaboration, in principle, held among the three programmes as shown in Fig. 1.

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3. TAICCAT: THE APPROACH

3.1 The Cross-Disciplinary Approach

The TaiCCAT was formed by the administrative office for interdisciplinary coordination (IC office) and three working groups for environment system analysis (WG1), vulnerability assessment (WG2), and adaptation governance (WG3). The IC office took a leading role to direct the programme. Major tasks included setting research goals, framing collaboration and developing international partnerships for experience sharing and knowledge exchange. The WG1 focused on the issues of the environment, especially in the fields of marine science, atmosphere, continent, geology, coast, and ecology. The assessment was mostly made by modeling and GIS spatial analysis. This helped to convert geographical features into fundamental information of climate change.

Studies of the WG2 were about socio-vulnerability as a result of the changing environment. Socio-vulnerability was a consequence of multiple factors addressed in parallel. Because of this, we made a great effort on shaping the framework for cross-factoral assessment. The performance was testified through practical issues as environmental disasters, public health, food security, coastal ecology, and water resources. Integrated relations would be presented. The WG3 put the efforts on socioeconomic fields of the impact on climate change. It explored the way in which adaptation governance could be addressed. Protocols and procedures were essential materials of assessment. The study had particular interests in governance, policymaking, spatial development, social empowerment, public participation, and co-design platforms. Stakeholder participation such as workshops and forums were used to demonstrate the importance of collaborative work and policy coherence in dealing with climate risk.

3.2 The Six-Step of Decision-Making Support

The six-step approach was comforted in the earlier stage by literatures and brainstorming among the professionals (Burton et al. 2002; Lim et al. 2004; IPCC 2007). It comprised the steps of (1) identifying problems and establishing objectives, (2) assessing and analysing current risk, (3) assessing and analysing future risk, (4) identifying and assessing adaptation options, (5) planning and implementing adaptation pathway, and (6) monitoring and modifying adaptation pathway. The steps run in order as a way to sustain knowledge transformation in policymaking.

With the original intention to dialogue with policymakers, soon we realised it contributed to set up collaboration and knowledge exchange among the WGs. Table 1 indicated the addressed works of the WGs. This clarified the collaboration while remained a room for individual interests. As shown in Fig. 2, the WG1 focused on steps 6, 1, 2, and 3 (clarified in green), the WG2 mainly worked on steps 1 to 5 (identified in orange), and the WG3's projects were more related to steps 4, 5, and 6 (signified in blue). The steps mainly applied in order. However, it was also possible for the WGs to start the round map in a specific step and also complete the circle.

4. SELECTED RESULTS AND LESSONS LEARNED BY THE PRACTICES

Running a cross-disciplinary programme is a great challenge. Struggles carry on the way, and, finally, grow pleasantly at the end. Two practical results can be presented in terms of knowledge transformation for policymaking. The first is about the ongoing publication, *Taiwan Climate Change Scientific Report Volume II: Impact and Adaptation*. In this book, we reviewed the development of climate adaptation in the Taiwanese context, especially in the fields of disasters, ecology, water resource, public health, food security, social economy, urban development, and planning. The *Taiwan Climate Change Adaptation Technology Knowledge Platform* (http://www.taiccat.net) was online for detail information. Selected paper, working reports and research highlight were published in this platform for open discussion.

Practical integration of the six-step decision-making support is also acknowledgeable. It earned positive feedbacks from both the national and the local government and was applied as a reference to direct the governmental projects (see Table 2). We expect more integration in the coming years.

Scientific results are no doubt fruitful. In this special issue, eight papers are selected to represent the significant findings in assessing environmental evidences, understanding socio-vulnerability and exploring governance of climate change adaptation. Kuo et al. (2017) devote their contribution on assessing the sea surface temperature in the Taiwan Strait. It explores the interannual variation associated with the Niño-Southern Oscillation and the decadal warming phenomena.

Both Amgalan et al. (2017) and Chang et al. (2017) present their studies of climate change in atmospheric science, with a different concern in regard to the extremity of precipitation and the gradual changes of dust events. The first points out the significant influences of the low-level wind speed, convergence and water vapor content on the rainfall potential of typhoon in couple with southeasterly monsoon. The second testify the performance of the assessment tool in monitoring the dust event in the Gobi Desert zone and the rest of the areas.

Lee (2017)'s article is set with a specific focus on the geological impact of climate change. It argues the interrelation between landslide failure, landslide susceptibility and rainfall parameters. The conclusion highlights a lower potential of landslide occurrences when rainfall value is less than a threshold value of the region. However, landslides increase exponentially when rainfall value is passing through

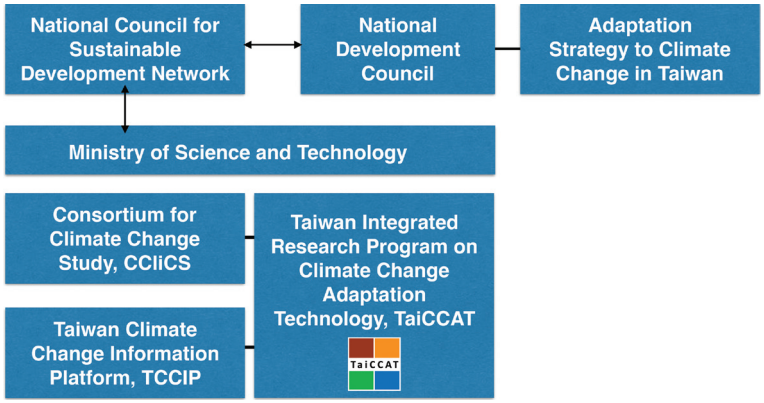

Fig. 1. The position of TaiCCAT under the national framework of climate change studies. (Color online only)

Table 1. The addressed tasks of the WGs.

The six-step of decision-making supports	WG1: environmental system analysis	WG2: vulnerability assessment	WG3: adaptation governance	Head office
Step 1: identifying problems and establishing objectives	Environmental system analysis and value-added • Ocean • Atmosphere • Continent • Regional geology • Coast • Ecology	Vulnerability assessment and framing resilience • Natural disasters • Public health • Food security • Ecology • Water resources		Interdisciplinary coordination
Step 2: Assessing and analysing current risk				
Step 3: Assessing and analysing future risk				
Step 4: Identifying and assessing adaptation options			Adaptation governance and decision-making for risk management • Institutions and policies • Spatial development • Local communities • Cross-sectoral participation • Co-design platform	
Step 5: Planning and implementing adaptation pathway				
Step 6: Monitoring and modifying adaptation pathway				

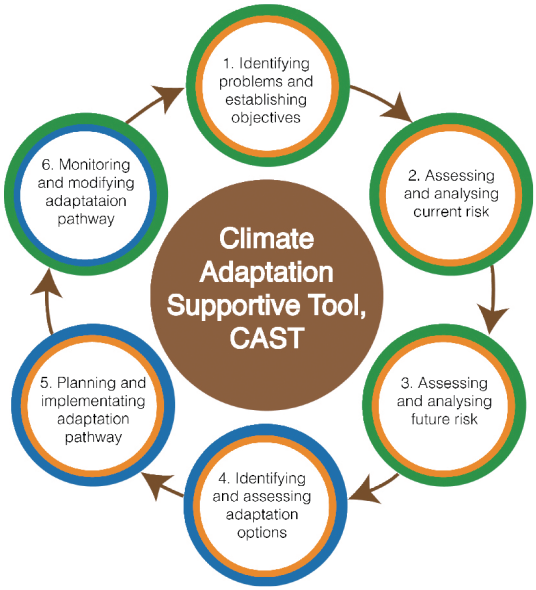

Fig. 2. The six steps of decision-making support. (Color online only)
Note: The WG1 (clarified in green), the WG2 (identified in orange), and the WG3's (signified in blue).

Table 2. Government projects that applied the six-step approach as references.

Government authorities	Year	Applying project	Intention & purpose
National Development Council	2015	Comprehensive plan of climate change adaptation in Northern Taiwan metropolitans	• to assess risks of climate change • to initiate climate change adaptation plans • to form public-private framework of collaboration in coping with climate issues • to establish practical strategies of climate change adaptation in higher-risk areas
Environmental Protection Aministration, Executive Yuan	2015	Working plan of assessing the impact of climate change and studying environmental adaptation	• to review existing studies of climate change adaptation • to develop environmental assessment tools of climate adaptation
Ministry of Education	2014	Integral plan – climate change adaptation in water resource management and disaster reduction	to publish the booklet: 'advanced course of climate change adaptation in water resource management and disaster reduction' as educational guidance
Ministry of Education	2015	Promoting plan – educational alliance of water resource management and risk reduction	to publish the booklet: advanced course of climate change adaptation in water resource for the use of educational alliance of water resource management and risk reduction.
Environmental Protection Agency, Kaohsiung City Governmant	2015	Promoting plan of climate change adaptation and sustainable development in Kaohsiung	to initiate climate change adaptation plan of Kaohsiung metropolitan
Environmental Protection Bureau, New Taipei City Govenrment	2016	Low carbon & sustainable city of New Taipei	to revise the local actions of climate change adaptation

the threshold. Lin and Tung (2017) presents a technical debate in applying the General Circulation Models (GCMs) for climate risk assessment. The GCMs, according to their studies, is needed to classify weather stations into climate zones. This can be applicable to studies in selecting the different GCM datasets.

Chiu et al. (2017) present a pioneer study on building a framework for risk assessment in regard to the adaptive capacity of climate change on the coastal ecosystem in Taiwan. The result indicates the adaptive capacity is related to the exploitation of their natural resources and inadequate biodiversity conservation. Li et al. (2017)'s article examines changes of water resources for agricultural usage and applicable improvements if adaptation measures were implemented. The combinations of desalination, reservoirs and public water conservation may provide beneficial effects in coping with the impact of climate change.

In the last article, Lu et al. (2017) evaluates the content of two local adaptation policies of climate change by considering the notion of resilience in framing adaptation governance. The result indicates that the assessed policies have a wider interest. Embedding resilience, in this regard, can not only present a better understanding of the policies but also generate cross-sectoral collaboration in local governance.

As an integrated programme for scientific knowledge transformation, we learn gratefully that a task-oriented network is essential to form cross-sectoral collaboration both in science and in policymaking. Misleading may occur. However, collaboration remains or even be strengthened if holding the specific issues. In a practical sense, a shared dataset is critical to exchange the information of the environment, whilst forums and workshops were more essential to provide successful feedbacks on vulnerability assessment and adaptive government. All of them can be valuable to frame scientific communication at the international levels in shaping strategies of climate change.

Finally, would science serve policymaking to adapt climate change? The TaiCCAT experience indicates that framing collaboration was perhaps the most critical value. Knowledge exchange and experience sharing play the important roles to confront and to sustain the framework. This requires a continual effort in science that can never reached an end state.

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