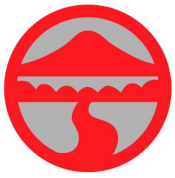

Lingnan 嶺南大學
University

CHINA AND GLOBAL CLIMATE CHANGE

Proceedings of the conference held at
Lingnan University, Hong Kong, 18-19 June 2009

Organised by the Centre for Asian Pacific Studies
and the Environmental Studies Programme,
Lingnan University

Paul G. Harris, Director

Proceedings of the conference on China and Global Climate Change, Lingnan University, Hong Kong, 18-19 June 2009

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CONTENTS

Preface viii

Introduction 1
Paul G. Harris

I. China and Climate Change Diplomacy

Papers presented at the conference:

Global Sustainability, Climate Change and China: The Need for a New Paradigm for International Cooperation 3
Mukul Sanwal

Climate Change, Water, and China's Security: Implications for Global Cooperation on Climate Change 20
Scott Moore

Papers submitted for discussion:

Getting Hotter: How Could China's Climate Change Policy Trajectory Impact a Post-Kyoto Accord? 38
Gloria Jean Gong

Two Logics of Climate Change Games: Environmental Governance and Know-How Competition 61
Hongyuan Yu

II. Ethics, Justice and Responsibility

Papers presented at the conference:

Differentiating (Historic) Responsibilities for Climate Change: Exploring the Case of China…… 78
Christian Ellermann and Niklas Höhne

The Chinese [Climate] Box: A Scalar Approach to Evaluating Ethical Obligations in Climate Strategies for China 100
Erich W. Schienke

The Right to Equal Aspirations and the Obligation to be Different, as a Basis for a Common Future 114
Olivia Bina

Papers submitted for discussion:

Climate Duties, Human Rights and Historic Emissions 128
Derek Bell

Mitigation of Short-Lived Greenhouse Gases as the Foundation for a Fair and Effective Climate Compromise Between China and the West..... 143
Frances C. Moore and Michael C. MacCracken

Social Economic and Political Aspects of Climate Change..... 157
Anandi Sharan

III. Sino-US Relations

Papers presented at the conference:

The Non-Cooperator Pays Principle: Pragmatic Norms and the US-China Greenhouse Standoff... 173
Jonathan Symons

WTO Law as Leverage: An Inquiry into the Dynamics of Climate Negotiations Between China and the United States 191
Dan Partan

Papers submitted for discussion:

Climbing the Great Wall: How the Interplay Between China and the United States Will Affect Mitigation in a Kyoto Successor Treaty 206
Elizabeth Dinello

China, the United States and Global Warming: A Planetary Prisoners' Dilemma 222
Philip S. Golub and Jean-Paul Marechal

Emerging Opportunities for Responding to Climate Change in the Obama Administration: Why China Should Propel Developing Countries Towards Global Carbon Reduction Cooperation..... 238
Richard Ingwe, S.P.I. Agi, and James Okoro

IV. China's Relations with Europe and Russia

Papers presented at the conference:

EU-China Relations on Climate Change Policies and the Role of Bilateral Cooperation for a Global Climate Change Regime 253
Astrid Carrapatoso

Reverse Positions: Can China Be the Winner in Sino-EU's Post-Kyoto Negotiations of Combating Climate Change? 269
Yu Qiao

V. Carbon Markets

Papers presented at the conference:

Sectoral Approach: What is in it for the Chinese Economy?..... 284
Joyashree Roy, Moumita Roy and Shreya Roychowdhury

Evaluating CO_2 Capture Ready Investment in New-Build Thermal Power Plants in China…… 296
Xi Liang, David Reiner, Jon Gibbins, and Jia Li

VI. Identifying Multilateral Solutions

Papers presented at the conference:

Liability for Climate Change: A Decentralized Approach to Long-Term Climate Policy……309
Detlef Spinz

Do All Roads Lead to Copenhagen? The Case of China's Participation in the Post-2012 Climate Change Regime..... 323
Ho-Ching Lee

Looking Beyond: Changes for Climate Change, Changes for Development..... 330
Gerald Schmidt

Paper submitted for discussion:

Asia-Pacific Partnership on Clean Development and Climate: China and International Climate Policy Beyond Kyoto..... 342
Christoph Holtwisch

VII. Climate Change Policies and Practices in China

Papers presented at the conference:

China's Dilemma in Climate Change Mitigation: The Energy Problem 351
Bo Miao and Graeme Lang

China's Renewable Energy Policy: From Project-Based to Strategic Policy Making: Cases of Wind and Solar 372
Veronica Pei-Fei Chang and Hans Bruyninckx

Modeling China's Climate Change Policy in a Post-2012 Framework: On the Perspective of Reputation..... 391
Edward Xue-dong Wang

Papers submitted for discussion:

Are There Policy Tunnels for China to Follow? … 401
Jan Kunnas and Timo Myllyntaus

Predictability and China's Legally Binding Goal of CO_2 Emissions in the Copenhagen Negotiation 413
Yuan Xu

VIII. Local Impacts of Climate Change

Papers presented at the conference:

Climate Change in Hong Kong: Observations and Projections 422
Edwin W.L. Ginn, T.C. Lee, and K.Y. Chang

The Integrated Impacts of Climate Change, Water Availability and Socio-Economic Development on China's Food Production 444
Wei Xiong, Declan Conway, Erda Lin, Yinlong Xu, Hui Ju, Jinhe Jiang, Ian Holman and Yan Li

Rural Livelihoods and Vulnerability to Climate Hazards in Ningxia, Northwest China…….. 460
Yue Li, Yanjuan Wu, Declan Conway, F. Preston, Erda Lin, Jisheng Zhang, Taoming Wang, Yi Jia, Qingzhu Gao, Shifeng, Hui Ju

Ecological Localness and Legitimacy of Science Policy: Mapping Climate Issue in Research Over China and Taiwan 485
Shih-Jung Chen

Papers submitted for discussion:

Climate Change and Heatwaves: China's Responsibility Before the Poor Elderly 502
José Azoh Barry

Land Use and Climate Change in China: Effects and Solutions at the Local Level 516
Mark Henderson

IX. Environmental Attitudes, Behaviour and Civil Society

Papers presented at the conference:

Sustainable Consumption and Production as Climate Change Mitigation Strategy for China…….. 530
Patrick Schroeder

Public Initiatives and Local Practices in China's Response to Climate Change ……..... 545
Lei Xie

Paper submitted for discussion:

Climate Change, the Traditional Chinese Calendar and Modernity 560
Rey Tiquia

X. Policy Opportunities

Papers presented at the conference:

Climate Protection in the People's Republic of China..... 575
Bartosz Rakoczy

Embedding Climate Change in the Curriculum 582
John Willott

Preface

The conference on China and Global Climate Change was held at Lingnan University, Hong Kong, from 18-19 June 2009. About 100 scholars from around the world participated in the conference. They served in various capacities, including as presenters, researchers, paper writers and/or discussants. The conference was jointly organized and sponsored by Lingnan University's Centre for Asian Pacific Studies (CAPS) and its Environmental Studies Programme (ESP). The objective of the conference was to examine the problem of how to reconcile China's growing greenhouse gas emissions with the Chinese government's unwillingness (so far) to join binding international commitments to reduce those emissions.

Since the start of international negotiations on climate change in the 1980s, the Chinese government has refused to be bound by commitments to limit its pollution of the atmosphere. This refusal is based on the historical responsibility of the world's wealthy countries for past emissions and China's status as a developing country. President Hu Jintao recently reaffirmed that China will not commit to mandatory emissions-reduction targets before the world's wealthy countries take the lead in addressing global climate change. He has also called on affluent countries to pay for emissions limitations in China and other developing countries.

Alongside these Chinese concerns about justice and historical responsibility is the new reality that China has become the largest national source of pollution causing climate change. Without China's involvement, notably limitations in its future greenhouse gas emissions, international efforts to mitigate global warming substantially are unlikely to succeed. This comes against the backdrop of increasing concerns among atmospheric scientists that global warming is happening more quickly than predicted, that climate change will be more severe than anticipated, and that the poorest countries and people of the world will experience monumental suffering in coming decades as a consequence.

Thus the conference aimed to assess how China's longstanding concerns about international fairness and justice can be squared against the pressing need for an effective international regime that limits greenhouse gas emissions – including those from China.

Conference Themes and Questions

Major themes underlying the conference included (1) practical considerations, including the latest findings on greenhouse gas emissions and climate change impacts, including in China; (2) ethical considerations, including questions of fairness, justice and human rights related to climate change and China's role; and (3) political considerations, including issues related to the domestic and international politics of climate change, the international climate change negotiations, and the political significance in other countries of China's climate change diplomacy and policies. The conference participants aimed to address these and other questions related to China and global climate change:

> Is there any common ground between China's concern with development and international justice, on one hand, and growing greenhouse gas emissions and the worsening problem of climate change, on the other?
>
> What must the developed countries do to persuade the Chinese government to commit to greenhouse gas limitations, and eventually reductions, in the future? How can they facilitate those limitations?

Does China's newfound wealth undermine the argument that it should not be required to limit its greenhouse gas emissions? What ethical arguments bolster or bring into question China's reluctance to restrain emissions?

How do the adverse impacts of climate change for China's poorest people, and indeed for poor people throughout the developing world, affect China's obligations? Does China have obligations to poorer countries just as wealthier countries have obligations to China?

How significant is it, practically, ethically and politically, that China is going down the same fossil-fuel development path as the West just as scientists are warning of the severe consequences of doing so? Does it matter that China's economic emergence has occurred against the backdrop of improving climate science, whereas the West was historically unaware that its development path was unsustainable?

Should China's new wealthy classes be allowed to hide behind China's developing-country status to avoid lifestyle changes increasingly demanded of most people, including poor ones, in the world's developed countries?

How is the failure of Western governments to implement major cuts in greenhouse gases a political issue in China? Do China's positions on climate change make it more difficult for developed-country governments to persuade their constituents to accept the major cuts in greenhouse gas emissions that will be required to address climate change?

Are workable and affordable technical solutions available to allow China to take a different development path so that its people can enjoy the fruits of modernity without causing monumental harm to the global environment? How can the West encourage and support those solutions?

Given that China and the United States are the largest national sources of greenhouse gas pollution, albeit with very different capabilities and historical responsibilities, how might they work together to protect the atmospheric commons?

Participants in the conference approached these and related questions from a variety of epistemological, empirical and ontological perspectives. While their conclusions varied, there was a strong consensus among delegates in attendance that it is vitally important to understand China's role in efforts to address climate change. The papers that comprise these proceedings make a major contribution to developing and advancing that understanding at a crucial stage in international efforts to curb and respond to atmospheric pollution.[1]

Acknowledgements
The conference would not have been possible without the work of more people than I can count. I am grateful firstly to the participants, especially the dozens of scholars who attending the meeting in Hong Kong and spent two days intensively sharing ideas about China's role in the climate change problem and related debates. A number of people at Lingnan University

[1] In addition to presentations related to the papers here, the conference included presentations only by Kevin DeLuca and Ye Sun, who spoke on "Framing China: US Media, Global Warming, and the Chinese 'Threat,' " and Sondra Venable, who talked about "Russian Resources, Chinese Emissions: The Greenhouse-Gas Footprint of Sino-Russian Trade."

have my gratitude for helping to organize and run the conference: Professor Brian Bridges, for acting as an experienced sounding board throughout the preparations; Dr. Jonathan Symons for helping to organize and plan the panels, and for serving as discussant; and Cyrus Lee, Yuen Chong Wai, and Tommy Wong from the Department of Political Science, and Dorothy Kok and Felix Tsang from the Institute of Humanities and Social Sciences, for helping on the day of the conference.

All of us are especially indebted to Roger Lee Huang, Research Development Officer in CAPS and ESP, for his monumental efforts in helping me with every aspect of the conference, including making the complicated arrangements for both bringing delegates to Hong Kong and getting their papers on the table at the conference; for taking care of a variety of unexpected problems before, during and after the conference; for making sure all of the delegates (especially those from overseas) were happily housed and fed; and – last but not least – devoting many hours indeed to collecting all of the papers together and formatting them for these proceedings.

Indeed, it is these proceedings that will outlast the conference. They will serve as the foundation for full-fledged publications to come, thereby building on the conference itself and adding to debates about how to solve the puzzle of China's growing affluence and its growing contribution to climate change.

Paul G. Harris
Hong Kong
June 2009

Ecological Localness and Legitimacy of Science Policy: Mapping Climate Issue in Research over China and Taiwan

Shih-Jung Chen[1]

Abstract

As science increasingly plays a vital role in global environmental governance, localness has become the focus in scientific interpretation of nature in terms of policy legitimacy and social communication. However, localness would not germinate until the issue of global change is linked locally, a social construction process which shapes the way of interpreting nature/society interaction and affects local ecological cognition. Localness thus indicates not only legitimacy but also an imperative for responsive actions in a society. It might be argued that although political consideration, with special respect to its stance in international negotiation, determines the extent to which national policy complies with environmental orders set by global regimes, local relevance established in domestic knowledge communication can facilitate policy adjustment. It is therefore crucial for further understanding the emerging and absence of the issues evolved in research agendas. This paper focuses on global warming issues in China and Taiwan for the purpose of mutual reference, and analyzes how ecological localness evolved in the problematization of climate science. Co-word analysis is employed to depict and evaluate the issue structure of the scientific domains and to highlight the relevant local issues which might be taken up by the local scientific community in order to fulfill its accountability as regards place-based communication.

1. Introduction

In the face of global environmental change with a high degree of abstraction and uncertainty as seen in the case of climate change, the relationship between science and society becomes critical. The role of science and technology in particular attracts a great deal of concern and attention(e.g. Haas, 1996; National Research Council, 1999; WGBU, 1996). This paper first articulates the role of "localness" in the communication function of science and highlights the accountability of scientific community in linking global change and local concerns. It then reviews the overall capacity building of climate research in China and Taiwan along with national climate policy, and analyzes empirically the extent to which they has addressed local ecological issues. To execute the assessment, co-word analysis is employed to depict and evaluate the issue structure of research problematization so as to draw out certain implication and suggestions to national science policy which is deemed to be critical as regards place-based communication.

2. Scientific Information and Local References

As far as global environment issues such as climate change are concerned, it is always the case that there is a cognitive gap between scientific interpretation of global threats and local public perception. One of the characteristics of the global environmental movement is that the achievement of creating a common image of earth runs parallel with many non-uniform images of environment based on "places" which people inhabit, along with their communities, lifestyles, and not least histories and memories (Jasanoff, 2004: 46). Scientific information with the appearance of global scale sometimes may appear alien to direct local concerns(Jasanoff & Martello, 2004). Contradictions in understanding between the global and

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local may occur, and these may even become severe when environmental issues are framed in a series of rules and orders set down by international regimes.

Localization of global change through domestic knowledge production is especially critical for developing countries(Jasanoff, 2004). There are at least two reasons for this. Firstly, due to the lack of sound scientific basis, research into global change in developing countries relies heavily on international patronages, which may lead to bias through the neglecting of locally unique nature/society interactions. As has been indicated, environmental research tends to miss the link between science and society owing to constraints in science enterprise, such as the interests of funding institutions (normally in countries of the North), the regulation of intellectual property and the specific local structures of innovation systems (Karlsson et al., 2007; Lahsen & Nobre, 2007: 66-70). The emphasis on localness in scientific research into global change serves a way of extending fact pursuance to include local relevant knowledge and concerns, which in turn enables the national scientific community to fulfill the accountability for the communication, translation, and mediation of knowledge (Cash et al., 2003; ICSU, 2002). Localization of global change in domestic knowledge production largely legitimizes public-funded research by introducing more focused scientific investigations, remedying the shortcomings that developing countries are always confronted by, such as an inadequate scientific basis, insufficient financial support, and manpower shortages. Moreover, the results of scientific research stressing on a place-based understanding of interactions between nature and society can enhance public communication and policy debates on global environmental change in a local setting where actions and responses are legitimized and hopefully resolved.

Secondly, in most countries of the South, global environmental agreements such as the Kyoto Protocol are the object of resistance owing to economic, political and cognitive factors. In the minds of some national policy makers and local stakeholders the impacts of new global orders may be just as serious as the impacts of climate change, as is illustrated by the case of the Kyoto Protocol, where the issue of global warming, focused on the reduction of greenhouse gas emissions, is a major political issue for individual political entities, especially in developing countries (Fogel, 2004; Pielke & Sarewitz, 2002). Challenges to the scientific community thus arise. Science is now demanded to contribute to the most heated agendas of global change in the domestic arena, where policy and action depend on a very different set of concerns, such as national interests, economic problems, institutional norms, life styles, beliefs, and so on (Mihelcic et al., 2003; Obasi, 2002: 12). Given the often state-central and economically orientated policy disposition in developing countries, policy-oriented research responding climate change is likely inclined to agendas that often center on increasing energy efficiency, upholding industrial reconstruction, and understanding overall impacts. Scientific information as such, which serves national needs to a significant degree, is characterized by conservatist and often disposed to passive responses or economic stabilization rather than active actions, since it delivers less tangible local references that can forester communication in public debate, social learning, and crisis perception. The lack of legitimacy and supports leads to failure or straddle in forming an active policy in responding climate change, which inevitably needs to make changes to lifestyle that people is accustomed to. An interpretation of nature based on the ecological localness helps to narrow the cognitive gap and stimulate constant debates about global environmental issues on the basis of local concerns. As has been pointed out by N. Luhmann (1989; 1995), scientific claim turns into “meaning” only when the ecological implications of the information are codified by the values and concerns of a given social system at a given moment. In other words, an ecological problem has no prior norm on its own. That is, an ecological problem becomes an ecological problem only through communicative construction and political disposition among various social systems. Researchers in many other fields have made

similar observations regarding the communication and dissemination of knowledge (Carley & Newell, 1994; Knorr-Cetina, 1981). Use-inspired orientation and appropriate institutional autonomy built in scientific conducts helps to take non-traditional themes and indigenous knowledge into account which can widen research topics by spanning spatial scales and diverse phenomena to address problems that are locally concerned and therefore remedy the above mentioned unbalanced policy disposition and agendas array. The inclusion of ecological localness into research, thus, demands the prevalent norms, institutions, and practices in science to be transformed to arrow for greater involvement in the definition of research agendas (Clark, 2003: 6-7; Lahsen & Nobre, 2007: 67).

The paralleling images of the global and local characterize the sophisticated social mechanism of ecological communication between science and society. Scientific information interwoven with placed-based ecological concerns thus is essential to the process of public deliberation and consensus building for global environmental governance and local initiations. Drawn on the above concerns this paper focuses on research problematization, that is, to reveal how local ecological issues have been embedded in domestic knowledge production regarding climate change and how the issue constellations have been evolved and changed over time. Localness understood within the framework of the nature/society relationship as discussed so far refers to the criterion that the problematization of scientific research in the topic of global warming adopts issues that are locally and ecologically relevant. China and Taiwan are taken as cases of study here for not just comparative references but also mutual understanding and learning.

To detect ecological localness in national research, the content of scientific production becomes the focus in this study and an aggregate approach is needed for evaluation. Since the exact content of localness is constructed by scientific community through cumulated works of investigation, the accountability of information delivery is imposed upon scientific community as whole, rather than individual scientists or one particular project. As have been mentioned, the institutional context of knowledge production plays a part in the evolution of research poblematization. A brief description about the political and institutional context of climate issue in China and Taiwan is worthwhile before looking into the detail of the aggregate evaluation.

3. Context of Knowledge Production

Only considering the task of reduction of carbon dioxide emissions, both China and Taiwan face tremendous social costs and vast economic impacts. In 2004, China produces 5007.1 million tones of carbon dioxide, ranking it as world's second largest contributor of carbon dioxide(UNDP, 2007: 310-311). Although the figure in terms of per head of population remains relatively low, about a quarter of that in the US, the growing trend of carbon dioxide emission in China is unlikely to be altered due to its heavy dependence on coal in meeting the soaring demand of energy. A recent announcement already indicates that China has overtaken the United States as the world's biggest producer of carbon dioxide, reaching 6,200 million tonnes in 2006 (PBL, 2007).

As one of world's leading countries, China has developed its own strategies in response to climate change and new global orders. However, along the process of international negotiation, official statements and often-expressed view of Chinese leaders emphasize that the developed countries must take the main responsibility for past greenhouse gas (GHG) emissions while recognizing the duty to equally share the burden of environmental protection for common resources (Harris & Yu, 2005; Heggelund, 2007). Although the above "common but differentiated" approach is consistent with the UN Framework Convention on Climate Change, which launched the Kyoto process and recognized that economic development is "overriding priority" for developing countries, the stance often leads to an impression that

China will not take on full emission reduction commitment(Heggelund, 2007). The absence of compulsory cap on emission carbon dioxide in the newly initiated National Climate Change Program is seen by many as certification to those criticism and skepticism. Looking back the development of China's climate policy, China's fundamental position iterated by the common but differentiated approach was gradually manifested through the 1990s. This fundamental position certainly had affected the content of scientific investigation. What is not clear is the extent to which localness in domestic research is constructed and defined.

When China joined the International Geosphere-Biosphere Program (IGBP) in the late 1980s, Duzheng Ye, founder of Chinese atmospheric physics, insisted Chinese research on global change had a definite national focus(National Research Council, 1992: 23-24). That is, "global" change, from the Chinese viewpoint, was too large a scale for their needs and current scientific and financial capacities. Hence, from the beginning, China has concentrated on areas that are of practical importance for China and that are at the same time scientifically challenging. Apparently, Chinese global change research priorities focus on the question of what is the impact of global change on China and, among others, economic impact is the foremost concern(National Research Council, 1992: 24). Localness in this respect could be referred to a broad scope of domestic phenomena, or maintains a narrow intent to either pursue impact knowledge for wining academic prestige or serve industrial reconstruction by highlighting the applied purpose. The exact content of "national focus" of China are needed to be clarified.

Given the state-centered nature of Chinese politics, the emergence of ecological localness in climate-related investigation therefore contains profound meaning for social communication, and implies a relative autonomy of scientific community in defining research agendas and influencing policy. From this view, the National Climate Change Program of 2007 to some degree marks China's relatively active responses to climate change issues, reflecting the reorganization of China's top policy making structure and the recognition of serious domestic environmental deterioration with regards global warming (Ma, 2007; Melting Asia, 2008, June 5; NDRC, 2007). The nuance of transition underlying the new initiative signals not only a much clearer political resolution in dealing GHG abetment but also the cumulative performance of scientific endeavors in revealing the impacts of global change on China.

As to Taiwan, like other newly industrialized countries, it also faces problems in curbing the rapid increase of carbon dioxide emission. Its per capita carbon dioxide emission soars to 11.87 million tonnes in 2006, ranking Taiwan the 16th position around the world, with almost four times higher than the global average (IEA, 2008: II.167). Considering its small size and population, the total amount of carbon dioxide emission at 270.33 million tonnes certainly gives Taiwan a "notoriety" in the international community.

Although Taiwan did not sign the Kyoto protocol, the government promised to work on reducing carbon dioxide emission. In 1998, the Taiwanese government held its first National Energy Symposium in response to the Kyoto Protocol, but unfortunately it was not until 2005 that the second conference took place. The second conference even reversed the consensus at the first conference, which set a target of maintaining Taiwan's carbon dioxide emission at the level of the year 2000, approximately 223 million tons. Although the Ministry of Economic Affairs (MOEA) in 2005 tentatively considered imposing restrictions on emissions from Taiwan's top 200 energy consumption enterprises, including the Formosa Plastics Group and the China Petroleum Corporation, which cut carbon dioxide emissions by 170-million metric tons per year, the move was eventually abandoned and replaced with a moderate scheme based on voluntary. The legislative progress of GHG reduction continues to be sluggish, due to the strong resistance from industrial sectors, the performance of which is always the top priority on the political agenda. Thus, in the past ten years, climate policy has

been almost inactive, despite the announcement of a "no-regret policy" by the former President Chen Shui-bian. It is interesting to note that the inertia in mitigation and adaptation policy has been severely and continuously criticized by scientific leaders and local environmental organization in Taiwan, albeit that their voices has been easily diluted by the heated political conflicts between the two major parties, Kuomintang (KMT) and Democratic Progress Party (DPP), as well as the ongoing economic downturn since year 1997 (Yue & Sun, 2003). Does this imply that in Taiwan scientific community have gained more autonomous in pondering and devoting the local ecological impacts of global warming? How does the less effectiveness of scientific advices in policy can be explained?

The systematic development of Taiwanese climate change research began with the involvement in the IGBP in 1989, and the IGBP Kuroshio-East China Sea Shelf Exchange Processes (KEEP-I) marked the start of Taiwanese climate change research. Later research extended to the Tropical Ocean Global Atmosphere program, the Climate and Air Quality Taiwan Station (CATS), the World Ocean Circulation Experiment (WOCE), Past Global Changes (PAGES), and so on. From the progress of Taiwanese research, it is clear that the local scientific community adopted the strategy of joining various international programs in order to develop research capacity, and it appears that research topics were discreetly chosen in terms of geographical connections with Taiwan, for the sake of legitimacy. Considering the still nascent stage of research capacity, this strategy is reasonable, though evidence has shown that Taiwanese scientific endeavors in the context of international programs tend to omit certain locally meaningful issues (Chen, 2007). Like other newly industrialized countries, energy efficiency probably is the most focused topics in policy-orientated investigation in Taiwan, for it perfectively fits the multiple national interests, such as economic, security, and environmental demands, but it may not be fully equivalent to the commitment of carbon reduction. How the ecological localness is addressed in scientific research needs to be further examined. In the last three years, the general public perception of climate issues has arisen dramatically in Taiwan, and KMT's regaining power in 2008 brings out much clearer energy saving and carbon reduction policies. The results of the policy initiation are yet to be observed.

Assuming that the relative advances in national climate policy are associated with scientific information in a long run, it is reasonable to infer that the localness content in scientific investigation are accord with the tendency in political disposition. Thus, for better articulating the evolution of research priorities, this study demarcates the observation of data into three different time frames, respectively representing the formation of passive policy baseline in the 1990s, recognizing local impacts after 2000, and policy transition in the last three year. This time segmentation would also help to restrict word meaning in order to enhance analytic precision which is useful for co-word analysis and will be discussed further below.

4. Methodology and Data

To detect ecological localness in research at the national level, it is necessary to delineate the issue structure of relevant scientific research. There are many ways to illustrate the evolution of research agenda in which hieratical and ethnographic investigations are the most popular approaches (Cooper, 2003; Kwa, 2005). Data collected from interview, observation and documentation may reveal the nuance in the development of research priority, but in delineating contemporary evolution of science they would find themselves difficult to make a generalization given their heavy dependence on micro-level study. Analysis in this study aims to delineate the aggregate structure of research issues and hence turned to collect scientific papers published in academic journals which often represent the main body of science in a given field and constitute a vital part of modern scientific institution. Co-word

analysis is therefore used to construct the issue structures of scientific papers in journals. The large number of words presents in papers' abstracts, titles, or key words make co-word analysis a particularly useful method to study and illustrate the issue structure of science domain, and to identify key concepts and themes of an entire discipline. Research has showed that co-occurrence words can be applied to mapping empirically the translation in the dynamics of science and technology in terms of the distribution and co-occurrence of words (Callon et al., 1986; Law & Lodge, 1984; Leydesdorff & Hellsten, 2005). Relying on words' distribution and co-occurrence and applying network analysis techniques to identify the embedded implications, co-word analysis arrows the investigation of research trends and priorities in a way that would be prohibitively time consuming or subject to human interventions with traditional tools of content analysis. The underlying logic of co-word analysis is based on communication theory that words are embedded in sentences and texts that provide them with meaning and special words can be regarded as carriers of meanings between science and society (Leydesdorff, 1997; 2001; Maasen & Weingart, 1995). Visualization and interpretation of co-word networks in the study are based on general concepts and techniques of social network analysis (Degenne & Forsé, 1994; Scott, 1991; Wasserman & Faust, 1994). Especial steps of analysis will be discussed below.

As regards scientific publications, data were retrieved from the online database of the Science Citation Index (SCI) as often applied in the field of scientometircs.[2] Although SCI database mainly collects publications written in English, which probably induces omission or biases in identifying the domestic evolution of knowledge production, articles collected from the SCI are often rigorous enough to gain recognition from scientific community therefore reflecting the creditable advance of scientific endeavors. By using *Global Warming* and *Climate Change* as the target terms and refining data though country code, 183 and 2133 articles published before the end of year 2008 were extracted from the SCI database which respectively represent the field of climate research in Taiwan and China (see Figure 1). From those extracted items, title words rather than key words or words in the abstract are set as the unit of analysis, since the precision of the title word in tracing topical concepts has been asserted (Leydesdorff, 1989). According to the discussion in the previous section, climate research as well as the content of localness in scientific problematization may be affected by domestic political disposition. Thus, for better describe the different stage of development of climate research in China and Taiwan and for better obtain word meanings in distinct periods of research evolution, the selected title words are segmented into three intervals of time, ranging the periods before 1999, between 2000-2005, and during 2006-2008. Because there are only 13 items of Taiwanese papers published before 1999, those 13 articles are discarded in view of the low communication function. After the data were retrieved, title words were processed and cleaned, and a set of title words were chosen with a frequency reaching the threshold beyond 50% of cumulative frequency of total words in each data set, with at least 2 times of occurrence (see Table 1). In the case of China, the numbers of selected words in the three time frames are 98, 139, and 149, while the Taiwan case has only two data sets as mentioned containing 123 and 144 selected words.

Those selected title words were then fed into Pajek software in order to map the issue networks.[3] The cosine for normalization was applied in order to obtain the vectors of the distribution of the words in the form of a network map (Salton & McGill, 1983: 121).[4]

[2] SCI Database is part of the ISI Web of Knowledge at http://portal.isiknowledge.com/.

[3] Pajek is a free, non-commercial software popular in the network analysis community. The Pajek web page can be found at: http://vlado.fmf.uni-lj.si/pub/networks/pajek/H.

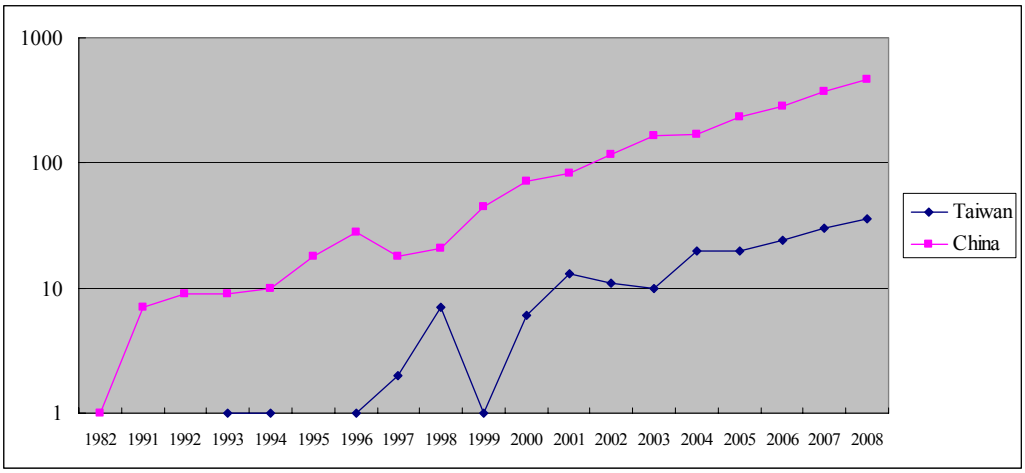

Figure 1. Distribution of articles of climate research in China and Taiwan
Notes: (1) Data are collected from SCI.
(2) Y-axis is based on logarithmic scale.

Table 1. Title words for analysis with thresholds

	Year	No of Articles	Total Words	Selected Words	Cumulated Freq.
China	1982-1999	166	635	98	53%
	2000-2005	840	1953	139	51.99%
	2006-2008	1127	2630	149	50.12%
Taiwan	2000-2005	80	485	123	53.11%
	2006-2008	90	554	144	55.39%

5. Issue Networks of Research

As sociologists have pointed out, the advance of science is based on a set of social institutions and norms, also referred to as "invisible colleges" (Crane, 1972; Merton, 1973). The self-organizational aspect of science thus allows one to depict the aggregate status of scientific production through individual publications. In this study, co-word analysis is used to construct the issue networks of title words so as to reveal the issue configuration of national climate research.

The main challenge of the study is to construct a unit of words that aggregately unfold the ecological localness in research publication over times. From the original issue networks of different time frames, the clusters of localness are extracted by employing the concept of "*k*-neighbors" to select a set of vertices centered on word *China* and *Taiwan* respectively with a direct link (*1*-neighbors). The clusters of localness represent title words of papers having a co-occurrence relationship with local geographic "metaphors" and thus allow one to closely exam the structure and evolution of research issues attending ecological localness. *China* and *Taiwan* here are seen as metaphors, meaning "messengers of meanings" across different subfields of climate research, and function as a punctuated tool to specify a localness cluster in terms of their symbolically spatial references (Leydesdorff et al., 2006: 233-235). To concentrate on "ecological" localness, the study in particular highlights the words connected with *China* and *Taiwan* which refer to the elements of ecosystem as tangible as possible,

[4] Salton's cosine is defined as the cosine of the angle enclosed between two vectors x and y as follows:

$$Cosine(x,\ y) = \frac{\sum_{i=1}^{n} x_i y_i}{\sqrt{\sum_{i=1}^{n} x_i^2}\sqrt{\sum_{i=1}^{n} y_i^2}} = \frac{\sum_{i=1}^{n} x_i y_i}{\sqrt{\left(\sum_{i=1}^{n} x_i^2\right)\times\left(\sum_{i=1}^{n} y_i^2\right)}}$$

including non-living and living components. What words can exactly be treated as having "ecological" references is left for subjective selection due to the fact that demands of information are determined by the lay people who search information by way of natural language not through academic jargons(Teil & Latour, 1995). It is worth noting that words with ecological references identified in the localness clusters are by no means subject to unrestricted interpretations. Although the bottom-up approach of aggregation arrows the subjective selection of words, the meanings of words however need to be judged in a structural view instead of an individual one in that the role of words in network is constituted by their co-occurrence relations. That is, the meaning and function of particular word in a co-word network are embedded and therefore constructed by others. For example, when *water* appear in a co-word network derived from article title of scientific publications, *water* itself cannot be arbitrarily interpreted as a specific kind of hydrological research in relation to climate change but in fact represents a bit of information regarding water which constitutes issue tendency with other words and therefore indicates an element of research problematization.

Based on the original issue networks and the clusters of localness within, the following section takes three further steps to execute network analysis:

1. to identify the presence and absence of vertices with ecological reference in the cluster of localness.
2. to compare the ratio of the word number of the localness clusters to the total words in the corresponding co-word map in different time frames, so as to distinguish the changing weight of the localness cluster against the overall research issues.
3. to compare the "relative closeness centrality" of words with ecological meanings in the localness cluster to reveal the strength of issues that occur in research across different time frames. The closeness centrality indicates the extent to which a vertex has central prestige in a network by measuring its accessibility to other vertices. When comparison across networks is needed, relative closeness centrality is applied.[5]

5.1 China's Climate Research Issues

By feeding the selected title words retrieved from SCI into Pajek, the co-word network of research issues of Chinese climate science are constructed. According to the three time frames as mentioned, the periods before 1999, after 2006 and in-between, three issues network are mapped, containing 98, 139, and 149 words respectively. A threshold cosine $\geqq 0.1$ is applied to produce a "restricted discourses". Upon these original issue networks, 1-neiborhor clusters centered on *China* are further extracted and form the clusters of localness as show in Figure 2, 3, and 4, representing the three time frames respectively. The clusters of localness visualize the issue distributions of localness in China's climate research.

[5] The index of vertex's closeness centrality is $C_C(n_i) = [\sum_{j=1}^{g} d(n_i, n_j)]^{-1}$, where $d(n_i, n_j)$ is the graph theoretic distance (length of shortest path) between vertices n_i and n_j, and g is set of all vertices; for the purpose of comparison across networks, relative closeness centrality is used and expressed as: $C_C'(n_i) = (g-1)C_C(n_i)$ (Wasserman & Faust, 1994: 184-185).

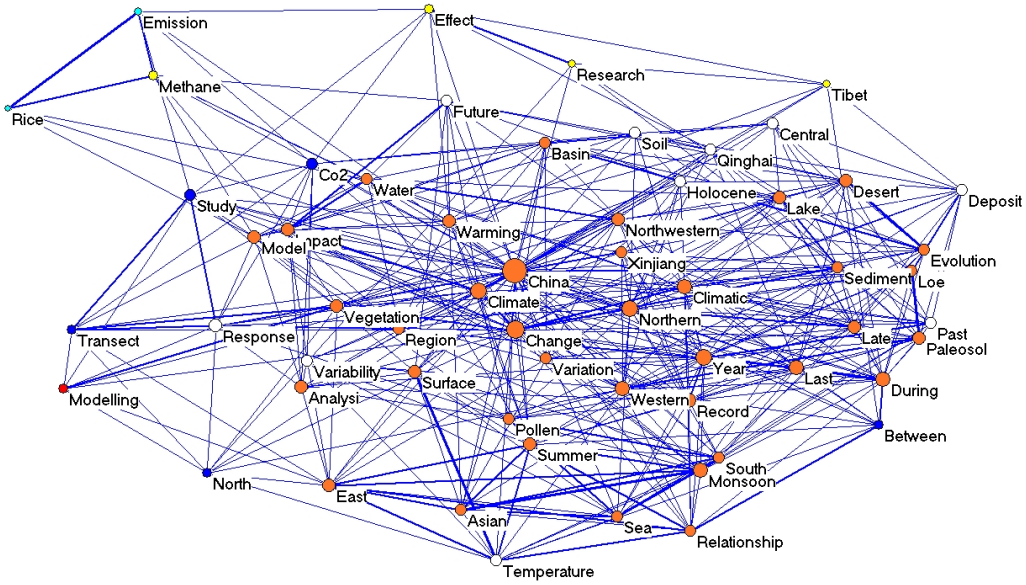

Figure 2. China's issue cluster of localness (59 words) in the period before 1999 at cosine ≧ 0.1, with illustration of 11-core sub-cluster

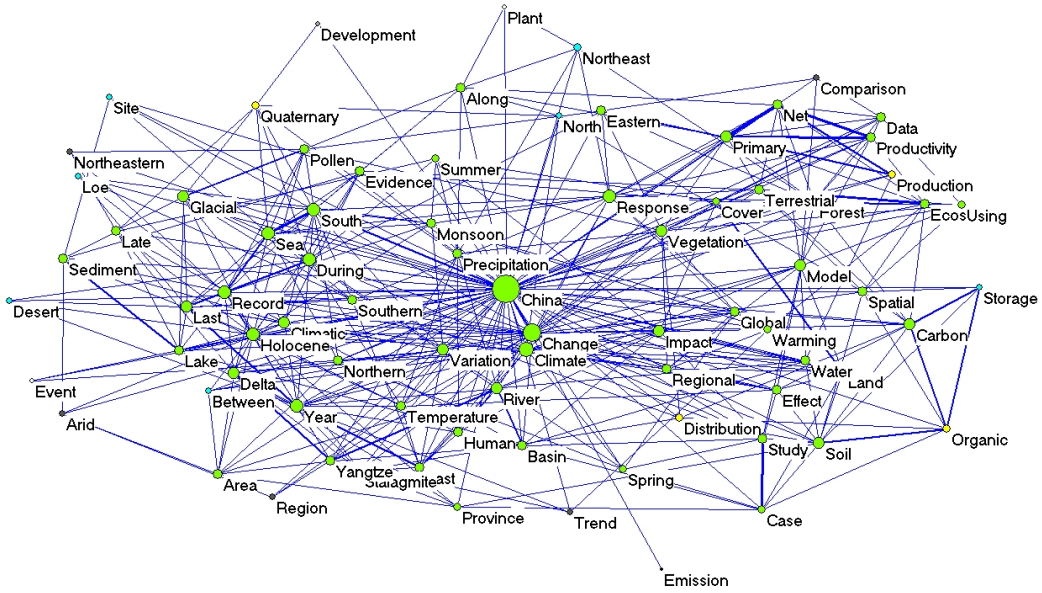

Figure 3. China's issue cluster of localness (80 words) during the period 2000-2005 at cosine ≧ 0.1, with illustration of 7-core sub-cluster

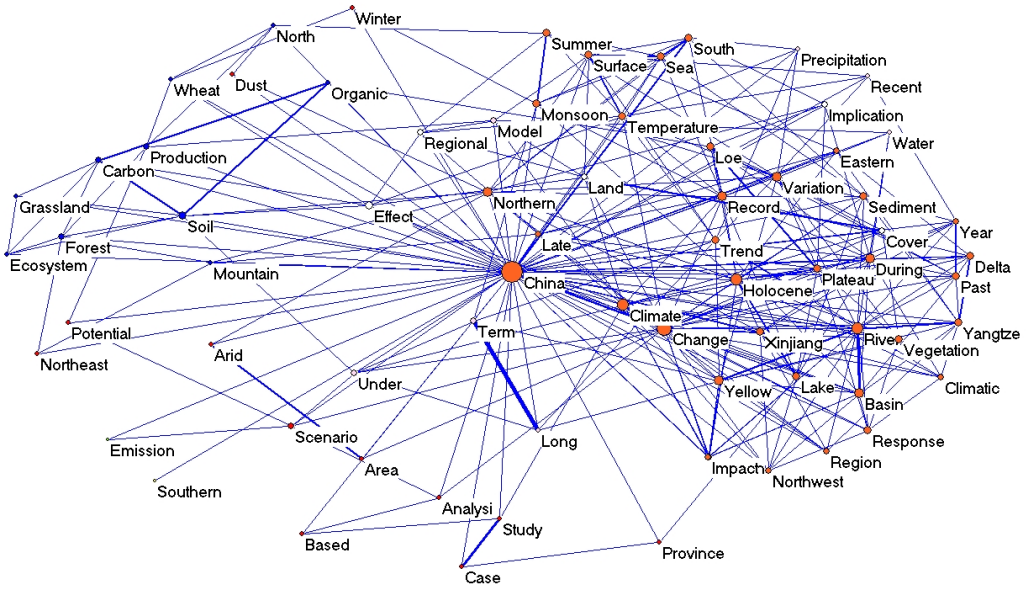

Figure 4 China's issue cluster of localness (70 words) during the period 2006-2008 at cosine ≧ 0.1, with illustration of 7-core sub-cluster

As expected, ecological references emerging in the research issues before 1999 are already various, including *Basin, Emission, Lake, Monsoon, Pollen, Rice, Sea, Soil, Summer, Temperature, Tibet, Vegetation, Water,* and *Xinjiang* (see Figure 2). The multiple issue distribution is somehow consistent with the local centered approach taken by Chinese scientific community in the initial stage of global change research in the 1990s and before. Interestingly, words in the cluster lack strong indicators suggesting the vigorous intervention of policy-oriented research, although this cannot infer an absolute autonomy of Chinese scientific community, which will be further discussed below. In the second time frame, between year 2000 and 2005, research issues embracing even much richer ecological implications, certain amount of which are newly emerging issues, comprising *Arid, Carbon, Desert, Ecosystem, Forest, Glacial, Human, Land, Organic, Plant, Precipitation, River, Spring, Terrestrial,* and *Yangtze* (see Figure 3). The large number of new research agendas with strong ecological references signifies that a variety of phenomena in relation to global change, including the extreme disasters as seen in floods and the extensively impacts such as dust storm, were rapidly explored by Chinese scientists with the build-up of their capacity through 1990s. Once the research manpower and capacity were expanded after 2000, knowledge gap was quickly filled up manifested by the increasing research agendas. This somehow illustrates the correspondence between the growing local knowledge and the active response regarding carbon reduction. With the increasing scientific information of climate change for the last twenty years, scientific evidences certainly attracts public attentions and constitutes policy learning and political pressures that push forward relevant policy actions.

The expanding trend of research topics has however relaxed in the last three years, while the emerging issues in the localness cluster are restricted to *Dust, Grassland, Plateau, Scenario, Wheat,* and *Winter* (see Figure 4). When examining the proportion of words in the localness cluster to the total words in the issue network, figures indicate a declining trend along the three time frames, running from 0.602, 0.576, to 0.469, suggesting the local-related issue are losing its weight while the research issues continuously increase. The rather contradictory trends demonstrate that the richness of localness in research may be attributed to the local-oriented science policy, but not imply a mature autonomy of scientific community. Thus, the expansion of research issues before 2005 simply represents the extreme want of understanding of the impacts of climate change, and the decline of weight of

localness implies the emerging concerns in research has undergone a change and may be reoriented to maintain other types of interests, such as scientific prestige or economic benefits.

In recent years China has been eagerly seeking foreign partnership for collaboration in exploiting renewable energy (Asia Society, 2009; Delman & Chen, 2008). With the increasing strength of policy configuration in response to climate change, the state starts to tap scientific intelligence for economic benefits. As indicated above, the exploitation of energy efficiency may be a vital pillar for GHG cutting, but most often economic fallouts and energy security are at stake. Thus, it becomes a challenge for China's scientific information dissemination to balance the shifting focus from social awareness to economic profits. The network analysis has found that some words existing in earlier climate research, such as *CO_2, Methane, Paleosol, Qinghai,* and *Tibet,* are absent in the localness cluster after 2000. In terms of the value of relative closeness centrality, comparison of words with tangible ecological localness across the three time frames shows that their weights against overall research topics are declining. Figure 5 shows the results of the comparison which are focused on words like *Basin, Lake, Monsoon, Soil, Temperature, Vegetation, and Water*.

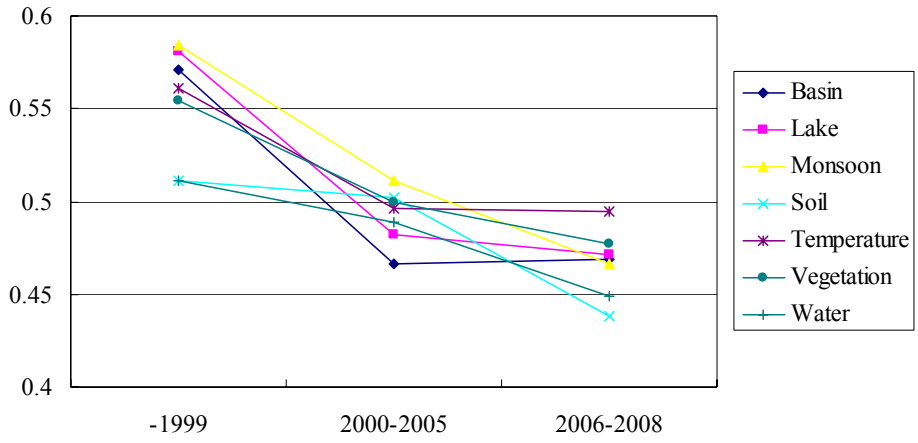

Figure 5. Comparison of relative closeness centrality of words with ecological relevance from China's issue cluster of localness across three time frames

5.2. Taiwan's Climate Research Issues

Due to the small number of items found in the 1990s, Taiwan's data in this period of time are discarded. As has been indicated, academic leaders in Taiwan play a vital role in the campaign of policy action in response to global warming. However, the small number of publications strongly implies that the domestic information of science did little to facilitate social communication of global change in Taiwan, although the scientific endeavors at the time would certainly paved the way for the further development of Taiwanese science basis for addressing global change in new millennium. Given the limited resources and manpower, for small nation like Taiwan the much focused research problematization is essential to bring out meaningful information for social communication.

Taiwan's localness cluster in the time frame 2000-2005 contains 44 words (see Figure 6). The localness cluster shows that words codified with obvious ecological relevance are *Asian, Crop, Dust, Energy, Gas, Pacific, Power, River, Spring, Summer, Water,* and *Yield,* manifesting a vivid and colorful problematization in research (see Figure 6). Among them, *Energy* however refers to scientific investigations targeting energy efficiency, which can be

judged by its associated words and similarities.[6] Although research on energy efficiency may still fit to the criterion of localness, as indicated before it may facilitate technological upgrade rather than social learning. Similar suspicion is also manifested from other aspect. When looking back to the original issue network containing 123 words (not shown here for the purpose of succinctness), it is found that some words did have ecological relevance but are not included in the 44-word cluster of localness. Supposed we consider issues like *Hazard*, *Abatement*, *Precipitation*, CO_2, and *Risk* to be of importance to climatic information which can be found in the original issue network, we may be surprised to know that those issues are not associated with *Taiwan*, at least in the aggregate level. This means that some Taiwanese scientific investigations are ecological relevant but not related to *Taiwan*, a spatial indicator here. The ratio (0.357) of the node number in the localness cluster to the total amount of nodes in the issues network also suggests a relative law proportion of local relevance in overall research problematization. Considering the small scale of geographic features of Taiwan Island, unlike China, the link from global change to local impacts is a substantial challenge to scientific observation. The limited manpower and resources make a locally centered research even more critical. Judging from these factors, it may be inferred that Taiwan's climate research urgently stands in need of taking ecological localness into account.

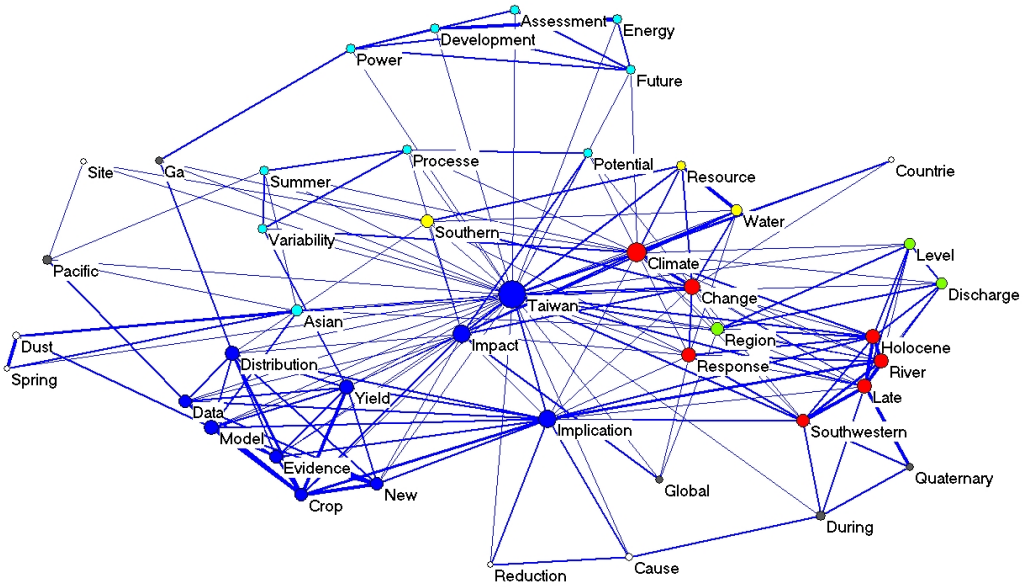

Figure 6. Taiwan's issue cluster of localness (44 words) during the period 2000-2005 at cosine ≧ 0.1, with illustration of 9-core sub-cluster

[6] The configuration of *Energy* clearly refers to energy efficiency research displayed by its co-word relations and in-between similarity as follow: *Assesment-0.333-Energy, Development-0.817-Energy, Efficient-0.817-Energy, Energy-0.418-Future, Energy-0.418-Power, Energy-0.817-Refrigerator, Eenergy-0.333-Study, Energy-0.126-Taiwan.*

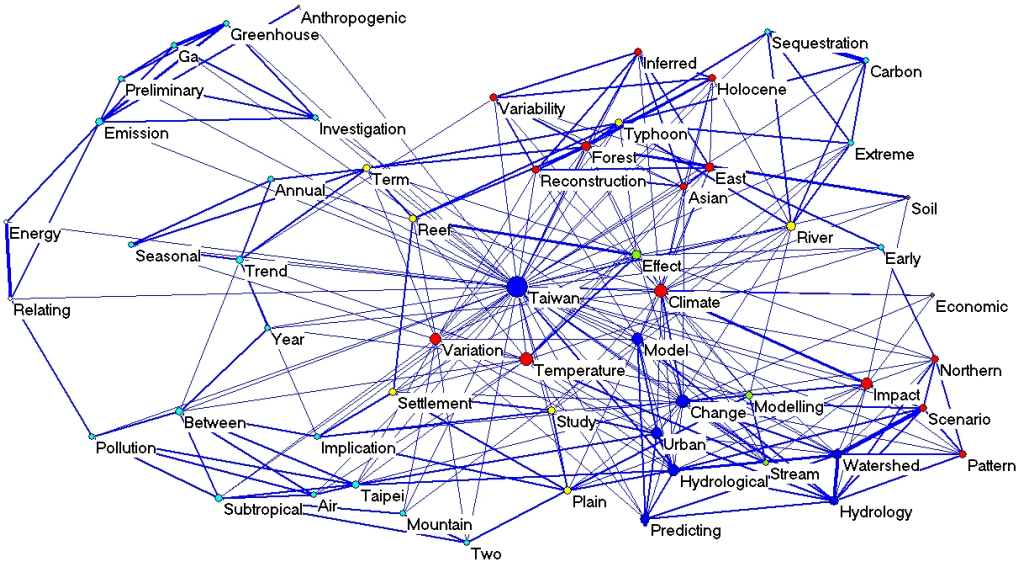

Figure 7. Taiwan's issue cluster of localness (60 words) during the period 2006-2008 at cosine ≧ 0.1, with illustration of 9-core sub-cluster

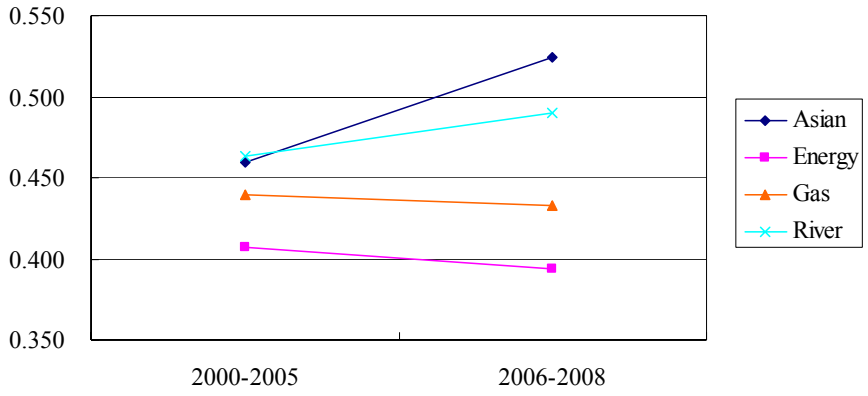

Figure 8. Comparison of relative closeness centrality of words with ecological relevance from Taiwan's issue cluster of localness across two time frames

Fortunately, after a decade of struggling, and alongside heated public discourse on carbon cutting, research issues in the past three year presented a transition of proliferation. In the 60-word cluster of localness extracted from the 144-word issue network representing data between 2006 and 2008, research priorities associated with local and ecological references increase and even cover new issues, such as *Air, Anthropogenic, Carbon, Economic, Emission, Forest, Greenhouse, Hydrology, Hydrological, Land, Plain, Pollution, Reef, Seasonal, Sequestration, Soil, Stream, Taipei, Temperature, Typhoon, Urban,* and *Watershed* (see Figure 7). These issues referring Taiwan's diverse natural and human phenomena have never been so saliently treated in the previous scientific productions. The proportion of words in the 60-word cluster to the total words is 0.416, higher than the previous value at 0.357, and suggests an increasing trend of research in addressing local relevance. This trend is correspondent to the initiative of climate policy of KMT administration in 2008.

While the proliferation of issues in Taiwan's climate research is evident, some issues existing in the previous time frame however lose their momentum in attracting researchers and disappear in the localness cluster of the last time frame, such as *Crop, Dust, Pacific,*

Power, Spring, Summer, Water, and *Yield*. In addition, few words with ecological localness can actually sustain across different time frames. Only *Asian, Energy, Gas,* and *River* exist in both data. The implication and directions resulted from the large scale of replacement of research problematization is still not clear. A further study is needed to pin down the effects. Similarly, the uncertain trend is also showed in figure 8, presenting an inconsistent patent of relative closeness centrality of words that survive through the two time frames. It might be judged at this stage that Taiwanese climate research has come to a critical time to focus on much use-inspired and action-oriented topics so as to contribute to social learning and communication. In network analysis, a *k*-core partition can be applied to identify the most efficient sub-cluster where a closer interaction among vertices are arrowed since any single vertex within the sub-cluster has at least *k* neighbors. Using *k*-core technique, it finds that only five words in Figure 7, including *Hydrology, Hydrological, land, Urban,* and *Watershed*, belong to the highest 9-core sub-cluster (signified by blue color). The limited number of words in the 9-core sub-cluster implies that the scientific community is in need of better agendas setting both in depth and width to facilitate social communication.

6. Conclusion

This study evaluates the content of China's and Taiwan's climate research at an aggregate level in order to reveal how far knowledge production has responded to locally relevant issues. The purpose of the study echoes the recently emerging concerns about the link between science and society, while understanding scientific activity may has multiple functions. To evaluate the content of scientific information and to meet the challenge of empirical study, co-word network analysis, a rather new way of text exploration of science, is employed for a better delineation of the structure and evolution of scientific problematiation over different time frames.

It begins by assessing the notion of ecological localness, and finds that there is a need to evaluate the structure of scientific problemization at national lever for better understanding current function of science in social communication. Aiming the issues of *Global Warming* and *Climate Change*, data are retrieved from SCI and Pajek software is used to conduct and visualize the co-word network analysis. Although having its limitations in micro-level depiction, co-word network analysis offers a feasible approach to surmount the challenge in apprehending main themes in an entire discipline of science, and allows one to explore the trend of research issues in terms of a bit of information decomposed from title words of journal articles, a developed method in science studies and information science.

The results of the study manifest that both China and Taiwan are in an increasing trend of building their own identifiable ecological localness, although two regimes have taken different approaches in research to address the localization of global warming. Differences are partially determined by different political disposition and scientific institution, which is beyond the scope of the study here. However, the co-word analysis do showed the proliferation of ecological localness embraced in research is correspond with the development of national policy in addressing climate change. Thus, the study empirically validates the value of ecological localness, under the concept of which research into global change are expected to be intertwined with meaning attachment in terms of local culture, ecology and lifestyles, aside from economic and political preferences. Based on the scientific information with ecological relevance, actions and policies are likely to gain legitimacy and hopefully to be brought out in practice.

The evolution of research derived the co-word analysis reveals that China's research agendas contain rather rich ecologic localness from the start and especially after year 2000. The richness and diversity of ecological localness may be attributed to its local-centered approach in science planning and therefore contribute to the transition of national climate

policy in general, but underneath the diversity of research agenda, "richness" itself implies tremendous and continuous demands for more scientific information in view of China's extensive territory, diverse natural conditions, large population, and complex anthropogenic impacts. Evidences derived from this study has revealed that along with China's development in both policy and science domain, research topics related to ecological localness have declined its weights against overall climate science. China's scientists now have to cope with challenge in balancing information dissemination, a problem often seen in developing countries that knowledge production is either distorted by policy-oriented applied research or dominated by pure fact pursuance.

As to Taiwan, it takes almost 15 year to build up its scientific capacity and then gradually shift its scientific priority in attending ecological localness. Although the aggregate analysis here is unable to judge the link from the limited scientific information to policy inertia during the 1990s, this study does show that although Taiwan has witnessed the proliferation of research issues after year 2000, the ecological localness in research problemization still fall short of saliency and momentum. Especially, during the recent years, scientific endeavors in offering information with ecological localness are losing focus and present tendencies of inconsistency and contingency, which of course will damp the function of science in facilitating social communication. The direction and effect of these tendencies need further investigation. Due to the small scale of geographic coverage and the economic vulnerability, conducting and transferring useful and meaningful scientific information are both a challenges to and accountability of Taiwanese scientific community for consolidating the link between knowledge and action.

Based on the findings of the study, it is concluded that ecological localness may realize its ideas more profoundly by setting itself up as one element of the constant negotiation between nature and society, the global and the local, and the international regime and the nation state. The assessment of China and Taiwan in this study suggests that communication between science and society is based on the unique local setting, in which constraints and opportunities are always mixed, and that this is particularly the case when dealing with global environmental issues. Programmatic initiatives aside, constant scrutiny and evaluation are necessary to create an alternative platform for communication between nature and society, and the purpose of this study itself is simply to play a part in the negotiation process.

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