Ecological Complexity 8 (2011) 294–298

Contents lists available at ScienceDirect

Ecological Complexity

journal homepage: www.elsevier.com/locate/ecocom

Integrating climate change factors into China's development policy: Adaptation strategies and mitigation to environmental change

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ARTICLE INFO

Article history:
Received 20 February 2011
Received in revised form 22 July 2011
Accepted 6 August 2011
Available online 3 September 2011

Keywords:
Ecological complexity
Climate change
Development policy
Mitigation
Adaptation
China

ABSTRACT

The National 12th Five-Year-Plan for Social and Economic Development (2011–2015) (national development policy) in China requires knowledge of ecological complexity to better guide policy development for adaptation strategies and mitigation to complex climate change. The thinking of human–environment interactions supplements climate change related policies in supporting sustainability through adaptation and mitigation. Based on a review of the climate change contents of the National 10th and 11th Five-Year-Plan in China, the paper illustrates the complexity of climate changes that have affected China's environmental sustainability now and offers policy viewpoints for the in-preparing 12th Five-Year Plan, with five core areas for the implementation of climate change policy: (A) development of the transition to a low carbon economy, (B) prevention and treatment of urban environmental negative effects caused by climate change, (C) adaptation to sea level rises in coastal zones, (D) maintaining the resilience of natural ecosystems affected by climate change, and (E) prevention and control of climate disaster and environmental risk.

1. Introduction

Complexity is a tremendous challenge in the field of ecology (Loehle, 2004). The science of ecological complexity seeks a truly quantitative and integrative approach towards a better understanding of the complex, nonlinear interactions that affect, sustain, or are influenced by all living systems, including humans (Li, 2004). With its complex climate, fragile environment and increasing human pressure on ecosystems, China is vulnerable to the adverse effects of climate change. Moreover, since China is a developing country with a large population and a major emitter of greenhouse gases, climate change has significant implications for its economic and social development (Piao et al., 2010). The national average temperature in 2007 reached a record high in the period dating back to 1951; coastal cities will suffer from more frequent extreme weather events and serious disaster losses as sea levels continue to rise (SOA, 2010). All of these factors exacerbate China's already difficult challenges in the fight against climate change. Given the tight relationship between climate change and other environmental problems, there is considerable benefit to research aimed at solving both within the framework of a transition towards a "low-carbon economy" (Xin et al., 2010).

China's Five-Year-Plans are a series of economic development initiatives. Since 1953, the People's Republic of China (PRC) has implemented a series of Five-Year-Plans that established the blueprint and targets for national social–economic development. This type of planning plays a leading role in mapping policies for economic development, setting growth targets, and launching reforms. This approach to planning is a key characteristic of centralized economies; one plan established for the entire country normally contains detailed economic development guidelines for all of its regions. The 10th Five-Year-Plan for Social and Economic Development (2001–05) (hereafter, "10th FYP") specified the goal of energy saving and defined quantified targets for energy conservation in high energy consumption industries (Government of China, 2006). However, these targets were not met by the end of 10th FYP (Xinhua, 2006). In 2006 the Chinese government defined an ambitious target to decrease the use of energy in the 11th FYP. One objective was to reduce the energy intensity of the economy by 4% by the end of 2006 and by 20% by 2010 (Richerzhagen and Scholz, 2008). The National 11th FYP emphasized that by the end of 2010 the energy consumption per unit of GDP should have

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doi:10.1016/j.ecocom.2011.08.001

decreased by approximately 20 percent, and the total emission volume of two key major pollutants (SO_2 and COD) should have decreased by 10 percent; these were recognized as important binding targets (Government of China, 2006; Lo, 2010).

Many complex forces influence China's environmental sustainability, such as governmental policy and globalization were having as great or even a greater effect on what people were doing to the environment (Müller and Li, 2004; Liu, 2010). Chinese policy makers have recognized the need to integrate thinking about climate change into development policy making, for examples: "China's National Programme in Response to Climate Change" by the State Council in 2007, a White Paper in 2008 and a proposal to "actively deal with climate change" in 2009 (NPC, 2009). By contrast, there has been relatively little attention placed on options for adaptation to complex climate changes in China's development policy. The challenge of integrating mitigation and adaptation strategies into China's national development policy system has not been adequately explored by academics or policy makers. The paper illustrates the complexity of climate changes that have affected China's environmental sustainability now and offers policy viewpoints for the future.

2. Adaptation strategies and mitigation to environmental change

The concept of ecological complexity stresses the richness of ecological systems and their capacity for adaptation and self-organization (Li, 2004). The key concept of adaptation is vital important today when addressing issues of adaptation and adaptive capacity in human populations coping with change, whether it is climate variability and climate change or change associated with policy (Müller and Li, 2004). What combination of emissions reduction and adaptation can best reduce the impacts of climate change? In general, policy responses to climate change involve some combination of reducing emissions, adapting to most of the remaining impacts, and bearing the costs of the unavoidable residual damage (Parry, 2009). How best to balance mitigation and adaptation is a central question that must be addressed in framework of the national 12th FYP in China.

Chinese environmental policy in responses to climate change can be divided into three categories: (1) double-effect behaviors (which result in both mitigation and adaptation occurring simultaneously); (2) mitigation-single-effect behaviors (which involve primarily mitigation); and (3) adaptation-single-effect behaviors (which involve primarily adaptation) (Fig. 1). Although using double-effect behaviors in environmental policy for climate change can be an efficient strategy, most measures alternate the use of mitigation and adaptation and are thus single-effect behaviors. Experience suggests that it is better to focus resources on single-effect mitigation or adaptation strategies, rather than on double-effect behaviors involving both mitigation and adaptation (Qin et al., 2005). Therefore, we argue that environmental policy for climate change should not over-emphasize double-effect behavior. Instead, it should place the emphasis on implementation of multiple single-effect policies, taking into account also the integration of climate change policies with other environmental issues.

Taking into account China's challenges in the 12th five-year period, we propose a framework for the 12th five-year environmental policy in response to climate change (Fig. 2). We argue here that a successful environmental policy system (EPS) will take advantage of double-effect response strategies where possible, but should also integrate single-effect response strategies targeted specifically to either mitigation or adaptation policy goals.

This proposed framework is based on several underlying considerations. First, many climate impacts are likely unavoidable

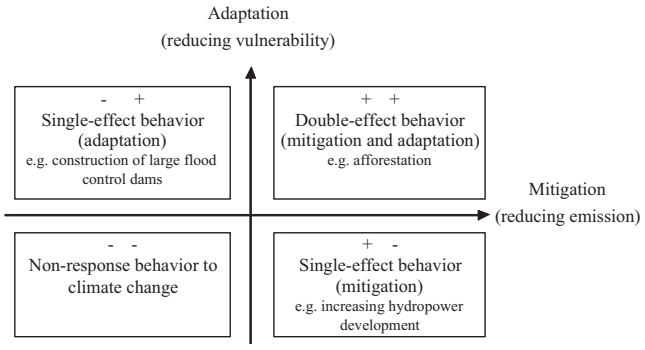

Fig. 1. Classification of climate response strategies based on their contribution to decreased vulnerability (adaptation) or decreased greenhouse gas emissions (mitigation) (adapted from Qin et al., 2005).
Note:
Double-effect behaviors (+ +) represent actions result in both adaptation and mitigation. For example, afforestation can both sequester CO_2 (mitigation) and contribute to reducing urban heat-islands (adaptation).
Adaptation-single-effect behaviors (− +) represent actions which contribute to human adaptation, but which may have adverse effects on mitigation efforts. Construction of large flood control dams, for example, while contributing to adaptation, can also result in substantial greenhouse gas emissions.
Mitigation-single-effect behaviors (+ −) represent actions which contribute to mitigation, but may also have adverse effects on adaptation efforts. Hydropower and wind power are considered cleaner energy sources, but may exacerbate ecosystem vulnerability to climate change.

given the time required to achieve effective mitigation targets, so that the need to adapt to a changing climate is now widely acknowledged. However, identifying what and how much adaptation required remains far from clear. Policy is an important aspect of the wider context in which adaptive decisions are made, but it is not the only determinant and probably not even the most important one. Urwin and Jordan (2008) suggested that governments are correct to raise the profile of adaptation by identifying and resolving the most obvious antagonisms between existing policies so as to facilitate robust adaptive planning. Second, there is large range of uncertainty surrounding the temperature outcomes for different courses of mitigative action, and these represent a major challenge for adaptation. Since adaptation costs increase steeply with the extent of adaptation required, there are difficult decisions to be made about how much climate change to prepare for (Parry, 2009). Third, to maintain China's greenhouse gas emission reduction goals, it is essential that the fast growing economy remain committed to mitigation actions so as to achieve the ultimate objective of climate stabilization. By 2030, China may have roughly 100 and 300 million people with per capita emissions equal or above today's US (20 t CO_2) and EU (10 t CO_2) averages, respectively (Chakravarty et al., 2009). Successful climate mitigation will require progressive involvement of all major contributors to climate change. Investment patterns indicate that policy anticipation could prompt early action in a major emerging economy such as China, and that such early action would materialize in earlier mitigation of CO_2 emissions (Bosetti et al., 2009).

3. Integration of natural and social processes in the policy

In the next few decades, given the predicted increase of GHG emissions in China, there is an urgent need to effective solutions for responding to the complex and negative environmental impacts of climate change. Here we recommend five core areas addressing climate change for the 12th five year environmental policy: (A) development of the transition to a low carbon economy (LCE), (B) prevention and treatment of urban environmental negative effects caused by climate change, (C) adaptation to sea level rises in

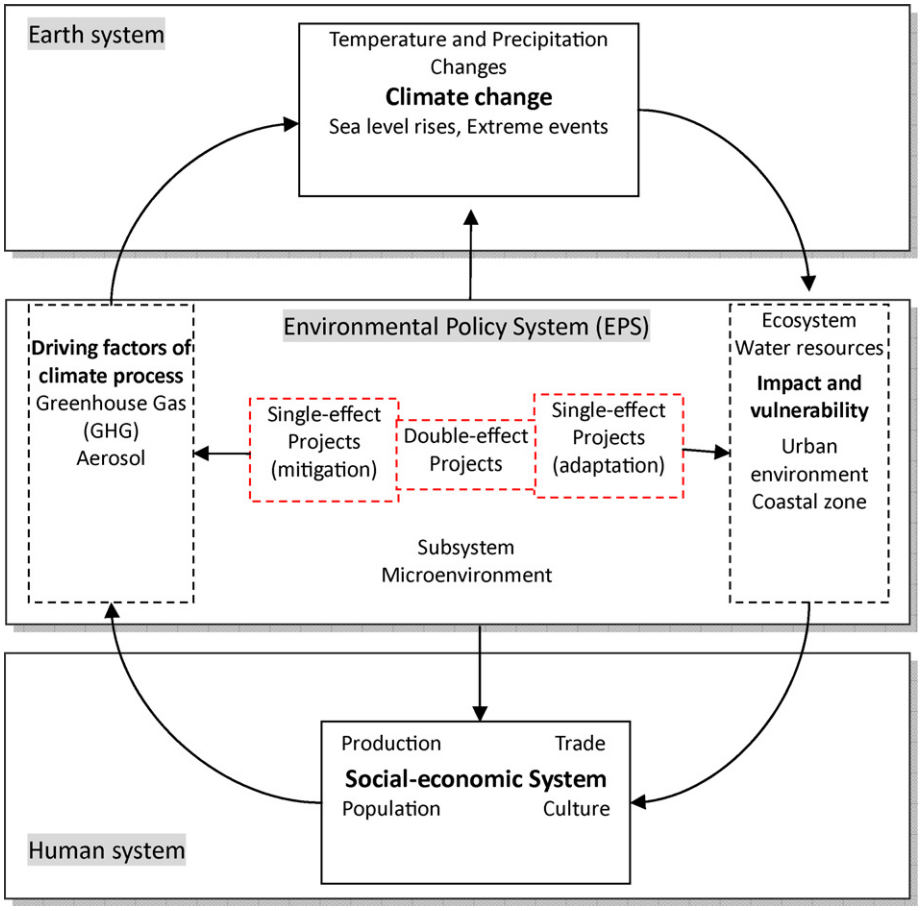

Fig. 2. A proposed framework for the implementation of environmental policy for climate change in China.

coastal zones, (D) maintaining the resilience of natural ecosystems affected by climate change, (E) prevention and control of climate disaster and environmental risks. These five core areas can be further categorized into three "layers" (Fig. 3): (1) objective actions (core area A), which represent mitigation efforts to decrease greenhouse gas emissions; (2) Interface actions (core area B), which represent efforts to both mitigate human impacts on the environment and decrease vulnerability to environmental change at the interface of human and natural systems; and (3) Natural support actions (core areas C, D and E), which contribute to the adaptation of human and natural systems to climate and environmental change. By including both mitigation and adaptation actions, this framework is consistent with the primary objective of the EPS proposed above. We suggest here that adaptation to the environmental impacts caused by climate change should be included as an explicit priority in Chinese environmental policy during the period of the 12th FYP.

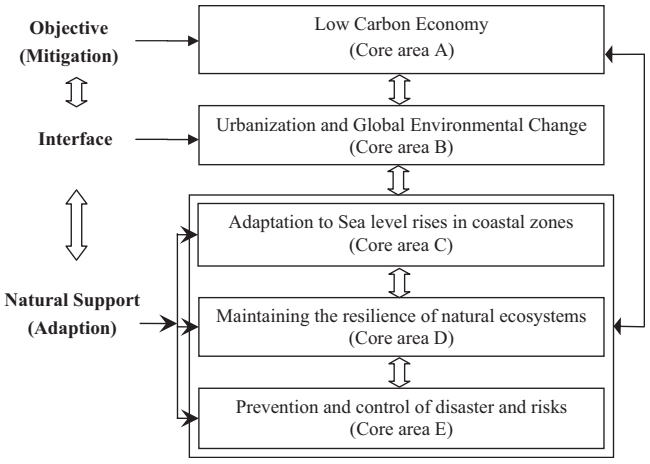

Fig. 3. Three levels of integrative environmental policy in response to climate change.

Along with economic development over the next few decades, energy consumption and emissions of carbon dioxide are still expected to increase in China (Fig. 4), which means that the requirement of a low-carbon economy (LCE) will create challenges for China's socio-economic sustainability. For example, China's auto production hit the 10-million mark for the first time in 2009, ranking the country 3rd in auto production, after the United States and Japan (Xinhua, 2009). The number of vehicles used domestically has also grown explosively, leading to increases in the amount of energy used, greenhouse gas emissions, traffic congestion and air pollution in cities (Parrish and Zhu, 2009).

China has committed to developing a LCE (core area A) and setting up a "three low" economic model based on low energy consumption, low pollution and low emissions. If China is to combine a LCE with economic vitality, feasible approaches will be needed, including regulation of energy structures, enhancement of energy efficiency, regulation of industrial structures, and development of potential carbon sinks. Accordingly, environmental policy must include instruments aimed at promoting a circular economy and cleaner production. For example, urban public transit is vital for future development and this sector is also making significant efforts to reduce GHG emissions and conserve energy. If energy-saving technologies can be used effectively across the nation's

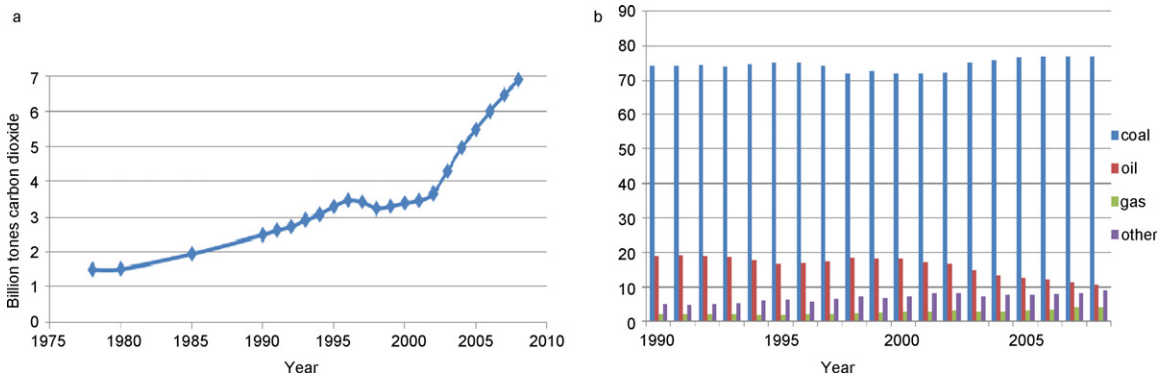

Fig. 4. Carbon dioxide emission (1978–2008) and energy consumption (1990–2008) in China.

energy system, the LCE model will be regarded as successful in accordance with China' current and future trend of clean energy and renewable energy development (Zeng et al., 2008). This approach will also gradually promote carbon trading at regional and local scales and enhance carbon sinks in ecologically protected areas and nature reserves.

The earlier China joins the research for low-carbon development strategies, the better for global climate and the competitiveness of the Chinese economy. A high carbon mode will severely restrict the development of China, while a LCE will represent an important breakthrough towards sustainable development. As such, we argue here that LCE development will not only contribute to climate mitigation goals, but can also decrease the vulnerability of the Chinese people and economy to climate impacts; this can be considered to be a double-effect response strategy, contributing to both mitigation and adaptation objectives.

Urban areas are hot spots that drive environmental change at multiple scales (Grimm et al., 2008). As complex systems with high openness and vulnerability, cities are also places which concentrate negative environmental effects and where new pollution problems both contribute to and are exacerbated by climate change. In core area (B), cities have received the level of attention they require in the area of global environmental change (Li and Zhu, 2010).

Coastal areas are the most densely populated and most active development regions in China. Over the last three decades, with an average annual increase of 2.6 mm per year, which is more than that of global average level, sea level rises in coastal zones in China have seen an upward trend; especially in 2009 saw the largest sea level rises of the past decade (Fig. 5). As a result of the acceleration of economic development and urbanization progress in China's coastal zones, a large population has flooded into this region, whose economic zones (e.g. five national economic and technical development zones in Liaoning Province, Caofeidian Project in Hebei Province, Tianjin Binhai New Area, Yangtze River Delta Economic Zone, Pearl River Delta Economic Zone and North Bay Economic Zone in Guangxi Province) have gradually moved towards marine areas. Most parts of this region are now vulnerable to sea level rises.

China's rising sea levels not only inundate low-lying coastal regions but also contribute to the redistribution of sediment along sandy coasts. Over the long term, sea level rise will cause a significant amount of damage to coastal ecosystems, which are already characterized by increased sewage discharge in coastal cities, salt water intrusion, coastal erosion, salinization of soil, etc. In core area (C), the EPS should develop coastal county-scale maps depicting areas which will require shore protection (e.g. dikes, bulkheads, beach nourishment) and areas which will be allowed to adapt naturally, identifying land use changes to ensure that wetlands migrate as sea levels rise in some areas. The EPS will need to engage state and local governments in defining responses to sea level rise.

Natural ecosystems are susceptible to climate change in China, which leads to ecosystem degradation, biodiversity loss and desertification. Human activities are deeply intertwined with climate change: the high-frequency of river desiccation, shrinking lakes, and wetlands loss/function degradation in China are all examples. That understanding and assessing the complexity of potential impacts of climate change on natural ecosystems are essential if policy makers attempt to minimize the negative consequences of climate change (Burkett et al., 2005; Prato, 2008). All climate-sensitive systems of the natural environment will need to adapt to a changing climate or possibly face diminished productivity, functioning and ecosystem health. In core area (D), successful adaptation will require a degree of coherent changes in habitats and ecosystems, supported by current and future institutional arrangements designed to provide protected areas for species and habitats. For example, a current environmental protection project, the "Tibet Plateau National Ecological Security Barrier Construction," would play a critical role in environmental protection and ecological enhancement. This project includes several components which illustrate how protected areas can also

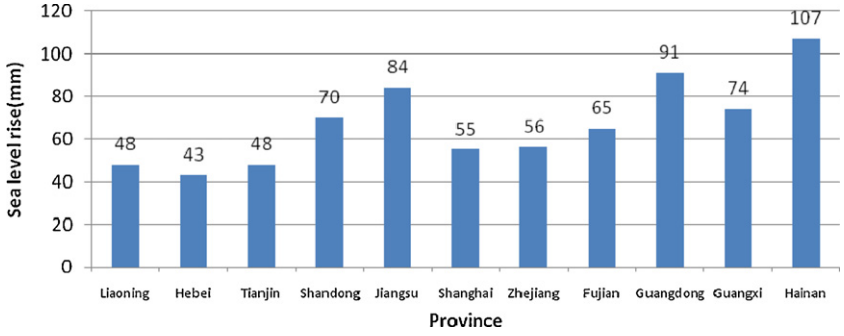

Fig. 5. Sea level rises relative to MSL in coastal zones of China (2009).

increase resiliency to climate change: (1) protection sub-projects (natural grassland protection, nomad protection, forest fire control and pest control, wildlife protection and wildlife protection zone construction, major wetland protection and alternative energy projects in rural areas); (2) construction sub projects (shelterbelt system construction, artificial grass construction, sediment control, erosion control, mine restoration and geological disaster prevention); and (3) support sub projects (ecological monitoring project and technology support project) (China Tibet Information Center, 2008).

Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk (IPCC, 2007). In core area (E), the plan considers not only the information on the impacts caused by probable climate change scenarios, but also events with low probability and high impact as well as assessment of the impacts of the policy consequences. However, risk events are typically difficult to identify and avoid in environmental policy. This requires the 12th five-year environmental policy to not only respond to the current urgent need for prevention and reduction for disasters, but also to control environmental risks in the context of climate change. Many Chinese cities are currently increasing their capacity to assess potential impacts; for example, the coastal city of Shenzhen, China, has developed a network of 2000 automatic meteorological data collection stations, to provide a monitoring range of 250 km (Kamal-Chaoui and Robert, 2009). Because environmental zones do not often fall within city boundaries, adaptation planning and management often requires horizontal coordination with multiple local governments within the same region as well as vertical coordination with regional and national governments.

4. Conclusions

The complex challenges of climate change require careful design and mixing of environmental policy and management approaches. Given China's circumstances, mitigation-based strategies are urgently necessary, but not sufficient. They must be complemented by a wide range of locally and regionally based adaptive responses which are included explicitly in policy and development policies.

As the largest developing country, China assigns high priority to meeting the challenge of climate change. How has China responded to the threats arising from climate change? In this paper we have considered the main climate-relevant policy fields in China – energy, transport, and environment – and presented a framework for the integration of climate-specific measures into environmental policy of 12th FYP.

Up to today, the effectiveness of environmental policy in China is weak, and its potential to support mitigative measures is therefore not fully utilized (Richerzhagen and Scholz, 2008). We recommend five core areas addressing climate change for the 12th FYP: (A) development of a low carbon economy, (B) prevention and treatment of urban environmental negative effects caused by climate change, (C) adaptation to sea level rises in coastal zones, (D) maintaining the resilience of natural ecosystems affected by climate change, (E) prevention and control of climate disaster and environmental risks. We have recommended that adaptation to the environmental impacts caused by climate change be included as an explicit priority in Chinese environmental policy during the period of the 12th FYP.

In the face of ecological complexity and uncertainty, further research need to discover dangerous climate thresholds, negative affections (Piao et al., 2010) and effective strategies to reduce social and ecological vulnerability of ecosystems to climate change (Prato, 2008).

Acknowledgements

We thank Prof. Bai-Lian Larry Li for his constructive comments and suggestions. Support from the National Natural Science Foundation of China (NSFC) grants 40901081, 40976021 and 41101141, National Major S&T Program for Water Pollution Control and Management of China (2008ZX07101-004) and the Soft Science Project of the Ministry of Housing and Urban-Rural Development of China (2009-R2-40) are gratefully acknowledged.

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