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Government response to climate change in China: a study of provincial and municipal plans

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In this paper, we provide an overview of local and regional climate change plans in China by scrutinizing planning documents from 16 cities, four autonomous regions, and 22 provinces. We develop and apply an evaluation protocol to understand goals, process, and strategies in these plans. We also conduct interviews with government officials to provide a context for subnational climate change planning. The results indicate that current climate change planning in China is characterized by the 'top-down' approach, in which the central governmental incentives play a vital role in shaping provincial and municipal plans. In addition, most plans have the following issues: vague definition of what characterizes a low-carbon city/region; deficiency in the quality of greenhouse gas inventory and reduction targets; insufficient strategies provided to respond to climate change; inadequate stakeholder engagement; and weak horizontal coordination. Finally, we offer recommendations to improve climate change planning in China.

Keywords: climate change; low carbon; plan evaluation; governance; China

1. Introduction

Climate change is considered as one of the most complex challenges in the twenty-first century, especially in the field of planning (Donaghy 2007; Wheeler 2008; Blanco *et al.* 2009). Urban areas are both significant contributors of greenhouse gas (GHG) emissions and where innovation and policy action take place (Satterthwaite 2008; Kennedy *et al.* 2009). Thus, cities and regions have been increasingly recognized as major sites to respond to global climate change (Kousky and Schneider 2003; Betsill and Bulkeley 2007; Dhakal and Betsill 2007; Donaghy 2007; Ruth and Coelho 2007; Pamlin, Pahlman, and Weidman 2009; While, Jonas, and Gibbs 2010). Meanwhile, a growing number of subnational governments have recognized that global climate change has an essential local and regional dimension. Some international programs, such as the Cities for Climate Protection (CCP) Campaign that encourages local government emission reductions, are vibrant examples of this trend (Betsill 2001; Kousky and Schneider 2003; Lindseth 2004; Lutsey and Sperling 2008; Wheeler 2008; Anguelovski and Carmin 2011).

China continues to experience rapid urbanization of unprecedented scope as it has in recent decades. The urbanization rate in China reached 53.73% in 2013 (National Bureau of Statistics of China 2014). The rapid urbanization process will possibly lead to more GHG emissions and make Chinese cities more vulnerable to climate change. According to *China's National Assessment Report on Climate Change* (2007), the surface temperature in

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China will increase by 1.3−2.1 °C by 2020 and 2.3−3.3 °C by 2050. Annual precipitation will increase by 2%−3% by 2020 and 5%−7% by 2050. In addition, Chinese cities will face more severe natural hazards caused by climate change, such as floods and droughts.

To meet the challenges brought about by climate change and by the resource and energy constraints stemming from rapid urbanization in China, the Chinese government has promulgated laws and regulations for cleaner energy production, energy savings, and emission reductions nationwide. However, it was not until 2007 that policies or action plans that deal specifically with climate change were put in place. Up until now, China has adopted climate change policies and actions from the central to local government level.

At the central government level, *China's national strategy for responding to climate change* was promulgated in 2007 as a major national policy guide. Subsequently in 2008, the Climate Change Division of the National Development and Reform Commission (NDRC)[1] was founded as a central government organization to address climate change in China. In 2009, the central government announced drastic goals to reduce GHG emissions per unit of GDP in 2020 by 40%−45% compared with 2005 levels (China Daily 2009). Since then, China began to take specific actions to combat climate change nationally.

As of 2009, 27 provinces and autonomous regions[2] in China had prepared plans to respond to climate change. These provincial climate change plans were developed by the provincial Development and Reform Commissions.[3] In 2010, the NDRC designated Guangdong, Liaoning, Hubei, Shaanxi, and Yunnan Provinces, as well as the cities of Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang, and Baoding, as pilot sites to promote low-carbon cities and provinces to combat climate change at the subnational scale (NDRC 2010). In December of 2012, the NDRC announced another set of 29 cities and provinces as the second wave of national low-carbon pilot cities and provinces (NDRC 2012).

Since 2009, low-carbon development has become a nationally adopted campaign to respond to climate change at the local level (Zhang 2010). According to Li *et al.* (2012), at least 74 cities in China have established the goal of developing low-carbon cities. Since low-carbon development is and will continue to be pervasive in China, it is important to analyze the range of strategies and policies currently adopted at municipal and provincial levels.

In recent years, a body of formal provincial and municipal plans has grown in China due to the subnational campaign of climate change planning. Evaluation of these plans is quite necessary to examine whether subnational climate change planning is the mainstream policy response to climate change in China and whether there are existing issues and challenges. Analyzing these climate change plans in depth would also help to better understand the current status of climate change governance in China. Meanwhile, climate change plans at the subnational level have already received significant attention in planning literature, focusing on the context of developed nations (Wheeler 2008; Bulkeley 2010; Bassett and Shandas 2010; Tang *et al.* 2010; Baker *et al.* 2012; Baynham and Stevens 2014).

The purpose of this study, therefore, is to provide a detailed work of climate change planning at the subnational scale in China by reviewing existing plans. The climate change plans in this study include the scopes of both climate change mitigation and adaptation. It is worth mentioning that the majority of current city-level climate change plans in China focus on climate change mitigation and are thus named 'low-carbon'

plans, whereas provincial level climate plans usually involve both mitigation and adaptation. We developed an evaluation protocol for climate change plans and applied it to 16 municipal and 26 provincial plans[4] in China. Following this, we analyzed policy actions and strategies of these plans by using a detailed evaluation framework. We further engaged in a series of interviews with government officials to provide broader context that is lacking from planning documents. Our results reflect the existing issues and challenges of climate action planning at the subnational scale in China. Finally, we analyzed the results and provided strategic recommendations to advance climate change planning in China.

2. A review of climate change planning and plan evaluation research

The earliest literature on local climate change policy and governance emerged in the mid-1990 s (Betsill and Bulkeley 2007; Bulkeley 2010). In recent years, a greater amount of literature on climate planning beyond international and national levels has begun to emerge. Recent studies have focused on using qualitative and quantitative methods to assess or evaluate climate action plans (Wheeler 2008; Bassett and Shandas 2010; Tang *et al.* 2010; Baker *et al.* 2012; Ng 2012; Baynham and Stevens 2014). Among these studies, Wheeler (2008) analyzed the first generation of local and municipal climate change plans in the USA in a systematic way based on planning documents and interviews. Bassett and Shandas (2010) continued to explore the local climate action plans built on Wheeler's work, focusing on the extent to which the local plans represent innovation in planning. Tang *et al.* (2010) examined 40 climate action plans in the USA by using their conceptual model to analyze how well local jurisdictions recognize and prepare for climate change. Ng (2012) provided a critical review of climate change strategy and action agenda in Hong Kong and concluded that more concerted and comprehensive efforts are needed. Baker *et al.* (2012) applied a quantitative and multi-criteria framework to evaluate climate adaptation plans in Southeast Queensland of Australia and concluded these plans would be ineffective in precipitating local government actions. Baynham and Stevens (2014) recently used content analysis methods to evaluate mitigation and adaptation content in official community plans in British Columbia, Canada. It is interesting to note that a large proportion of the existing literature has focused on cities and states in developed countries while research on climate change planning in China is limited (Li *et al*. 2011; Li 2013).

Meanwhile, a large body of widely cited studies concerning plan evaluation has mainly focused on analyzing plans of natural hazard mitigation (Godschalk *et al*. 1999; Nelson and French 2002; Brody 2003; Burby 2005; Tang *et al*. 2008; Berke, Smith, and Lyles 2012) and sustainability (Berke and Conroy 2000; Berke 2002; Conroy and Berke 2004) in developed countries. These plan evaluation studies demonstrate that planning researchers measure plan quality by analyzing the extent to which a plan articulates clear vision and goals, provides a detailed fact base assessing risks and capabilities, includes a diverse range of valid actions, offers strategies for implementation and monitoring, exhibits inter-organizational coordination, and results from a participatory process involving stakeholders (Godschalk *et al*. 1999; Brody 2003; Conroy and Berke 2004; Tang *et al*. 2008; Berke and Godschalk 2009; Berke, Smith, and Lyles 2012). Current plan quality evaluation theory and methods are relatively mature and have been used frequently in the context of plans in developed countries. In recent years, these theories and methods have been used in evaluating the content and quality of climate change plans (e.g., Tang *et al.* 2010; Baker *et al.* 2012; Baynham and Stevens 2014). To date, no

research has systematically evaluated subnational climate change plans in China. To address this gap, this study seeks to adapt previous plan evaluation methods and framework for climate change plans in China, and to test the validity of these well-accepted plan evaluation concepts in a developing-nation context. In addition, our study could potentially provide empirical evidence for plan quality and offer recommendations for improving the quality of subnational climate change plans based on our evaluation results.

It is also worthwhile to note that the 'multi-level' governance structure, which emphasizes both vertical relationships between different levels of governments and horizontal interactions between various agencies and sectors within municipalities, is increasingly highlighted in recent literature on climate change planning (Betsill and Bulkeley 2006; Betsill and Bulkeley 2007; Bulkeley *et al*. 2009; Kern and Bulkeley 2009; Bulkeley 2013). The 'multi-level' governance approach is important in terms of addressing issues such as leadership, political will, resources, competencies, and responsibilities (Bulkeley *et al*. 2009), but literature to date provides a mixed picture concerning whether either vertical or horizontal coordination has been achieved in 'multi-level' governance structure (Betsill and Bulkeley 2006; Bulkeley *et al*. 2009). In addition, there have also been studies indicating that the local and regional efforts on climate change have been considered as 'bottom-up' approaches (Rabe 2004; Lutsey and Sperling 2008; Wheeler 2008), especially in the cases of the USA (Rabe 2004; Lutsey and Sperling 2008; Wheeler 2008) and Australia (Baker *et al*. 2012). This 'bottom-up' climate change governance approach has advantages in that municipalities can demonstrate leadership without political authority from higher levels of government and thus enhance their capacity to act (Bulkeley *et al*. 2009). However, this approach still suffers from the lack of support from higher tiers of government, especially when the capacity to act and implementation of programs at the local level require additional support (Bulkeley *et al*. 2009). Interestingly, based on China's centralized and hierarchical political system, the current climate change governance follows neither the 'multi-level' approach nor the 'bottom-up' approach. In this regard, our study would contribute to the existing literature for the reason that it could tentatively explore how climate change planning functions, based on China's centralized political system, and how a different governance structure affects climate change planning and the content of climate change plans.

3. Research approach

3.1. Site selection

To comprehensively analyze climate change plans in China, all of the 22 provinces and 4 autonomous regions with existing planning documents available are included in our study. Tibet is not included in our study because we cannot obtain its climate change planning documents. We also selected 16 cities (see Appendix 2) as case studies. The first eight officially appointed low-carbon pilot cities were all included in the case study (Figure 1) because all of these cities have complete, existing planning documents, which may best depict the first generation of municipal climate actions plans in China. The other eight cities in this study are of various sizes and geographic locations, four of which are Centrally Administered Municipalities (Beijing and Shanghai) or Provincial Capital Cities (Shijiazhuang and Chengdu). Four smaller jurisdictions (Wuxi, Jilin, Guangyuan, Dezhou) with populations fewer than 2,400,000 were also included in our study.

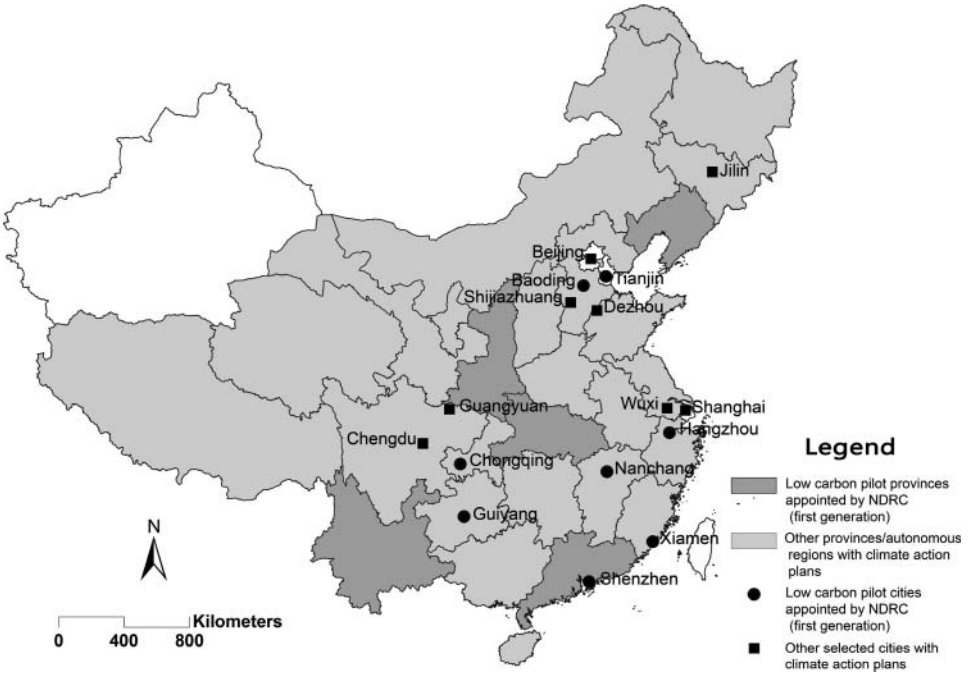

Figure 1. Provinces and cities with climate change plans reviewed in this study.

We gathered planning documents and relevant materials from these cities and provinces under the topic of climate change.

3.2. Content analysis

The climate change plans should include five necessary milestones, described by International Council for Local Environmental Initiatives as follows (ICLEI 2002):

(1) Conducting a base year emissions inventory and forecast;
(2) Setting a GHG emission reduction target;
(3) Developing the local-level action plan;
(4) Implementing the measures and policies in the action plan;
(5) Monitoring progress and reporting results.

In our study, based on ICLEI's framework as well as previous studies of plan evaluation, five climate change plan components (fact base; vision, goals and targets; policy actions and strategies; implementation strategies; monitoring and review) were used to evaluate the climate change plans. Evaluation concepts and criteria (Table 1) were developed, primarily building on existing climate change plan studies by Tang *et al.* (2010), Baker *et al*. (2012), and Baynham and Stevens (2014).

Of all these components, policy actions and strategies represent the heart of a plan (Brody 2003). Thus, we did an in-depth analysis of this component: first a complete list was made of planning interventions that could potentially mitigate or adapt to climate

Table 1. Description of climate change plan[a] document evaluation protocol.

Plan component	Evaluation concepts	Carrying out evaluation
1. Fact base	Current and future conditions regarding the cause and effect of climate change	1.1 Analysis of current and future GHG emissions. 1.2 Sector-specific GHG baseline inventory and forecast. 1.3 Information about climate change impacts, vulnerability, risks, and mitigation/ adaptation capabilities.
2. Vision, goals, and targets	Both short-term and long-term vision of mitigation and adaptation	2.1 Goals to mitigate and adapt to climate change. 2.2 Quantifiable objectives regarding GHG reduction.
3. Policy actions and strategies	Adequate and effective climate change solutions across a wide range of sectors to achieve mitigation and adaptation goals	3.1 The breadth and depth of every key strategy identified in the framework in the sectors of energy, industry, transportation, buildings, land-use, waste, lifestyle, water, and agriculture. 3.2 The integration of mitigation and adaptation strategies (e.g., gaining synergies, or avoiding maladaptation).
4. Implementation strategies	Detailed and specific strategies on implementing the policy actions	4.1 Identified funding and potential actors. 4.2 Timetables and priorities for implementing the actions.
5. Monitoring and review	Systematic framework of monitoring and reviewing the progress and results	5.1 Mitigation and adaptation progress monitoring/ reviewing and annual GHG reduction report.

Notes:
[a]City-level climate change plans in China are usually named 'low-carbon plans'.

change. We developed this list based on critical analysis of the following important sources:

(1) 'Best practice' actions to address climate change recommended by member cities of ICLEI;
(2) Annual reports of *China's Policies and Actions for Addressing Climate Change*;
(3) Existing best practice literature on climate action planning at regional and local scales.

Following this, we divided these strategies into the sub-categories of energy, industry, transportation, buildings, land use, waste, lifestyle, water, and agriculture. Then we consolidated the strategies that are similar in content. Finally, we reclassified the key strategies that have the same policy goals to form our evaluation framework. Thus, 52 key strategies were identified in our framework. Then the two authors coded all of the 52

key strategies in each plan independently on a 0−2 ordinal scale with a score of 0 indicating that the strategy is not included in the plan, 1 indicating that the strategy is included without justification/detailed information, and 2 indicating that a strategy is fully considered in the plan with justification and detailed information. Each plan was coded three times by both of the authors. Then an intercoder reliability score was computed, which indicates the percentage of items that were coded the same value by both of the two coders. Intercoder reliability scores were 90.3% for provincial plans and 86.6% for city plans. Since both of the intercoder reliability scores range from 70% to 97% in the existing plan quality literature (Berke and Godschalk 2009), we deem that our results are acceptable in terms of reliability. Following this, we calculated the breadth and depth of each key strategy (Tang *et al.* 2010): the breadth measures the percentage of plans that identified the relevant strategies for adoption, while the depth of each strategy indicates how fully developed or justified it is.[5]

3.3. Interviews

In order to triangulate results from reviewing these plans and gather more in-depth insights on subnational climate change planning in China, we conducted semi-structured interviews with local and provincial government officials from March 2013 to March 2014. Informants were from 16 local governments and 16 provincial governments, whose climate change plans we evaluated. Our local interviewees represent government sectors of Development and Reform Commission, Planning, Construction, Transportation, and Environmental Protection, who have professional knowledge of climate change planning. The provincial-level informants were from Departments of Development and Reform Commission and Housing and Urban-Rural Development. These officials were from provinces of Heibei, Shanxi, Heilongjiang, Jiangsu, Zhejiang, Fujian, Jiangxi, Shandong, Hunan, Guangdong, Hainan, Sichuan, Guizhou, Yunnan, Shaanxi, and Gansu. In total, we interviewed 76 local and 32 provincial government officials. We structured 10 open-ended questions (Table 2), which are relatively difficult to investigate from the planning

Table 2. Abbreviated interview protocol.

1.	To what degree is your jurisdiction willing to adopt a climate change/low-carbon plan[a]?
2.	Which climate change/low-carbon initiatives or networks has your jurisdiction joined?
3.	How long did it take your jurisdiction to develop the climate change/low-carbon plan?
4.	What are the emphasized components of the climate change/low-carbon plans in your jurisdiction?
5.	What is the funding source for implementing the climate change/low-carbon plan?
6.	What do you think of your jurisdiction's expertise in terms of developing and implementing the climate change/low-carbon plan?
7.	Which sectors are involved in developing and implementing the climate change/low-carbon plan?
8.	From your perspective, how is the coordination of these sectors involved in developing and implementing the climate change/low-carbon plan?
9.	What do you think of the public participation and stakeholder involvement process of developing and implementing the climate change/low-carbon plan?
10.	What are the main barriers to developing and implementing the climate change/low-carbon plan?

Notes:
[a]City-level climate change plans in China are usually named 'low-carbon plans'.

documents. We expanded these questions as needed in order to obtain more detailed information. All the questions were asked in an unprompted manner. We also asked our informants to send us documents on planning process if available. All the interviews were recorded and coded inductively for further analysis: one research assistant was in charge of transcribing and coding the response from our informants. The two authors double checked the coding, identified the cross-cutting themes, and discussed and interpreted the interview data for this paper.

Overall, our research approach enables us to grasp the main planning interventions taken by Chinese cities and provinces to respond to climate change. It is worth noting that our methods focus on the planning stage rather than the implementation stage, although we covered some questions about implementation in our interview.

4. Findings

We present our results below. We create tables summarizing the climate change planning networks that the cities and provinces have participated in and the main approaches to climate action planning; we also provide a summary of the GHG inventories and targets of the selected cities (see Appendices 1 and 2).

4.1. Plan content and process

Notably, climate change plans in our study are associated with some international or national programs. Most cities (14 of 16) and some provinces[6] (6 of 26) participate in one or more climate change initiatives or networks. International programs in which the case cities participate include the Low Carbon City Initiative by the World Wildlife Fund and the Clinton Climate Initiative of the Large Cities Climate Leadership Group (C40). Examples of national programs are the National Development and Reform Commission's Low Carbon Pilot City/Province Program, the Ministry of Housing and Urban-Rural Development's Low Carbon Eco-Demonstration City Project, and the Low Carbon City China Alliance's Low Carbon City China Program. It is worth noting that all of these climate change initiatives or networks in China are relatively nascent, and there exists no tradition of municipalities/provinces cooperating or learning from each other on climate change issues, which is partly due to the difficulty in establishing formal horizontal networks in China (Li and Wu 2012).

In addition to networking, the content of plans is essential for effective outcomes. Most plans we reviewed have a comprehensive awareness of climate change impacts in their specific region. For instance, earlier chapters of Guangdong's plan systematically assessed the temperature and precipitation change trends in the province and analyzed the potential impacts on coastlines, water resources, agriculture, built environment, economic development, and human health. Nevertheless, the assessment of climate change vulnerability and mitigation/adaptation capabilities are rarely included in most of the plans evaluated.

Developing a GHG inventory is an initial step in climate action planning. Without a credible and reliable GHG inventory and forecast, a jurisdiction may encounter difficulties in setting reasonable GHG reduction targets and cost-effective GHG mitigation strategies. In our study, only a small proportion of case cities (6 of 16) have created some sort of municipal GHG inventory. Other jurisdictions have not included any baseline GHG inventories or forecasts in their low-carbon plans. They have directly

proceeded to the development of their GHG reduction targets and action plans without GHG inventories or forecasts.

Setting specific GHG reduction goals is also an essential part of climate action plans. In our study, all the plans have goals of reducing local GHG emissions. Therefore, all 16 cities and 26 provinces/autonomous regions studied have set targets for GHG emissions reduction. Unlike the members of ICLEI, whose emission targets are set based on the proportion of GHG reduction from the baseline, Chinese local jurisdictions usually set their targets based on proportions of GHG reduction per unit of GDP or GHG reduction per capita. Thus, their reduction targets are not absolute GHG reduction amounts but rather GHG intensity targets related to indicators of economic output and population.

Processes through which these plans are developed are also summarized: the majority of planning documents we reviewed are prepared by the Development and Reform Commission because of the pervasive national Low Carbon Pilot City/Province Program, which is initiated by the National Development and Reform Commission. Nongovernmental sectors are rarely mentioned in the plan creation process. Nevertheless, there is one exception: in the process of developing Jilin City's low-carbon development plan, the local university and outside consultants were highly involved. Notably, in none of our case cities or provinces does a traditional municipal planning department play a primary role in leading climate action planning. Furthermore, we find little evidence of public meetings or stakeholder involvement from these planning documents.

Most of the plans do not include implementation strategies, as they do not identify funding, potential actors or lay out timetables for implementation. It is also worthwhile to mention that none of the jurisdictions have any form of follow-up monitoring, progress evaluation, or GHG reduction results reporting process to date.

As mentioned in the research method section, we analyzed the policy actions of these plans in detail. Figure 2 shows the breadth of strategies in our evaluation framework for the plans we reviewed. We do not report our findings related to depth in this paper since all the depth scores are very low, and there are little variations between different strategies.

Overall, the breadth scores are low, which indicates that many key strategies are not well identified and adopted in the plans we reviewed. It is both surprising and disconcerting to find that a large proportion of strategies in the land-use and transportation sub-categories have low breadth scores. Provincial and municipal plans also differ greatly in the breadth scores. We found that the sub-categories of transportation and buildings are overlooked in most provincial plans since these plans are developed by the provincial Development and Reform Commissions who have less power over the building and transportation sectors, while municipal plans, many of which are named low-carbon plans, usually leave out sub-categories of water and agriculture and focus predominately on climate change mitigation.

Both local and provincial jurisdictions in our study have realized that the power sector is fundamental to mitigate GHG emission. The main policy approaches on power generation in their plans focus on increasing the share of renewable energy. In total, 100% of the provincial plans and 88% of the local plans identify solar energy utilization as an important policy action. It is worth noting that the breadth score of local plans are generally lower than that of provincial plans in terms of increasing the use of a certain type of renewable energy, which is likely explained by local constraints. Meanwhile, 44% of the municipal plans and 27% of provincial plans indicate developing distributed renewable energy systems as a major supplemental strategy in addition to increasing the use of renewable energy. Most plans state that jurisdictions will increase the local share

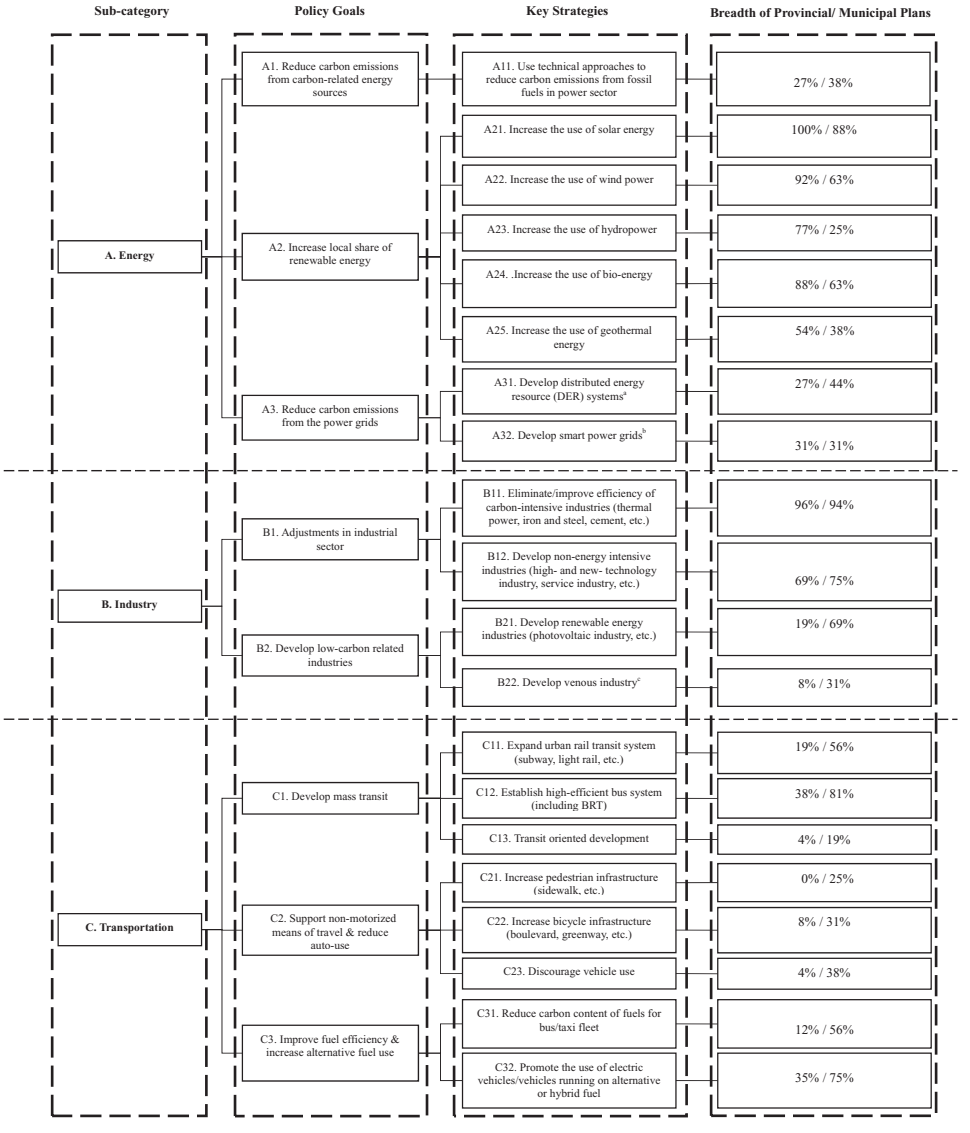

Figure 2. Framework and breadth of policy actions and strategies.
Notes:
[a]Distributed energy resource (DER) systems refer to small-scale, decentralized power generation sources located close to where electricity is used.
[b]Smart power grids denote modernized electrical grids which use advanced technology to gather and act on information, so as to improve sustainability of production and distribution of electricity.
[c]Venous industry is a term mainly used in Asia, which refers to resource recycling industry.

of alternative energy sources. However, the plans fail to mention explicit goals in terms of meeting a particular percentage of their electricity needs from alternative energy sources within a specific period of time.

The industrial sector has been the main focus of Chinese jurisdictions' efforts to combat climate change and to achieve low-carbon development. Many jurisdictions deem the industry sector the priority in their low-carbon development plans. Baoding and

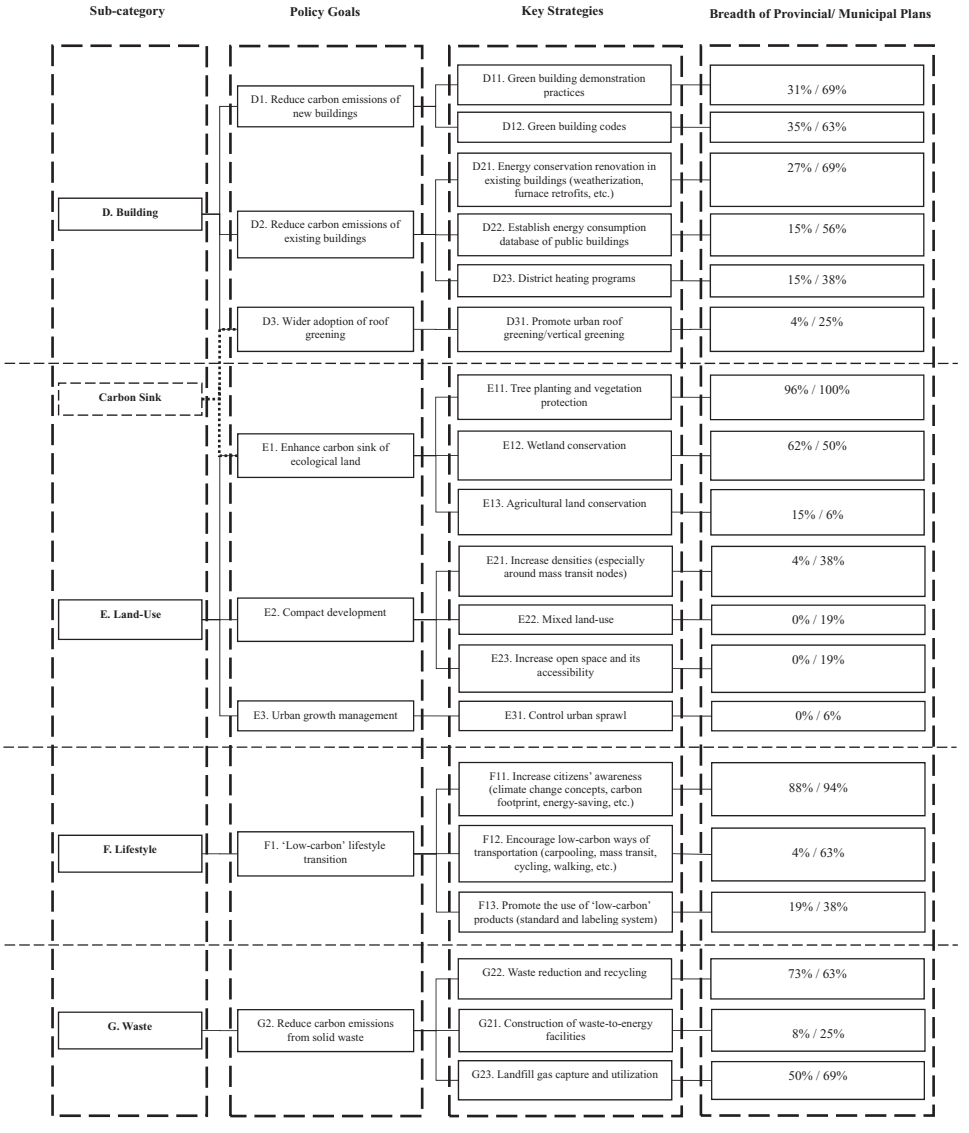

Figure 2. (Continued)

Dezhou's low-carbon strategies are predominantly focused on the adjustment of local industrial structures and development of green economic clusters. Among the plans we reviewed, most jurisdictions count a 'low-carbon industry' as an important dimension of climate action. The corresponding measures include: (1) eliminating or improving efficiency of carbon-intensive industries (the breadth scores of provincial and municipal plans are 96% and 94%, respectively); (2) developing non-energy intensive industries (the breadth scores of provincial and municipal plans are 69% and 75%, respectively); (3) developing renewable energy industries and venous industries. However, whether some so-called low-carbon industries (e.g., the highly promoted photovoltaic industry) can reduce local GHG emissions remains debated (Liu and Wang 2010). For instance, the

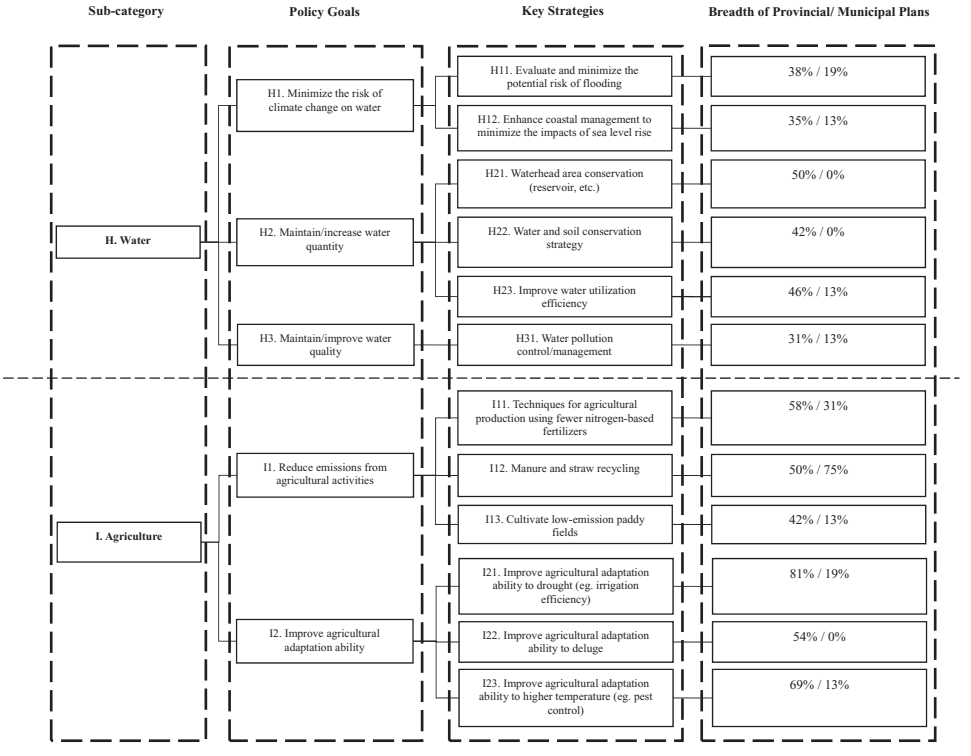

Figure 2. (Continued)

photovoltaic industry itself will create GHG emissions locally although its products could produce renewable energy.

The transportation sector is somehow ignored, especially in the provincial plans. The majority of the plans do not include policy actions to support non-motorized means of travel or reduce automobile use. The well-adopted local strategies include expanding urban rail transit systems (the breadth score of municipal plans is 56%), establishing efficient bus systems (the breadth score of municipal plans is 81%), and reducing carbon content of fuels for bus/taxi fleets (the breadth score of municipal plans is 56%). It is worth noting that one common local government action in transportation is to promote the use of electric vehicles or vehicles running on alternative or hybrid fuel, which is adopted by 75% of the case cities.

The building sector is also an essential area of low-carbon strategy; however, it is also neglected in most of the provincial plans. The breadth score of provincial plans for each key strategy is below 40%. The local plans show that the case cities are trying to reduce emissions from the cities' new buildings by operating green building demonstration projects (the breadth score of municipal plans is 69%) and adopting green building codes (the breadth score of municipal plans is 63%). In addition, setting up programs to improve energy efficiency of existing buildings through weatherization is also a common action adopted by the case cities (the breadth score of municipal plans is 69%). Nevertheless, this action is limited to the public sector in some cities. Xiamen, for example, only has initiatives to 'green the public and government buildings' (City of Xiamen 2010). It is also notable that 38% of the municipal plans include actions to promote district heating reform.

Other mitigation strategies that jurisdictions have undertaken are in the sub-categories of land-use, lifestyle, and waste. Surprisingly, most plans do not underline land-use approaches to climate change. Among all the plans reviewed, the compact development mode is rarely mentioned. A mere 4% of provincial plans and 38% of municipal plans emphasize high density. Moreover, mixed land-use is mentioned in only 19% of the local plans. Among all the local plans, only Hangzhou's plan promotes comprehensive land-use approaches to achieve low-carbon development that include ecological land conservation, compact development, and urban sprawl control (City of Hangzhou 2011). It is also interesting to note that many jurisdictions contemplate encouraging 'low-carbon lifestyles' to respond to climate change. In total, 88% of the provinces and 94% of the case cities recommend educating citizens about low-carbon concepts in their plans. In addition, 63% of the cities have low-carbon transit encouragement programs, and 38% of the local jurisdictions have low-carbon product promotion strategies in their plans. In the aspect of waste management, relevant strategies focused on solid waste. Many jurisdictions (73% of the provinces and 63% of the cities) consider promoting waste reduction and recycling programs in order to save resources and reduce emissions. Several local jurisdictions also consider constructing waste-to-energy facilities (25%) or use landfills as an important energy source (69%).

The climate adaptation strategies of the plans focus on water and agriculture sub-categories. Most of the local plans lack the dimension of adapting to climate change, while provincial plans usually include climate adaptation chapters. Among the municipal plans, only the plans for Beijing, Shanghai, Tianjin and Chongqing contain some notable chapters of strategies for adapting to climate change, although many plans have common strategies for urban forestry and tree planting, which can be seen as adaptation strategies. It is worth noting that Chongqing has six dimensions in its adaptation chapter, dealing in detail with agriculture, water, forestry, biodiversity, built environment, and human health (City of Chongqing 2009). Tianjin focuses its adaptation strategies on coastlines, agriculture, forestry, and hazard mitigation (City of Tianjin 2010). Many provincial plans highlight strategies such as improving agricultural adaptation ability to drought (81%) and warmer temperatures (69%). In addition, for plans that include climate adaptation components, the climate adaption and mitigation components were developed separately and arranged in different sections, with little evidence of integrated assessment of policies and strategies for climate mitigation and adaptation to promote synergies and avoid maladaptation.

4.2. Informant interviews

Among interviews, a general consensus was that central incentives are necessary and significant. Officials we interviewed often indicated that their adoption of climate change plans is related to the central government's initiatives. They are willing to join the Pilot City/Province Program and the Low Carbon Eco-Demonstration City Project, which have been initiated by central government ministries. They also stated that they are less interested in joining international climate change initiatives or networks unless they can receive substantial funding from these resources. Interviewees from the local governments mentioned that climate actions are usually not on their priority lists unless these actions are associated with potential economic growth. They also stated that support from central government is a determining factor of their willingness to adopt climate change/low-carbon plans.

In terms of plan content, interviewees suggested that much more emphasis is put on the industrial sector to mitigate GHG emission, which is consistent with our plan evaluation results. They also mentioned the 'low-carbon industry' and 'low-carbon economy' frequently. Some informants suggested a lack of professional knowledge about climate actions. Several of them equated 'low-carbon city' to 'low-carbon industry'; yet few mentioned climate change adaptation, which indicates they do not have a comprehensive understanding of climate change actions. We also found that local officials were more likely to mention the building and transportation sectors than provincial officials, which coincides with our previous result that the breadth scores of building and transportation strategies in municipal plans are generally higher than those in provincial plans. Most of the officials claimed that the Development and Reform Commission has played the main role in making and implementing these current plans. Some interviewees also stated they are more interested in the Low Carbon Eco-Demonstration City Project which is initiated by of the Ministry of Housing and Urban-Rural Development. In some cities, interviewees mentioned that local city planning departments or environmental protection bureaus are involved in plan making. According to the interviewees, the plan development process lasted from one month to two and a half years.

Interviewees also frequently mentioned institutional barriers to making and implementing these plans. Officials from local governments demonstrated a lack of local intergovernmental coordination in planning and implementation stages, saying that it is extremely difficult to involve so many sectors in implementing these ambitious low-carbon plans. Nevertheless, they realized that climate actions require a systematic framework that should involve a substantial number of government sectors. They also stated that a specific government sector is supposed to take the lead on developing and coordinating climate change actions, yet how to develop a local governmental mechanism remains unclear.

Most of the officials showed limited knowledge about stakeholder involvement. Some of them even did not consider stakeholder involvement necessary to create low-carbon/climate change plans. They also stated that most of the plans are closed-door documents without citizen mobilization. Only three local officials interviewed indicated that they have plans to launch public education programs to enhance climate change knowledge among local stakeholders, although our plan review results indicate that 94% of local plans have included strategies of increasing citizens' awareness of climate change.

Finally, our interviews revealed the perceptions regarding main barriers in terms of developing and implementing climate change plans. The top five frequently-mentioned barriers include: (1) lack of comprehensive awareness/knowledge of climate change among governments and the general public; (2) lack of funding to implement climate change plans; (3) insufficient governmental actions which give impetus to implementation; (4) weak technical support (e.g., techniques of developing GHG inventory and monitoring GHG emissions); and (5) lack of coordination between local government sectors.

5. Discussion: existing issues and challenges

China is currently experiencing rapid economic development with industrialization, making GHG emission reductions in conjunction with sustaining economic growth a significant challenge (Liu and Deng 2011). Clearly, there is a long way to go for Chinese jurisdictions to find effective climate change solutions. Challenges and critical issues are evident in climate change plans and planning to date.

5.1. Vague definition of what characterizes a low-carbon city/region

Although developing low-carbon cities/provinces is currently pervasive, the definition of what characterizes a low-carbon city in China remains unclear. Xin and Zhang (2008) stated that low-carbon city development refers to the development of a city that is characterized by rapid economic growth, as well as low energy consumption and CO_2 emission. The Study Group of China Energy and Carbon Emissions (2009) defines a low-carbon city as being characterized by a low-carbon economy, low-carbon lifestyle, and low-carbon society. Liu and Deng (2011) argue that low-carbon cities are characterized by the dissociation of GHG emissions from economic development and urbanization. Li *et al.* (2012) proposes the definition of a low-carbon town with clear targets and concrete actions planned to realize both with a considerable reduction of CO_2 emissions intensity in the short term and transition to a low-carbon economy and society in the long term.

Based on our study, Chinese jurisdictions seem to deem the goal of the low-carbon city as low GHG per unit of GDP since their ultimate planning goal is to reduce this indicator. Thus, the low-carbon cities, in their vision, are not characterized by absolute low GHG emissions but rather a relative indicator of emissions that is associated with economic growth. For instance, the city of Xiamen's vision of 'a low-carbon city' is characterized by carbon emissions per unit of GDP 40% below 2005 by the year 2020 (City of Xiamen 2010). However, according to the plan, the absolute GHG amount in Xiamen will increase, which is 68,640,000 tons by the year 2020, 4.28 times the amount of emissions in 2005. Clearly, even if the city of Xiamen implemented its low-carbon city plan and realized its relative reduction target by the year 2020, it cannot be deemed a 'low-carbon city' due to its large amount of GHG emissions.

Therefore, Chinese jurisdictions have not found the 'silver bullet' to define a low-carbon city/region. Moreover, both officials and academicians have thus far neglected that responding to climate change has an essential adaptation dimension. Our interview results also indicate that local government officials frequently equate 'low-carbon city' to 'low-carbon industry', which might be a barrier to finding comprehensive climate change solutions locally.

5.2. Deficiency in the quality of GHG inventories and reduction targets

Although all the jurisdictions in our study have established relative reduction targets for GHG mitigation, the lack of credible GHG inventories and forecasts has undoubtedly made these reduction targets and relative strategies impossible to confirm with evidence. In fact, the GHG inventory is a relatively new field that is highly technical and requires a systematic set of data. More importantly, conducting more accurate GHG inventories usually runs counter to the long-standing traditions of non-disclosure by many sectors.[7] In our study, only six cities have included some form of local GHG inventories in their low-carbon plans, some of which are not sector-specific and detailed enough. Furthermore, few jurisdictions in our case study have forecasted the local GHG mitigation efforts to help target setting and policy development. Our interviewees also identified techniques for developing GHG inventories and monitoring GHG emissions as the main barriers to finding sensible climate change solutions.

In terms of the GHG reduction targets, none of plans has included absolute GHG reduction targets. All cities and provinces have set the mitigation targets based on GHG per unit of GDP in accordance with the national emission reduction targets by the central government. However, as analyzed previously, reduction goals of GHG per unit of GDP

may not act as an effective target to reduce absolute carbon emission amounts. Moreover, few jurisdictions have set long-term goals. Most plans reviewed only have short-term goals for the year 2020. Many jurisdictions only have goals for 2015 because their climate change plans are associated with the relevant 12th five-year plan[8] by the central government.

5.3. *Insufficient strategies and measures to respond to climate change*

Based on our findings of this study, the climate action plans we read contain many similar strategies and actions, which is quite evident in provincial-level plans. This is partly because the central government has required each province to develop climate change actions plans within a short time frame, which leads to the situation that most the provincial plans simply follow the guidelines from the central government. For example, existing plans highly recommend increasing the use of solar energy, improving efficiency of carbon-intensive industry, etc. However, the traditional land-use and transportation strategies that are more relevant to planning are ignored by provincial jurisdictions. Moreover, we scarcely find any local innovations in these documents, many of which have similar content to other plans. In addition, as mentioned previously, most local plans do not cover climate change adaptation; only the four Centrally Administered Municipalities emphasize adaptation in their climate change plans since they are better positioned in terms of technical capacity.

Some strategies that might be potentially useful to reduce local GHG emissions are also overlooked by jurisdictions in our study. Among the 42 jurisdictions, none has mentioned levying carbon taxes on the industrial sector. Only the cities of Beijing, Shanghai, Guizhou, Yunnan, and Qinghai provinces have included the relevant carbon-trading policies in their plans. Moreover, only Shanghai's plan mentions strategies for reducing carbon emissions from air travel, which is recognized as an important emission sector.

Furthermore, none of the plans we reviewed has quantified the GHG reduction that can be expected from successful implementation of proposed mitigation actions, which echoes similar findings for plans in the USA and Canada (Boswell, Greve, and Seale 2010; Baynham and Stevens 2014). In fact, quantified GHG reduction amounts associated with mitigation strategies should be included in climate action plans, especially considering that currently some of the commonly adopted strategies in the climate action plans reviewed may not work well to reduce GHG emissions in Chinese cities. For instance, a related study indicated that high emission levels of coal-fired power plants will negate any gains made by electric vehicles' potential emission benefits in China (Huo et al. 2010). Since electric vehicles still require the use of electricity mainly produced by coal-fired power plants, the strategy of promoting electric vehicle use may not be a low-carbon solution in Chinese cities.

5.4. *Inadequate stakeholder engagement*

Public participation is especially important for climate change issues because it is the essential approach to advocate for a social movement to change people's carbon emitting behavior and to build resilience to climate change impacts (Blanco *et al*. 2009). In addition, effective public participation programs would help make climate change plans inherently more localized and contextual (Baker *et al*. 2012). Although the majority of plans we reviewed have strategies for raising public awareness and educating citizens about climate change concepts, we find little evidence of public participation and

stakeholder engagement in the plan creation process. Most of the plans were prepared by local Development and Reform Commissions without a broad stakeholder constituency involved, which confirms Li's (2013) findings that the making of climate adaption policies in China only includes government stakeholders and scientists and excludes other affected stakeholders such as the local residents and smaller businesses. Our interview results also indicate that there is a lack of understanding of stakeholder participation among government officials. In this sense, involving the public and other relevant stakeholders in developing future climate action plans will be an enormous challenge for Chinese jurisdictions.

5.5. Weak horizontal coordination

In effect, the current local climate change planning and policy formation are still concentrated in limited agencies and departments within municipalities in different climate change governance contexts (Betsill and Bulkeley 2006; Bulkeley and Kern 2006; Wheeler 2008; Bulkeley *et al*. 2009; Baker *et al*. 2012; Kasa, Leiren, and Khan 2012). Our results confirmed this issue in the Chinese context: little evidence of horizontal coordination in climate change planning stages was found since the plans are usually exclusively developed by the Development and Reform Commission, whereas it requires all relevant government sectors and some private sectors to implement them. Based on our interview results, the inter-organizational coordination in the implementation stage is also found to be lacking: most relevant local government sectors have little incentives to implement the strategies mentioned in the plans since they cannot gain immediate benefits from them. Although the Development and Reform Commission has more power and authority compared to other government sectors, it is still difficult to coordinate implementation of climate change actions, which are often deployed in a highly fragmented manner across a jurisdiction (Bulkeley *et al*. 2009).

The horizontal networking and cooperating between jurisdictions is also currently lacking. The central government has made significant efforts in establishing national pilot programs to enhance local networking and learning among local governments on addressing climate change issues. However, such horizontal network is generally not easy to establish or act effectively based on the current centralized political system in China (Li and Wu 2012). Our interview results also confirmed this since there is little actual evidence of municipalities/provinces cooperating or learning from each other, even when the national pilot programs provide a good institutional foundation. However, it is worth noting that networks and programs that operate at various political levels have been recognized as critical to enhance local capabilities by exchanging information and experience, providing access to expertise, *etc* (Betsill and Bulkeley 2006; Bulkeley *et al*. 2009; Bulkeley 2013).

5.6. Top-down nature of climate change planning in China

Based on China's current centralized and hierarchical political system, provinces, autonomous regions, and municipalities need to seek the approval of the central government to obtain support and legitimacy for subnational governance and management (Li and Wu 2012). This is evident with current subnational climate change planning in China in that cities and provinces are eager to become low-carbon pilot cities and provinces in order to get support and legitimacy from the central government. Based on our study, central governmental incentives currently play an important role in shaping

provincial and municipal plans. This is in contrast to the findings of similar studies conducted in developed countries, where the local and regional efforts on climate change policy development have been deemed 'bottom-up' approaches (Rabe 2004; Lutsey and Sperling 2008; Wheeler 2008) or 'multi-level governance' approaches (Betsill and Bulkeley 2006; Betsill and Bulkeley 2007; Bulkeley *et al.* 2009; Kern and Bulkeley 2009; Bulkeley 2013).

That is, the Chinese government has set up a subnational climate change planning framework that is characterized by the 'top-down' approach. Some of the horizontal coordination issues discussed in the previous section stem from this 'top-down' planning routine. The central government has used its power to establish the appropriate context and environment for provincial and municipal action, which is important. However, given the complicated nature of subnational politics and administration in China, coordination of the power and needs between the central, provincial, and municipal government in addressing climate change is still a huge challenge. In the current governmental setting, the central government has power and responsibility for energy supply, infrastructure investment, and planning, as well as the approval power for land acquisition and management. It is worth noting that after economic reform, political power has somehow devolved from the central government to provinces and municipalities, and a significant degree of administrative power was delegated to local governments: individual localities in China have become significant decision-making bodies on the use of their own revenue (Li and Wu 2012). City governments has gained administrative resources such as the ability to make comprehensive plans and effective power to control development process, lease urban land and grant urban land-use, and manage residential and commercial development. Localities also have autonomy to some extent in setting local tax rates and controlling local industrial, agricultural, energy, waste, and water sectors. A typical example could be the local governments' authority to levy tax on coal burning and to subsidize cleaner energy sources (Koehn 2008). These local government powers are all closely related to climate actions. However, one significant issue with the current system is the difficulty with allocating local/provincial governmental power on climate change issues due to the fact that economic growth is still the most important factor in assessing the performance of subnational governments and their officials (Li 2013). The 'top-down' approach on climate change planning will still be constrained by this governance bottleneck.

6. Conclusions and strategic recommendations

Chinese cities and provinces have begun to take important steps to reduce carbon emissions and to combat climate change through climate change planning. Our review of 42 municipal and provincial plans provides a big picture of the current trend of subnational climate action planning in China. Our results indicate that current climate change planning in China is characterized by the 'top-down' approach, in which the central governmental incentives play a leading role in shaping provincial and municipal plans.

Our plan evaluation methods and framework adapted from widely cited literature in developed country contexts is still valid in terms of comprehensively analyzing the quality and contents of subnational climate change plans in China. Our plan evaluation results indicate that this 'top-down' approach has significant influence on the contents of subnational plans. This is quite evident in that most subnational plans set short-term mitigation targets based on the proportion of GHG reduction per unit of GDP, which

generally coincides with the emission reduction targets set by the central government. A large number of the plans are similar in content, without evidence of local innovation. In addition, most of the plans have a comprehensive awareness of climate change impacts but fail to assess local vulnerability and mitigation/adaptation capabilities. Sector-specific GHG baseline inventories and forecasts are rarely present in either provincial or municipal plans. Implementation strategies and follow-up monitoring/evaluation progress are also currently lacking.

The planning interventions of the 42 jurisdictions cover a wide range of strategies, which include changes in the built environment (e.g., land-use, transportation, buildings), natural environment (e.g., water, agriculture, carbon sinks), economic sector (e.g., industry) and people's behavior (e.g., lifestyle shifts). The current climate action plans in Chinese jurisdictions focus predominantly on the industrial and energy sectors, while the land-use and transportation strategies for addressing climate change are somewhat neglected. Moreover, most local plans pay little attention to the dimension of adapting to climate change; little evidence was found regarding mitigation and adaptation integration to identify synergies and avoid maladaptation.

The planning and implementation of climate action in China are anticipated to continue in the following years. At this point, it is far from clear how municipal and provincial governments can best mitigate and adapt to climate change and achieve low-carbon development through planning. Given current issues and challenges, the following recommendations are made to advance climate change planning in China.

The definition of a low-carbon city/region should be clarified. Detailed guidelines for developing subnational climate change plans with long-term, clarified and standardized goals need to be put forward to improve the quality and consistency of provincial and municipal plans. Both climate change mitigation and adaptation toolkits are needed as guidance for Chinese jurisdictions. Moreover, because of the varying socio-economic and urbanization stages of different jurisdictions in China, local jurisdictions need more innovative policies, strategies, and tools that reflect local geographic and socio-economic realities in order to better mitigate and adapt to climate change. Local and provincial plans need to connect their mitigation actions with estimated GHG reduction amounts, which would enhance the credibility of the plans and also ensure that the given policy regimes would be likely to lead to the targeted regional/local GHG reduction goals (Baynham and Stevens 2014). In addition, mitigation and adaption policies and actions should be developed in an integrated manner with concerns about the risks of maladaptation and identification of potential synergies.

Given the current 'top-down' nature of climate change planning in China, higher tiers of government could consider mandating the inclusion of climate change targets and policies in local comprehensive plans. Such form of 'planning mandate' has potential to lead to better quality plans (Berke and French 1994; Burby and May 1997; Tang *et al.* 2010) and increase the chance of achieving desired planning outcomes (Burby and May 1997; Burby 2005; Baynham and Stevens 2014). In addition, incorporating climate change into comprehensive plans may address the concerns of plan integration and promote more efficient use of resources, as many comprehensive plans may already include information, goals, policies, and implementation strategies directly relevant to climate change. Local comprehensive plans can also serve as an effective means for citizens and officials to create visions and develop goals and objectives to deal with climate change issues locally. Furthermore, comprehensive plans could help to better coordinate the actions of various local government sectors which may play important roles in climate change (Burby 2005).

Meanwhile, local capacity to develop and evaluate climate change plans should be enhanced. For Chinese jurisdictions, conducting reliable GHG inventories and establishing efficient reduction targets are urgent endeavors. It is also imperative to establish long-term systematic planning frameworks in which GHG mitigation progresses are monitored and evaluated on a regular basis and actions can be revised if they do not work well to combat climate change. Of course, technical capacity is not enough. Future climate change planning in China should include community engagement and public participation, which promote social and institutional learning, and might further lead to cultural shifts on climate change issues.

Allocating local/provincial governmental power on climate change issues would still be a significant challenge, but it might be achievable if the current bureaucratic assessment system is reformed and the internalization of addressing climate change issues is disconnected with economic growth (Li 2013). Vertical intergovernmental coordination is extremely important in the Chinese context, in which reconciling central and local interests would pave the way for implementation. Moreover, as is also indicated in this study, horizontal coordination across different sectors of local government is important to avoid the problem of 'institutional silos' (Baker *et al*. 2012) since climate change is a cross-sectoral issue for localities. It is necessary to develop an inter-governmental framework for horizontal coordination. For instance, a local government office or committee with defined leadership on climate change mitigation and adaptation can be established to coordinate with all horizontal government units to designate policy and action implementation to responsible agencies, and to oversee progress made by each government unit.

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Notes

1. The National Development and Reform Commission, previously known as State Planning Commission, is a powerful central governmental organization under Chinese State Council, which has broad administrative and planning control over national economic and social development. The major function of National Development and Reform Commission is to formulate and implement macroeconomic policies. It also has broad political power over the nation's energy sector, climate change policy, regional planning, etc.
2. In Chinese terminology, autonomous regions refer to minority entities that have high populations of particular minority groups. Autonomous regions and provinces are first-level administrative subnational levels of government in China, which are directly under the administration of the central government. Currently, there are five autonomous regions in China, which include Xinjiang, Inner Mongolia, Tibet, Ningxia, and Guangxi.
3. The Development and Reform Commission exists at multiple levels of government in China, including the central government, provincial government, municipal government, and county government. It is usually considered to have more power than other governmental sectors at the same horizontal level.

4. The 26 provincial plans in our study include climate change plans of 22 provinces and four autonomous regions.
5. The indicators of breadth and depth are calculated by the following equations:

$$\mathrm{BS}i = \frac{Ni}{N} \times 100\%, \quad (1)$$

$$\mathrm{DS}i = \frac{\sum_{i=1}^{Pi} Si}{2Pi} \times 100\%, \quad (2)$$

where BS*i* represents the breadth score of the *i*th indicator; *Ni* represents the number of plans which include the *i*th indicator; *N* is the total number of plans in the study; DS*i* is the depth score of the *i*th indicator; *Si* is the score that the *i*th indicator receives (0 = not mentioned; 1 = generally mentioned; 2 = justified/detailed).
6. We counted autonomous regions as provinces in our findings since they are both of the same administrative subdivision level. When calculating the breadth scores for each strategy, autonomous regions were also treated as provinces.
7. We thank one of our reviewers for this viewpoint.
8. The 12th five-year plan is the national social and economic development plan for 2011–2015, issued by the Chinese central government. The five-year plans in China are considered to be the national policy guidelines for economic development and reform.

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Appendix 1. General description typical provincial plans reviewed

Province	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Guangdong	83,740,000	Low Carbon Pilot Province Program of the NDRC (first round)	*Guangdong national low carbon pilot province plan* (Guangdong Province, 2010)	Developing inventory	35% below 2005 by 2015; 45% below 2005 by 2020 (carbon emissions per unit of GDP)	• Promoting low-carbon industry • Optimizing the energy structure • Energy saving and energy efficiency improvement • Developing low-carbon transportation (local and regional) • Promoting low-carbon buildings (existing and new) • Enhancing regional carbon sink	Yes	Annual reports
Liaoning	42,538,200	Low Carbon Pilot Province Program of the NDRC (first round)	*Liaoning strategies for responding to climate change* (Liaoning Province, 2009)	n/a	20% below 2005 by 2010; 20% below 2010 by 2015 (energy consumption per unit of GDP)	• Structural adjustments in industrial sector • Technical innovation to improve energy efficiency • Promoting clean and renewable energy • Developing circular economy to improve the efficiency of resource utilization • Agricultural and forestry management to enhance carbon sink • Adaptation strategies on agriculture, forest, water resource, coastlines and hazard mitigation	None	n/a
Hubei	53,197,600	Low Carbon Pilot Province Program of the NDRC (first round)	*Hubei action plan for responding to climate change* (Hubei Province, 2009)	n/a	15% below 2008 by 2012 (energy consumption per unit of GDP)	• Optimizing energy structure to reduce carbon emissions • Energy saving and energy efficiency improvement • Ecological conservation to enhance forest carbon sinks	None	n/a

(*continued*)

Appendix 1. (*Continued*)

Province	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
						• Adaptation strategies on agriculture and water management • Establishment of disaster prevention and mitigation system		
Shanxi	38,333,700	Low Carbon Pilot Province Program of the NDRC (first round)	*Shanxi plan for responding to climate change in the twelfth five-year period* (Shanxi Province, 2011)	Developing inventory	17% below 2010 by 2015 (carbon emissions per unit of GDP); 18% below 2010 by 2015 (energy consumption per unit of GDP)	• Readjustment of industrial structures to promote low-carbon industrial system • Optimizing the energy structure and increasing the share of renewable energy • Energy saving and energy efficiency improvement • Promoting tree planting programs to enhance carbon sink • Developing recycle economy • Adaptation strategies on agriculture, ecosystem and water management	None	Mentioned in the plan
Yunnan	28,454,200	Low Carbon Pilot Province Program of the NDRC (first round)	*Yunnan low carbon development plan* (Yunnan Province, 2011)	Developing inventory	35% below 2005 by 2015; 45% below 2005 by 2020 (carbon emissions per unit of GDP)	• Optimizing the energy structure • Energy saving and energy efficiency improvement in industry, buildings and transportation • Promoting forestry and urban greening • Structural adjustments in industrial sector • Promoting low-carbon concept and low-carbon behavior	Yes, detailed and funding identified	n/a

Notes:
n/a = not applicable.
[a]Population data are for the year 2009 from *Urban Statistical Yearbook of China*.

Appendix 2. General description of municipal plans reviewed

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Baoding	1,061,800	Low Carbon City Initiative of WWF; Low Carbon Pilot City Program of the NDRC (first round); Low Carbon City China Alliance	*Baoding strategies for developing a low-carbon city* (City of Baoding, 2008)	n/a	25% below 2005 by 2010; 35% below 2010 by 2020 (carbon emissions per unit of GDP)	• Encouraging investment in and export of sustainable energy products • Networking on sustainable energy knowledge management and technology cooperation • Design and implementation of a Solar Energy Demonstration City • Development of a wind and solar technology industrial park	None	n/a
Beijing	11,808,700	Low Carbon Pilot City Program of the NDRC (second round)	*Beijing comprehensive strategies for energy saving and climate change in the twelfth five-year period* (City of Beijing, 2011)	n/a	18% below 2010 by 2015 (carbon emissions per unit of GDP)	• Setting low-carbon standards for industry and buildings • Establishment of the low-carbon market (e.g., carbon-trading demonstration) • Readjustment of industrial structures • Promoting the clean energy source • low-carbon strategies for agriculture, waste and urban green space • Adaptation strategies on infrastructure and human health	None	n/a
Chengdu	5,280,100	None	*Chengdu low carbon city action plan* (City of Chengdu, 2010)	n/a	Below 1.15 tons/10,000 RMB[b] by 2015 (carbon emissions per unit of GDP)	• Readjustment of industrial structure to promote the low-carbon economy • low-carbon and energy saving strategies for industry, buildings, transportation and public sector • Promoting energy-saving lighting • Raising public awareness to build the low-carbon society (e.g., low-carbon lifestyle promotion, tree planting programs)	Some, potential actors identified	n/a

(*continued*)

Appendix 2. (*Continued*)

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Chongqing	14,265,800	Low Carbon Pilot City Program of the NDRC (first round)	*Chongqing strategies for responding to climate change* (City of Chongqing, 2009)	2007	Below 2 tons/10,000 RMB by 2010 (carbon emissions per unit of GDP); below 4tons/year by 2010 (carbon emissions per person)	• Readjustment of industrial structure • Promotion of clean and low-carbon energy source • Reforestation and ecological restoration to increase carbon sinks • Promoting the recycling economy in the traditional industrial sectors • Promoting ecological agriculture practices • Climate change adaptation strategies concerning agriculture, water resources, forestry, biodiversity, built environment, and human health	None	n/a
Dezhou	619,200	Low Carbon City China Program of Low Carbon City China Alliance	*Low carbon Dezhou development plan* (City of Dezhou, 2009)	n/a	25% below 2005 by 2015 (carbon emissions per unit of GDP)	• Focusing on the development of the solar industry • Promoting solar energy use in the city • Energy-saving program in the building sector • Reducing emissions from local public transportation (alternative fuel vehicles for city fleets) • Conserving green space and wetlands to enhance carbon sinks	None	n/a

(*continued*)

Appendix 2. (*Continued*)

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Guangyuan	927,600	Low Carbon Pilot City Program of the NDRC (second round)	*Guangyuan low carbon development plan for the twelfth five-year period* (City of Guangyuan, 2010)	n/a	30% below 2010 by 2015 (carbon emissions per unit of GDP); below 3.5 tons/year by 2015 (carbon emissions per person)	• Development of a local low-carbon energy system in power generation • Restructuring the low-carbon industry system • Promoting the low-carbon relevant technology • Promoting the low-carbon buildings • Constructing the low-carbon transportation system • Raising public awareness and promoting low-carbon consuming behavior	Yes, detailed timetables and priorities	n/a
Guiyang	2,204,100	Low Carbon Pilot City Program of the NDRC (first round)	*Guiyang low carbon development action plan* (City of Guiyang, 2010)	2009	40%–45% below 2005 by 2020 (carbon emissions per unit of GDP)	• Increase the local share of clean energy sources • Reducing emissions from key energy-intensive industries • Developing the service industry • Promoting energy saving in buildings and developing green buildings • Constructing the low-carbon transportation system • Enhancing carbon sinks through green space and forestry management • Waste recycling and waste management	None	n/a

(*continued*)

Appendix 2. (*Continued*)

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Hangzhou	4,321,300	Low Carbon Pilot City Program of the NDRC (first round)	*Hangzhou low carbon city development plan for the twelfth five-year period* (City of Hangzhou, 2011)	2005, 2010	20% below 2010 by 2015; 40% below 2005 by 2015 (carbon emissions per unit of GDP)	• Development of a low-carbon industry and low-carbon economy • Improving energy efficiency in existing buildings and constructing new green buildings • Promotion of green transportation • Encouraging low-carbon consumption and green lifestyles • Urban greening to increase forest carbon sinks	Yes	n/a
Jilin	1,835,200	Low Carbon Pilot City Program of the NDRC (second round)	*Jilin low carbon development plan* (City of Jilin, 2010)	n/a	58% above 2005 by 2020 (GDP per unit of carbon emission)	• Reducing emissions from the city's key industry sector (e.g., petrochemical industry) • low-carbon strategies for local electricity and heating systems • Improving energy efficiency of buildings • Developing low-carbon transportation system • low-carbon strategies for agriculture, forestry and land-use	Yes, very detailed	n/a
Nanchang	2,221,900	Low Carbon Pilot City Program of the NDRC (first round)	*Nanchang national low carbon pilot city plan* (City of Nanchang 2011)	2005	38% below 2005 by 2015; 45%–48% below 2005 by 2020 (carbon emissions per unit of GDP)	• Development of a world-class solar photovoltaic industrial park • Development of low-carbon eco-industrial systems • Prioritizing the development of the photovoltaic industry • Development of the semiconductor illumination industry and service outsourcing industry	Yes	Mentioned in the plan

(*continued*)

Appendix 2. (*Continued*)

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Shanghai	13,375,300	Low Carbon City Initiative of WWF; Clinton Climate Initiative of C40;	*Shanghai energy saving and climate change plan in the twelfth fifth-year period* (City of Shanghai, 2012)	n/a	19% below 2010 by 2020; 35% below 2005 by 2020 (carbon emissions per unit of GDP)	• New eco-building demonstrations • Energy efficiency improvement of existing large commercial buildings • 20 ways to 20% energy conservation campaign to raise public awareness of energy efficiency • Readjustment of industrial structure • Promotion of green transportation • Prioritizing the development of Dongtan Eco-City, Lingang New Town, and Hongqiao Business District in accordance with the low-carbon concept	None	n/a
Shenzhen	2,529,200	Low Carbon Pilot City Program of the NDRC (first round); Low Carbon Eco-Demonstration City Project of MOHURD	*Shenzhen low carbon city development plan* (City of Shenzhen, 2011)	n/a	30% below 2005 by 2015; 45% below 2005 by 2020 (carbon emissions per unit of GDP)	• Focus on green building development • Development of a leading low-carbon industry • Development of industrial parks in accordance with the low-carbon concept • Development of green transportation by promoting the use of electric vehicles • Encouraging low-carbon green lifestyle and consumption • Setting Guangming New District as a pilot site for the development of a low-carbon city	Yes	n/a

(*continued*)

Appendix 2. (*Continued*)

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Shijiazhuang	2,433,300	Low Carbon Pilot City Program of the NDRC (second round)	*Shijiazhuang low carbon development plan in the twelfth five-year period* (City of Shijiazhuang, 2012)	n/a	20% below 2005 by 2015; 36% below 2005 by 2020 (carbon emissions per unit of GDP)	• Reducing emissions from the energy sector • Improve the local traditional carbon-intensive industries • Strategically developing new and innovative industries • Developing the service industries (including carbon financing) • Energy saving strategies for buildings • Promoting the low-carbon consumption behavior	None	n/a
Tianjin	8,049,600	Low Carbon Pilot City Program of the NDRC (first round)	*Tianjin strategies for responding to climate change* (City of Tianjin, 2010)	2008	Below 2.0 tons/10,000 RMB by 2010; 15.5% below 2010 by 2015 (carbon emissions per unit of GDP)	• Improvement of energy efficiency and energy mix • Readjustment of industrial structures • Encouraging low-carbon consumption • Increasing green spaces and forest carbon sinks • Planning Sino-Singapore Tianjin Eco-City to be the best example of new low-carbon town in China	None	n/a
Wuxi	2,383,600	None	*Wuxi low carbon city development plan in the twelfth five-year period* (City of Wuxi, 2010)	n/a	20% below 2010 by 2015 (carbon emissions per unit of GDP)	• Constructing the low-carbon industry system (e.g., venous industry) • Promoting energy saving in various sectors to reduce emissions • Promoting low-carbon buildings • Development of green transportation • Conserving natural resources to enhance carbon sinks • Develop relevant low-carbon technologies	None	n/a

(*continued*)

Appendix 2. (*Continued*)

City	Population[a]	Initiatives or networks	Plan name and year	Emissions inventory	Emissions targets	Key approaches	Implementation strategies	Follow-up reporting or monitoring
Xiamen	1,786,000	Low Carbon Pilot City Program of the NDRC (first round)	*Xiamen low carbon city comprehensive* plan (City of Xiamen, 2010)	2008	Below 68,640,000 tons by 2020 (carbon emissions); 40% below 2005 by 2020 (carbon emissions per unit of GDP)	• Promotion of renewable energy (solar, geothermal, and wind energy; seawater heat pump power generation) • Fuel switch from coal to natural gas in power generation • Energy efficiency improvements, especially in energy-intensive sectors and buildings • Promotion of low-carbon transport by improving public transportation, rapid bus transit system, and electro-mobility	Yes	n/a

Notes:
n/a = not applicable.
[a]Population data are for the year 2009 from *Urban Statistical Yearbook of China*.
[b]RMB is the basic unit of the official currency of China.