JANUARY 2017

ADDRESSING GAPS IN CHINA'S ENVIRONEMNTAL DATA: THE EXISTING LANDSCAPE

Angel Hsu, Chendan Yan, and Yaping Cheng

INTRODUCTION

Environmental management in China is at a critical crossroads. Double-digit annual economic growth has expanded per capita GDP more than 30-fold since China began market reform in 1978, and the country is today the world's second largest economy. China's industrial growth and increased consumption have also led to pernicious levels of air pollution, a precipitous increase in greenhouse gas emissions, and widespread water and soil contamination. The 2016 Environmental Performance Index (EPI) ranked China 109 th out of 180 countries, indicating that the country's environmental quality has fallen behind other emerging economies like Brazil, South Africa, and Russia.[1] The need for China to address its mounting environmental crisis is plainly urgent.

The clear imperative to reduce pollution, clean up contamination, and diminish environmental degradation is, unfortunately, not met with data commensurate to create effective policies and develop best management practices.[2] Experts have historically criticized China's economic data,

CONTENTS

such as GDP growth, describing the reported information as inaccurate and misleading.[3] Some observers have gone so far as to condemn China's entire statistical reporting system as "enmeshed in a wind of falsification and embellishment" that has led to "universal falsification of statistics."[4] China's environmental data, in particular, are notoriously opaque and problematic. Researchers have pointed to problems with data availability, interruptions in time series, and inconsistencies between sources reporting energy and air quality statistics.[5] China's government has historically considered a large portion of environmental data, including soil quality statistics, to be state secrets.[6]

To address these issues, China's leadership has emphasized developing more quantitative, scientific approaches to environmental management. Adopting a goal to achieve an "ecological civilization" (*shengtai wengmin*), China's leaders have increased the number of energy and environment-related indicators in both the 12th (2011-2015) and 13th (2016-2020) Five-Year Plans, the country's major social and economic development blueprints. The 13th FYP includes the greatest number of binding environment-related targets, with 10, of any FYP.[7] To support and track progress towards these targets, China requires major investment in monitoring and data collection systems.

This paper provides an overview of China's current environmental data landscape for major policy issues: Air,

Box 1: Towards a China Environmental Performance Index: First international assessment of China's environmental data

Researchers from Yale and Columbia universities, the City University of Hong Kong, and the Chinese Academy for Environmental Planning (CAEP) collaborated from 2008 to 2010 to develop a credible indicator system to track environmental performance at the provincial level in China. As part of the feasibility study, the team evaluated all available baseline official data at the provincial and national levels that could be used to construct credible indicators for measuring progress towards environmental targets. The study concluded that data gaps, a lack of transparency, and inconsistencies in China's baseline official data were too prevalent to allow for the construction of a consistent and comparable provincial China Environmental Performance Index (EPI).[8]

Water, Soil, Biodiversity and Habitat, Fisheries, and Climate Change and Energy. For each of these topics, the next section details the 1) Policy use and context; 2) Data availability and gaps.

INDICATOR-SPRECIFIC ANALYSIS

Air

Policy Context

The 13th Five Year Plan (FYP) sets ambitious targets to address air pollution. By 2020, air quality in 338 cities at and above the prefectural level should reach "good" or "excellent" levels for more than 80 percent of the year, which is at least a 3.3 percent increase from the actual 76.7 percent these cities achieved in 2015. Reaching this goal would mean that these cities score below 100 on China's Air Quality Index (AQI), which ranges from 0 to 500. The number of heavily polluted days should decrease by 25 percent in cities at and above the prefectural level. In cities with concentrations of $PM_{2.5}$ exceeding mandated limit (annual average $PM_{2.5}$ concentration should not exceed 35 $\mu g/m^3$), levels of the pollutant are to decrease by 18 percent. As previous targets were reached, control of four primary air pollutants intensified in the 13th FYP: 15 percent reduction for sulfur dioxide and nitrogen oxides (SO_2 and NOx) and 10 percent for chemical oxygen demand (COD) and ammonia nitrogen. [9]

For the first time ever, the 13th FYP plan introduces an ambitious reduction target for Volatile Organic Compounds (VOCs), calling for a drop of at least 10 percent in major cities and industries. The reduction of VOCs as primary pollutants requires the control of a much wider range of pollution sources than those that produce sulfur dioxide and nitrogen oxides, sources that include fossil fuels as well as paints, solvents, and various industrial processes.[10] While the control of $PM_{2.5}$ has been a hot topic of discussion, it is mostly a secondary pollutant, unlike VOCs, formed from pollutants that are already regulated in China, including sulfur dioxide and nitrogen oxides.

The 13th FYP targets coal combustion as the single largest source of air pollution, calling for the reduction of coal consumption with a regional emphasis on Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta. The plan stipulates that new coal-fired power plants meet an "ultra low emissions" standard. The use of natural gas is to be increased by 45 billion cubic meters in key cities, replacing 189,000 steam tons of coal-fired boilers.[11] Along with quantitative targets, the 13th FYP also proposes qualitative measurements for pollution control. Production of clean fuel for vehicles at the China V standard (equivalent to the Euro V standard adopted at the European Union in 2009) is to be increased.[12] Elimination of old and yellow-label vehicles that are not qualified for designated emission levels will be accelerated.[13]

In September 2014, China's State Council released the National Air Pollution Prevention and Control Action Plan (also know as the "Air Ten Plan") with targets consistent with those proposed in the 13th FYP. The Air Ten Plan sets an overarching goal that national air quality to significantly improve in five years from 2013, meaning that the number of days with severe air pollution is targeted to decrease in five years and be eventually eliminated through continuous pollution control efforts. Similar to the 13th FYP, the Air Ten Plan has a regional emphasis and imposes the most stringent standards on the Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta regions, requiring that these severely polluted areas with strong economies significantly improve their ambient air quality.[14] Since 2013, the Ministry of Environmental Protection strengthened enforcement and carried out monthly inspections of environmental violations in regions of emphasis. Drone technology has been leveraged for large-scale inspection,[15] although there are still reported incidences of some officials tampering with air quality data.[16]

The Air Ten Plan sets four main targets for 2017: (1) concentration of coarse Particulate Matter (PM_{10}) in urban areas will decrease by 10 percent compared with 2012 levels; (2) the number of days with fairly good air quality will increase annually[17]; (3) concentrations of fine particulate matter ($PM_{2.5}$) in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta region will fall by around 25 percent, 20 percent, and 15 percent, respectively; (4) concentration of fine particulate matter ($PM_{2.5}$) in Beijing should be controlled under 60 micrograms per cubic meter.[18] The Air Ten Plan sets concrete implementation guidelines for VOCs reduction goals that were introduced in the 13th FYP, calling for VOCs control measures to be carried out in petrochemicals, organic chemicals, surface coating, packaging, printing and other relevant industries.[19]

The Plan introduces qualitative as well as quantitative measurements to strengthen control of coal consumption. Import of low quality coal with high ash and sulfur content will be banned. Coal washing rate will be increased to over 70 percent in existing and new coal mines. In regions of emphasis, coal will be gradually replaced by natural gas, imported electricity, and non-fossil energy sources. By 2017, production of low-capacity coal-fired boilers will be phased out. In areas without gas and heating supply, clean coal, electricity and other energy-efficient boilers will be used. With interim coal consumption caps, national coal consumption will be reduced to less than 65 percent of total energy mix by 2017.[20]

The Plan also proposes ambitious targets for vehicle emissions control. In regions of emphasis, five million "yellow label" (i.e., cars that fail to meet emissions standards) vehicles will be phased out by 2015, with those registered before 2005 eliminated. By 2017, almost all yellow-label vehicles will be eliminated nationwide. Specific targets were also set for fuel type control. National Stage IV gasoline will be supplied by the end of 2013, Stage IV diesel by the end of 2014. Before the end of 2015, Stage V gasoline and diesel will be supplied in key cities in regions of emphasis and scaled up to the national level before the end of 2017. Meanwhile, inspection for fuel type control will be strengthened and substandard fuel will be banned entirely.[21]

China has made impressive progress implementing the Air Ten Plan since its debut. In 2014, 6,113,400 old and yellow-label vehicles were eliminated nationwide, surpassing the 6 million target the Air Ten Plan set for 2014.[22] Seventy-four key cities have drafted and implemented their own five-year air pollution prevention plans. From 2013 to 2014, the concentration of 5 primary pollutants ($PM_{2.5}$, PM_{10}, sulfur dioxides, nitrogen oxides and carbon monoxides) decreased in these cities.[23] Regions of particular policy focus, including the Beijing-Tianjin-Hebei area, decreased $PM_{2.5}$ levels by 12.3 percent. Concentrations of ozone, however, have increased along with the number of days with ozone as the primary pollutant - meaning ozone concentrations exceed PM levels on these days. Under the stringent Ambient Air Quality Standards, launched in 2012 and implemented in January 2016, 66 out of 74 cities had pollutants exceeding limits to various extents, among which particulate matter was the primary concern.[24] Eight of the 10 cities with the fewest number of days reaching "good" air quality on the Air Quality Index (AQI < 100) in 2014 are in Hebei province.[25] The Ministry of Environmental Protection is currently drafting the mid-term evaluation report of the Air Ten Plan.[26]

Data Availability and Gaps

Outdoor air quality monitoring and reporting in China has improved significantly in the last few years. Since the launch of the new Ambient Air Quality Standards in 2012, data quality improved significantly in terms of timeliness, spatial coverage and data accessibility. Real-time outdoor air quality readings from 338 cities and 1,435 monitoring stations are available online. Air quality reporting takes two main forms: concentration of primary pollutants and Air Quality Index (AQI), which informs citizens about the level of air pollution, primary pollutant, and health advisories. China National Environmental Monitoring Center (CNEMC)'s National Air Quality Real Time Publishing Platform and MEP's National Air Quality Index are the two major government sources. Released in 2012 and implemented in 2016, the Ambient Air Quality Standards are used to manage official air quality monitoring. The MEP has established technical regulations on the AQI and real-time reporting to ensure consistent practices. Other sources include provincial or city governments, US consulates in five Chinese cities, and non-governmental organizations that compile and recalculate governmental data.

In contrast with outdoor air quality data, government data on indoor air quality in China is close to nonexistent. Existing indoor air quality datasets are mostly small-scale, made up of data sampled in individual studies. Early in 1994, the World Health Organization compiled indoor air pollutant measurements in Chinese urban and rural areas between 1980 and 1994 from 110 publications into one large dataset for public access, making it one of the most extensive datasets of its kind but unfortunately outdated.[27] A large-scale indoor air quality monitoring platform has yet to be developed in China.

Despite China's progress in spatial coverage and timeliness of air quality monitoring and reporting, there are lingering doubts about the credibility of government air quality data and statistics. Concerns have arisen in the past about the government altering data formats,[28] inexplicably moving monitoring stations, and deliberately manipulation data.[29] After the central government set a target for local jurisdictions to achieve a requisite number of "blue-sky days" (e.g., a day where the AQI falls below 100 on a scale of 0 to 500, with 0 representing the best air quality), some studies questioned whether officials were manipulating statistics to reach these targets.[30] In 2006 and 2007, for instance, two monitoring stations in heavily polluted areas were eliminated and the government would declare days with AQI slightly above 100 to be "blue-sky days," resulting in the reporting of an additional 93 "blue-sky days" in Beijing.[31] A 2014 study finds that around half of Chinese cities' self-reported PM_{10} data from 2001 to 2010 appear to be dubious and show signs of data manipulation.[32] Concerns of air quality data manipulation have largely been addressed through the establishment of real-time monitoring systems of major government-controlled pollution sources, although Chinese officials recognize that some issues remain regarding the stability of monitoring equipment and spatial coverage of monitoring stations.[33]

Outdoor Air Quality

Since the launch of the Ambient Air Quality Standards in 2012, air quality monitoring in China has made great strides, with the rapid construction of a national monitoring network encompassing real-time air quality monitoring platforms. The number of monitoring stations increased from 49 in 74 key cities to 1,436 in 338 cities, all using the same technical regulations outlined in the new Ambient Air Quality Standards.[34] An hourly AQI reporting on the concentrations of 6 primary pollutants ($PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3, CO) is now available at China National Environmental Monitoring Center (CNEMC)'s National Air Quality Real Time Publishing Platform. CNEMC also releases detailed monthly air quality reports on 74 key cities, synthesizing data on pollutants from the air quality index.[35] The MEP's National AQI releases daily indices in 367 cities. Thirty-one provinces and municipalities also publish hourly information on primary pollutant concentrations, AQI, an air quality snapshot, air quality forecast and health advisories from provincial and CNEMC's national environmental monitoring centers. In some key regions of interest, such as Beijing-Tianjin-Hebei, air quality forecasting and warning systems are up and running. Super air quality monitoring stations, which employ cutting-edge technologies and collect data for over 20 indicators on weather, particulate matter, and other air pollutants,[36] have been launched in several cities. [37]

Certain NGOs are increasing air quality data accessibility by compiling and visualizing data through interactive websites and mobile apps. Shanghai Qingyue compiles and recalculates (according to Ambient Air Quality Standards) hourly and daily data on AQI, air pollutants, and air forecasting history from national and provincial environmental monitoring centers from 2013 to 2016 as well as US consulates in 5 Chinese cities from 2008 to 2016.[38] Qingyue requires user registration and limits access of its datasets to registered environmental NGOs, research institutions, and donor organizations in order to effectively track the impacts of its work on opening data and better understand the types of organizations and projects using its data. Archived historical air quality data are no longer available at CNEMC or on most EPB websites. Websites like Qingyue, however, have begun to provide historic datasets for the development of mobile apps and web platforms. The Institute of Public and Environmental Affairs (IPE) Pollution Map also compiles regional air quality rankings from CNEMC data and cities' air quality profiles, displaying information on primary air pollutants and annual average rain pH – an indicator of SO2 emissions, which cause acid rain.[39] According to IPE, cities' air quality data are not up-to-date or complete mostly because information has not been disclosed by local EPBs or IPE has not updated data in a timely fashion.

Dangerously high air pollution levels have inspired the creation of new apps and websites that compile official and unofficial data and disseminate the information to expat populations in China. This process can affect real change, as foreign involvement creates pressure on the Chinese government to improve the transparency of air quality reporting. In 2008, the US Embassy in Beijing installed an air quality monitor on its roof and created a twitter account (@BeijingAir) that publishes hourly air quality levels and, for the first time in China, $PM_{2.5}$ readings. Originally intended for U.S. citizens in Beijing, alarming air quality readings attracted attention from a broader Chinese audience and pushed the Chinese government to improve its official monitoring system.[40] The independent monitoring network of US consulates in China has expanded to Shanghai, Guangzhou, Chengdu, and Shenyang, now releasing $PM_{2.5}$ and AQI readings. World Air Quality Indicator Project (AQICN) grew from a desire to share US Embassy Beijing's data on a larger scale. AQICN now publishes real-time air quality readings at 4,000 monitoring stations throughout the world from governmental and non-governmental sources. AQICN also welcomes data contributions from users' air quality monitors. [41]

Improving data quality and reporting is not explicitly stated in the 13th Five Year Plan as a priority for reaching the Plan's qualitative targets. In 2015, MEP released a series of datasets, along with a document called "project management responsibility for primary pollutants emission reduction targets,"[42] comprised of data collected specifically to track the 12th Five Year Plan's progress, including, for example, a list of power industries[43] and cement industries with NO_x treatment.[44] Other government data useful for tracking progress of policy implementation are also available from MEP. For the "Desulfurization-SO_2 control" target, for example, in the Air Ten Plan requiring installation of desulfurization facilities in every coal-fired power plant and coal-fired boilers with over 20 tons of coal burnt per hour, MEP published a list coal-fired unit with desulfurization facilities in August 2014.[45]

Indoor Air

Most of the world's countries do not have large-scale governmental indoor air quality monitoring platforms. China is no exception. China's indoor Air Quality Standard, released by the General Administration of Quality Supervision, Inspection and Quarantine, Bureau of Health, and the MEP and implemented in 2013, sets official benchmarks for indoor air quality parameters and technical standards for testing procedures.[46] According to the Standards, the pollutants most pertinent to indoor air quality are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), carbon dioxide (CO_2), ammonia (NH_3), particulate matter (PM), and Total Volatile Organic Compounds (TOVCs). [47]

Polluted indoor air is a serious hazard in China. The government had not until recently regulated VOCs emitted from building materials such as glues, particleboard, and paints in new construction projects. The targets for VOCs reductions set in the 13th Five-Year Plan and the Air Ten Plan are important steps forward in VOCs regulation. Heavy use of lead has also created major hazards in China. Sources of lead include paint, gasoline, and plumbing. Although China has passed several regulatory measures for lead control, lead use has not been eliminated and was recently found in decorative paints. [48]

There is urgent need in China for large-scale indoor air quality monitoring. A 2015 study of indoor air quality in 160 office buildings in Beijing showed that indoor air was just as polluted as the air outside. Twenty-five percent of the buildings surveyed had worse air quality inside than outdoors. LEED certified offices account for 12 percent of the worst performing building on $PM_{2.5}$ reduction, partly due to a lack of government and LEED standards on indoor $PM_{2.5}$ levels.[49]

Water

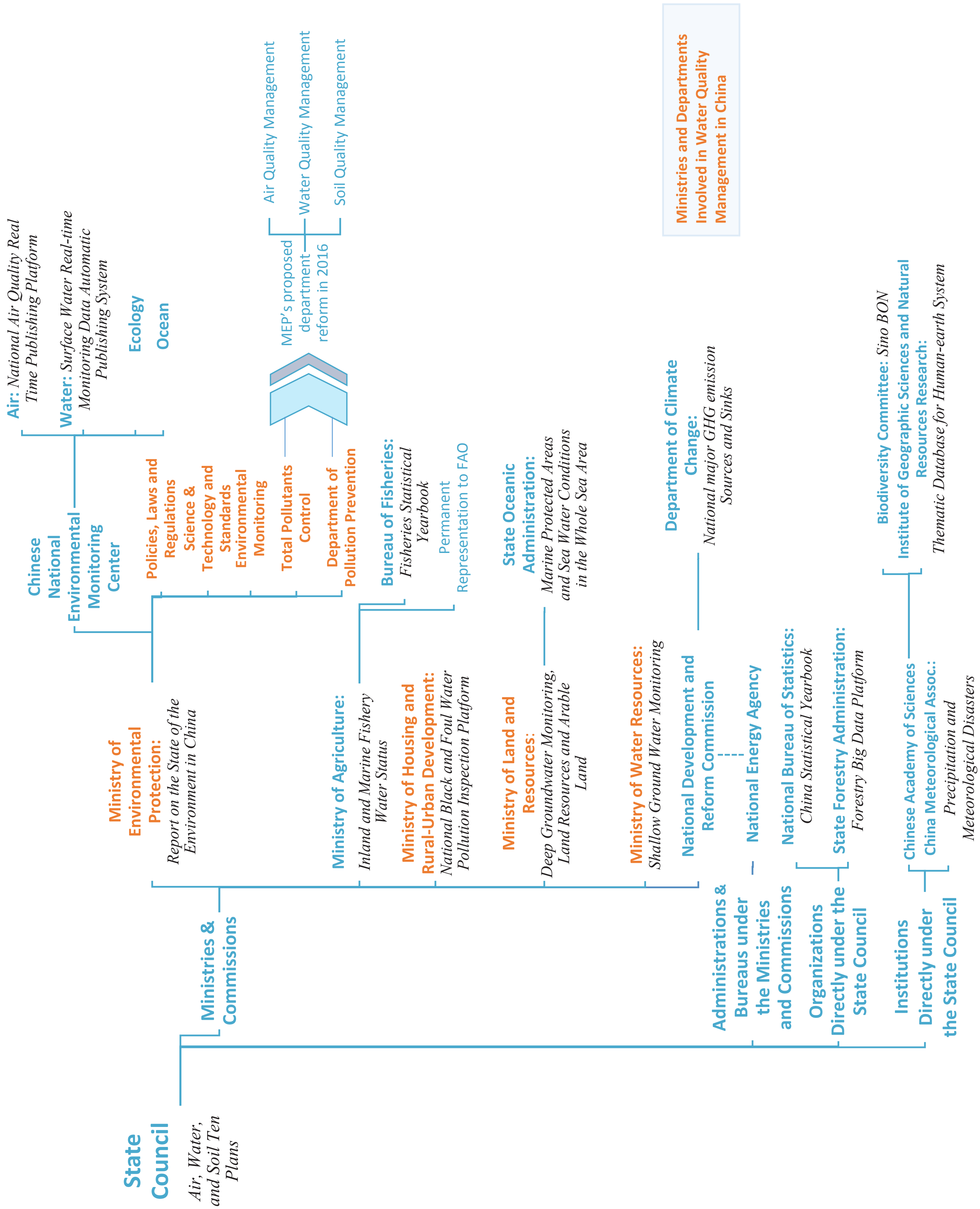
Policy Use

China has a severe water pollution problem, an issue targeted in the 13th FYP. The Plan proposes the construction of urban sewage treatment and supporting facilities, urban stormwater capture and recycling, and the reduction of waste pollutants.[50] Chemical oxygen demand (COD) and ammonia nitrogen concentration are two measures of water pollution under the Plan. In the next five years, both pollutants must be reduced by 10 percent. The Plan also targets overall waterway health, setting a goal that 80 percent of major waterways meet a tier-three standard, up from the reported current requirement that 76.7 percent of waterways be kept that clean.[51]

In April 2015, China's State Council released the Action Plan for Prevention and Control of Water Pollution (or known as the "Water Ten Plan"), the official roadmap to tackle worsening water pollution and the most comprehensive water policy to date. More than 12 ministries and government departments worked together to develop the Water Ten Plan, a policy that sets out 10 general measures and 38 sub-measures with deadlines and responsible government departments identified for each action.[52] Key indicators in the Water Ten Plan target surface water, including black and odorous water bodies, centralized drinking water sources, groundwater and offshore water. Targets on water quality are mostly measured using a categorization system that specifies five classes, ranging from first class, or drinkable water, to fifth class, or heavily polluted water that is black and smelly. Classes I-III are considered water bodies in good condition.[53] With surface water, targets include improving the proportion of water in seven basins that reaches or exceeds Class III to 70% or above by 2020.[54]

Data Availability and Gaps

Figure 1. This organizational chart shows major databases and Chinese governmental institutions that are in charge of setting environmental policy and standards and for monitoring and reporting environmental data. Illustrating water quality monitoring's complex governance structure, institutions involved in water quality control and pollution prevention are shown in dashed blue boxes. *Source: authors*



Poor availability and accuracy for water data in China raises serious concerns. Long regarded as “departmental resources,” to remain hidden from the public,[55] transparency and timeliness of water quality data lags far behind that of air quality.[56] The scale of the country’s water pollution remains hidden from the public. Ministries responsible for water data collection have not disclosed results from past surveys and the formation of a national monitoring network has stalled. [57-58]

The governance of water quality monitoring in China is complex and often unclear. Multiple ministries have overlapping responsibilities in a system that is not conducive to effective groundwater monitoring and management. Insufficient coordination between provincial and national departments that monitor water quality creates discrepancies in data. In China, the Ministry of Environmental Protection (MEP), the Ministry of Water Resources (MWR), and the Ministry of Land and Resources (MLR) are the departments managing water pollution control and prevention, each with different but overlapping responsibilities.

Involvement of many national ministries and departments at multiples levels has created a host of difficulties. Inconsistent data quality is a primary problem. Real-time surface water data is publicly available through CNEMC’s Surface Water Quality Real-time Monitoring Data Automatic Publishing System,[59] yet groundwater and drinking water data are published only monthly, sometimes with discrepancies due to lack of coordination among reporting ministries (see Figure 1). MEP’s annual *State of Environment Report* demonstrates the need for improving data quality. The report summarizes key water quality statistics, showing that data from different ministries are often untimely, presented in inaccessible formats (e.g. low resolution images that cannot be downloaded from the web in tabular format), and without information on original data sources or methodologies.[60]

In China, drinking water comes from surface water and groundwater, which are each monitored separately by different departments. MEP is mainly responsible for surface water, which includes streams, lakes, wetlands, bays and oceans. The management structure for groundwater is more complicated. MLR and MWR are both in charge of underground water quality monitoring, each with a separate focus. MLR’s 4,896 stations mainly monitor deep groundwater, while MWR’s 2,103 stations focus on shallow groundwater.[61] Among MLR’s stations, around 3,000 are provincial stations, some of which are quite old. Before submission to MLR, data from provincial stations is aggregated at the provincial level, a procedure that could contribute to data discrepancies. Following the launch of the national groundwater monitoring project in 2011, MLR and MWR set out to build an additional 20,401 water quality monitoring stations. As of April 2016, only 326 stations had been constructed, although an ambitious plan has been proposed to complete the entire network by the end of 2017.[62]

Surface Water

Surface water data is more plentiful and of higher quality than drinking water and groundwater data, but a large portion of surface water information is not open to the public. Out of MEP’s 972 monitoring stations, real-time results from only 100 monitoring centers are published through the Surface Water Quality Real-time Monitoring Data Automatic Publishing System.[63] Published data includes temperature, PH, dissolved oxygen (DO), conductivity, turbidity, permanganate index, total organic carbon (TOC), etc.

MEP publishes the *Weekly Water Quality Monitoring Info for Major River Basins in China* on their website,[64] summarizing water quality data such as pH, DO, COD, and NH3-N, and allowing comparisons of water quality among different river basins across time.[65] The Ministry of Housing and Urban-Rural Development and MEP established the Black and Foul Water Treatment Information System in 2016, an innovative program that engages the public with monitoring surface water quality.[66] Citizens can use Wechat, the most widely-used mobile application in China, to locate and report polluted water bodies. Confirmed polluted water bodies are published online and compiled into a downloadable spreadsheet including details such as the location and area of the polluted water body, the responsible party, and the required treatment deadline.

Academic institutions in China also collect and process surface water data. China’s Institute of Geographic Sciences and Natural Resources Research (CAS), for example, manages the Thematic Database for Human-Earth system[67] and publishes hundreds of water datasets on specific topics, such as water supply and consumption by province, urban water conservation by cities, and industrial wastewater discharge. CAS's website, however, has provided only two datasets on total amount of surface water for 20 provinces and 19 watersheds that date back to 1996. Given that access to more recent datasets and datasets with better spatial resolution is limited to Chinese institutions that have established contractual relationships with CAS, the intended audience of this database may be academic institutions.

Leading Chinese environmental NGOs are making government data more accessible. The Institute of Public & Environmental Affairs (IPE) launched the China Water Pollution Map[68] in 2008, which compiles surface water data from official government reports and ranks regional pollutant discharges by city.[69] The searchable pollution map provides summarized water quality data by region and by river basin, as well as water pollutant discharge data by region, by facility and by river basin. IPE's efforts to expose water violations by local and multinational companies operating in China have pressured industrial manufacturing giants to clean up their acts, and the group's regional pollutant discharge rankings encourage cities to improve discharge treatment and data transparency.

Groundwater

Real-time surface water data is available through the Surface Water Quality Real-time Monitoring Data Automatic Publishing System, yet groundwater data is accessible only through monthly reports processed by groundwater monitoring centers of the Ministry of Water Resource (MWR) and its branches in 19 local governments.[70]

Media attention recently given to MWR's data revealed the opacity of China's water quality reporting and frequent data mismatches even within the same department. Chinese and international news channels erroneously reported that 80 percent of China's groundwater is unsafe for drinking, after misinterpreting MWR data. Chen Mingzhong, head of MWR's department of water resources, responded to these reports that groundwater is not the same as drinking water. Most of the samples cited in the mistaken reports were drawn from shallow wells that are used by farms, factories, and mostly rural households, whereas urban drinking water normally comes from treated reservoirs, deep aquifers, or rivers.[71]

Without disclosing raw data on groundwater quality, Chinese officials' discrepant conclusions drawn from summarized statistics are confusing and unreliable. As Chen Mingzhong contended in 2016, approximately 85% of China's underground drinking water sources meet required standards according to a 2014 survey.[72] Jiao Yong, Deputy Minister of MWR, stated in 2014 that 80.9% of China's underground drinking water sources were up to standard, a 4.1 percent difference from Chen's claim in 2016.[73]

There are also data mismatches from MLR and MEP, two other departments that are responsible for groundwater monitoring. The MLR's 2015 State of National Land and Resources Report stated that, in 2014, 42.5% of groundwater was found to be of "poor" quality and 18.8% to be "extremely poor". [74] MEP's 2014 State of Environment Report, however, said that 61.5% of groundwater monitoring sites was of "poor" (45.4%) or "extremely poor quality" (16.1%).[75] Peng Yingdeng, a researcher at the State Laboratory for Urban Pollution Control Technology, says that the different locations of national and provincial monitoring stations, unstandardized sampling methods, and varied expectations of outcomes from different departments that share funding allocated for water quality monitoring all contribute to data discrepancies.[76]

Drinking Water

Drinking water data is geographically scattered and often not up to date. In 2005 MEP established a monthly reporting system for drinking water in 113 key cities.[77] But today there is no central monitoring platform in China for drinking water quality. Raw data used to produce the monthly reports were never published, and results of a national drinking water quality survey completed in 2009 are not open to the public.[78] Ministry of Housing and Urban-Rural Development (MOHURD) has many times used an "authorization" classification to fence off public scrutiny of the 2009 survey data. After an unfulfilled promise to clarify 2009 survey results to the public, MOHURD failed to respond to a citizen's freedom of information request on the locations of drinking water supplies that MOHURD said are substandard and the metrics by which these supplies failed.[79]
NGOs have contributed drinking water data from their independent surveys. A 2015 report from China Water Safety Foundation found

that only half of the 29 large and medium-sized cities it surveyed, representing approximately 80 million people, passed its test on all 20 selected indicators from the National Drinking Water Standard.[80] Without open data covering an extended period, however, it is not possible to observe changes in drinking water quality over time.

China has demonstrated progress on protection and monitoring of drinking water sources, despite much needed improvements that remain incomplete, including the establishment of clear quality standards and enhanced transparency of data reporting. In 2010, MEP led a group of national ministries issuing the first drinking water sources protection plan from 2008 to 2020. MEP's survey results, released in 2011, showed that 94.3 percent of surface water sources and 87.6 percent of groundwater met its standards.[81] Despite these positive survey results and new indicators outlined in the 'Surface Water Environmental Quality Standard' for drinking water sources, there is no specific quality standard for drinking water source in China. The claim that water quality meets the MEP's standard is ambiguous. While the official standard requires Class II water sources to be used for drinking water, an officer with the MEP Drinking Water Office revealed that in actuality some sources only meet Class III qualifications, most likely due to the scarcity of Class II water.[82-83]

Because local EPBs report drinking water quality separately, civil society efforts to compile publicly available government data are greatly improving the transparency and accessibility of drinking water data. The Open Environmental Data Center, launched by Shanghai Qingyue in 2015, compiles historical drinking water data published on local EPB's websites and formats the data into downloadable files.[84] Data for ten cities is now available. Shanghai Qingyue recently conducted research on data transparency for drinking water quality in 12 cities and successfully requested 28 provinces and cities to disclose (or partially disclose) their drinking water source data.[85-86]

There is optimism that the gaps in drinking water data may be closed in the near future. The Water Ten Plan-requires every municipality to publish drinking water source and safety data quarterly starting in 2017,[87] which would be a step towards more timely and useful data.

Soil (Toxicity & Land Management)

Policy Use

Soil pollution and soil quality are critical and sensitive topics in China, often considered "state secrets."[88] Until the release of the MEP and MLP soil survey in 2014, very little information on soil pollution was publically available. Soil pollution's close linkage to food safety makes data on soil quality particularly sensitive from the government's perspective.

In May 2016, the State Council released the Soil Pollution Control Action Plan (also known as the "Soil Ten Plan"), as promised in the 13th Five-Year Plan. The Soil Ten Plan is a joint-effort of 35 central government agencies including the NDRC, MEP, Ministry of Land and Resources (MLR), and Ministry of Agriculture (MOA).[89] One of the Soil Ten Plan's top priorities is to conduct a nationwide soil survey to determine the scope and scale of China's soil pollution problem. The Plan's goals include building a national monitoring system of contaminated soil sites by 2017; completing an investigation on tainted agricultural land by 2018; and developing an understanding of the distribution and risk of key polluted construction sites by 2020. Given the Soil Ten Plan's complexity and scale, departments need to enhance coordination with one another to effectively implement the Plan's actions and avoid data discrepancies similar to those observed in water data.

Included in the Soil Ten Plan's two land-use categories – agricultural land and construction sites – two sub-categories are respectively highlighted: arable land and industrial land. The Soil Ten Plan aims to remediate 90 percent of contaminated arable land and more than 90 percent of contaminated industrial land so these lands are safe to use by 2020. Given that the government reported 20 percent of China's arable land to be severely polluted in a 2014 report, the target in the Soil Ten Plan is quite ambitious.[90] The Plan does not specify, however, what qualifies as safe use. The lack of specifications regarding standards may make it difficult to align the Plan's targets with specific actions and determine whether the plan on its own would be enough to reach the 90 percent goal.[91]

The absence of binding legislation could compromise the Plan's implementation, despite its ambitious goals.[92] China's government is currently working on the country's first-ever soil pollution prevention law to combine existing air and water quality laws to curb rampant pollution. The soil pollution prevention law, expected for introduction in 2020, will stipulate the division of duties between government agencies, the establishment of a surveying and monitoring system, and increased funding, among other regulations, according to the National People's Congress (NPC) Environmental Protection and Resources Conservation Committee.[93] The Soil Ten Plan could facilitate the introduction of this soil protection law, but legislative progress remains too slow given the scale of China's pollution problems.

Data Availability and Gaps

There is scant publicly available data on soil pollution, a politically sensitive topic in China.[5] In early 2014, however, MEP and MLR released results from a 2005 to 2013 national soil pollution survey for the first time ever,[94] showing that the government was "not optimistic" about the nation's soil conditions.[95] This report represented the government's first effort to unveil the severity of the country's soil pollution, although the disclosure came with major data gaps in the survey. Details concerning the spatial location of sampling sites, survey methods, the levels of exceedance for individual points, and the original survey results were not provided to the public.[96] Given that soil pollution is often not apparent, it is difficult to undertake pollution prevention and remediation efforts without information on affected sites and levels of pollution. These data gaps seriously compromise the survey's capacity to provide a clear and realistic picture of soil pollution's scale and severity in China.

There is scarce publicly available data on soil quality beyond land area information. The MLR publishes the National Land and Resources Report annually providing aggregate statistics on agricultural land and construction sites. The 2015 report was released in April 2016, disclosing data on land area, agricultural land quality, and construction land use.[97] As with similar government reports, however, raw data used for the report was not disclosed.

Arable Land

According to the 2015 National Land and Resources Report, 70.6 percent of China's arable land was "average" or "low" quality.[98] Arable land is graded on a 15-level scale: levels 1-4 are "excellent", 5-8 are "good", 9-12 are "average", and 13-15 are "low". The report does not specify the standards that correspond with quality levels nor the raw survey results, throwing doubt on the accuracy, reliability and usefulness of these grades. China's historic problem of heavy metals soil contamination was not in any way reflected in the report's summarized figures. The central government's Ministry of Agriculture's Rice and Product Quality Supervision Inspection and Testing Center found in 2002 in a nationwide test 28.4 percent of sampled rice was tainted by unsafe levels of lead,[99] and there has been no information released to indicate whether the issue is being addressed or not.

The Soil Ten Plan recognizes the inadequacy of the current arable land grading system and proposes a categorization of agricultural land by degree of pollution. Under the proposed system unpolluted and slightly polluted agricultural land will be protected, mildly and moderately polluted agricultural land will be made safe to use, and severely polluted agricultural land will be "strictly controlled." Arable land will take priority over other types of land classified for agricultural use. But as with other pollution plans, the Soil Ten Plan needs to clarify how it classifies different degrees of pollution.

The Ministry of Agriculture and MEP are developing a national monitoring network to fill information gaps on arable land pollution. 107 arable land monitoring sites have been built throughout China, and 152,000 monitoring points will be established to monitor and control pollution in agricultural production areas.[100]

Industrial Land

Information on industrial land, including summarized statistics, is scarce. In a Soil Ten Plan press release in June, the MEP reported a sample survey's findings showing that 36.3% of land around polluting companies, 34.9% of industrial wastelands, and 29.4% of industrial parks exceeded standards.[101] The press release did not disclose further details.

The Institute of Public and Environmental Affairs (IPE) made initial efforts this year to open soil-related information to the public. IPE published the first soil pollution source map in April that pinpoints pollution sources and gauges risks to public health and other safety hazards.[102] The map was created with filtered data from 4,500 companies and 729 industrial parks in 13 heavy-polluting sectors such as petrochemicals, mining, and metal smelting.[103] Locations marked on the map are considered brownfield sites, and if the companies currently occupying these areas decide to move the sites will require remediation.[104] It is worth noting though that the map only displays potential sources of soil pollution and is not the same as showing results of a soil pollution survey.

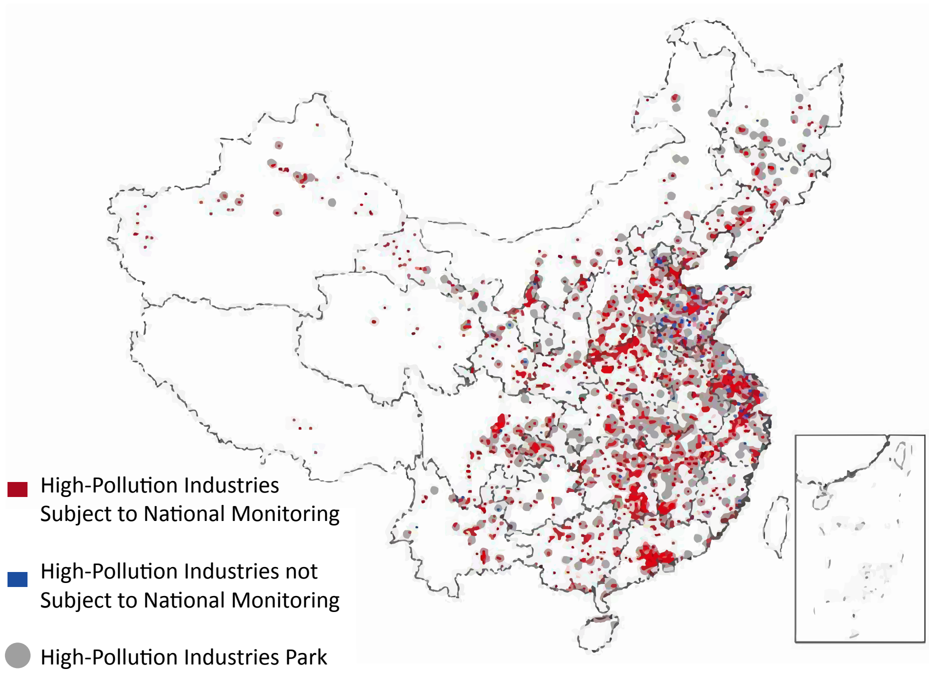


Figure 2. IPE's soil pollution source map. *Source: Adapted from IPE, 2016*[105]

The Soil Ten Plan emphasizes information transparency and features specific action plans for improvement on this front. One action plan requires local governments in areas chosen by industrial and mining companies' locations and emissions to produce a list of firms that will be subject to soil pollution monitoring. The companies on these lists are obligated to perform annual soil quality monitoring at their sites and open their results to the public, though it is not yet known what content will be made public.[106]

Biodiversity and Habitat

Policy Use

China has experienced severe habitat and species loss in recent decades, belying the countries status as one of the world's 12 mega-biodiverse countries. In 1993, China ratified the Convention on Biological Diversity (CBD), a multilateral treaty with the aim to spur national plans for the conservation and sustainable management of biological diversity. CBD currently has 196 parties that adhere to the

Aichi Biodiversity Targets. The two main targets address terrestrial and marine protected areas: global terrestrial protected areas should increase from a 2010 baseline of 13 to 17 percent and marine protected areas should increase from a 2010 baseline of 5 to 10 percent.

China has undertaken several measures to achieve the CBD goals. Following ratification in 1993, the State Council released China's first Biodiversity Conservation Action Plan. The most recent national plan, the National Biodiversity Strategy and Action Plan (NBSAP) covering 2011 to 2030, was released in 2010 with 3 targets, 8 strategic tasks, 10 priority domains, 30 priority actions, 35 priority areas for conservation and 39 priority projects for implementation.[107-108] China also signed onto a suite of other international conventions, including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Wetlands of International Importance (the Ramsar Convention), the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification (UNCCD). Biodiversity conservation has been a reoccurring theme in comprehensive national policies as well, including the Water Ten Plan, which proposed several quantitative targets for biodiversity and habitat conservation.[109]

China has taken important steps on biodiversity conservation, significantly increasing the number of nature reserves, forest parks, national scenic areas, and national geological parks within its borders. Protected areas now cover around 17 percent of China's total land area. China has also established 17 national marine reserves and mandated a suite of standards for sustainable fishing practices, including institutionalizing a fishing licensing system, a fishing ban season, a non-fishing area system, and a "zero or negative increase" policy in marine fish catches.[110] Completed in 2014 by MEP, the Fifth National Report on the implementation of the Convention on Biological Diversity recorded in great detail the country's progress towards the Aichi Biodiversity and NBSAP Targets. The report describes outcomes of efforts to meet interim national targets and provides indicators designed to assess China's progress towards reaching these targets.[111] Researchers find, however, that China's actual enforcement of protected areas is not commensurate with the growth in officially designated protection. A large portion of China's protected areas lack human resources, funding, and proper management. Revenue generation often becomes a priority over biodiversity conservation for reserve managers.[112]

Data Availability and Gaps

Unlike most widely used international biodiversity databases, Chinese governmental data on natural resources and biodiversity mainly takes the form of large-scale surveys conducted by various agencies. Several these large-scale surveys have been completed in recent years,[113] including national natural resources surveys like the State Forestry Council's 2014 Eighth National Forest Resources Inventory and Ministry of Agriculture's 2nd National Survey on Livestock Genetic Resources. Surveys on biodiversity include the State Forestry Council's 2009 to 2013 Second National Wetland Survey following the CBD's Ramsar Convention's guidelines and the State Oceanic Administration's Marine Species and Atlas, released in 2012.

Despite the many national and subnational surveys conducted, these surveys are difficult to access online and many have yet to be digitized from their original print versions. The ones that are online are scattered on various agency websites. They are hidden in disorganized online structures and often published in inaccessible data formats, and they lack interactive maps, which are common features of international biodiversity databases. The Forestry Council's Forest Resources Inventory and 2014 Forestry Statistical Yearbook are, for instance, only available in low resolution scans of the print version.[114-115] The recently launch forestry big data platform is an exception, as wetland resources and biodiversity databases, previously included in State Forestry Administration's *Forestry Statistical Yearbook*, are now available online.[116]

The lack of a central monitoring network is a key reason why data are so scattered and difficult to access. Previous efforts to create a central monitoring network have been unsuccessful. For instance, the CAS Institute of Zoology's Chinese Biodiversity Information System (CBIS) – previously a coordinating network for 36 databases of biodiversity data – lists mostly non-functioning links to these online databases. Given the vast array of existing databases found in an initial survey, CBIS is nowhere near comprehensive, adding noise to the already chaotic field of biodiversity data in China.

Fortunately, China is gradually making progress on establishing a central biodiversity monitoring network. Founded in 2004, China Forest Biodiversity Monitoring Network (CForBio) is the nation's first biodiversity monitoring network, covering different types of forest vegetation at different latitudes. As of 2012, CForBio has established 12 major monitoring sites that each covers an area from 9 to 25 hectares.[117] Once CForBio developed a foundation for biodiversity monitoring, CAS allocated funding specifically for the China Biodiversity Observation and Research Network (Sino BIO) as part of China's 12th and 13th Five-Year Plan.[118] Sino BIO consists of a zoological diversity network, botanical diversity network, microbial diversity network, and a monitoring and management center. The center is charged with formulating and implementing monitoring standards, managing and publishing data, and collecting and analyzing remote sensing data (Figure 3). Keping Ka, a researcher at CAS, believes that China should integrate existing databases, develop monitoring standards and regulations, and design indicators to upgrade the current system.[119]

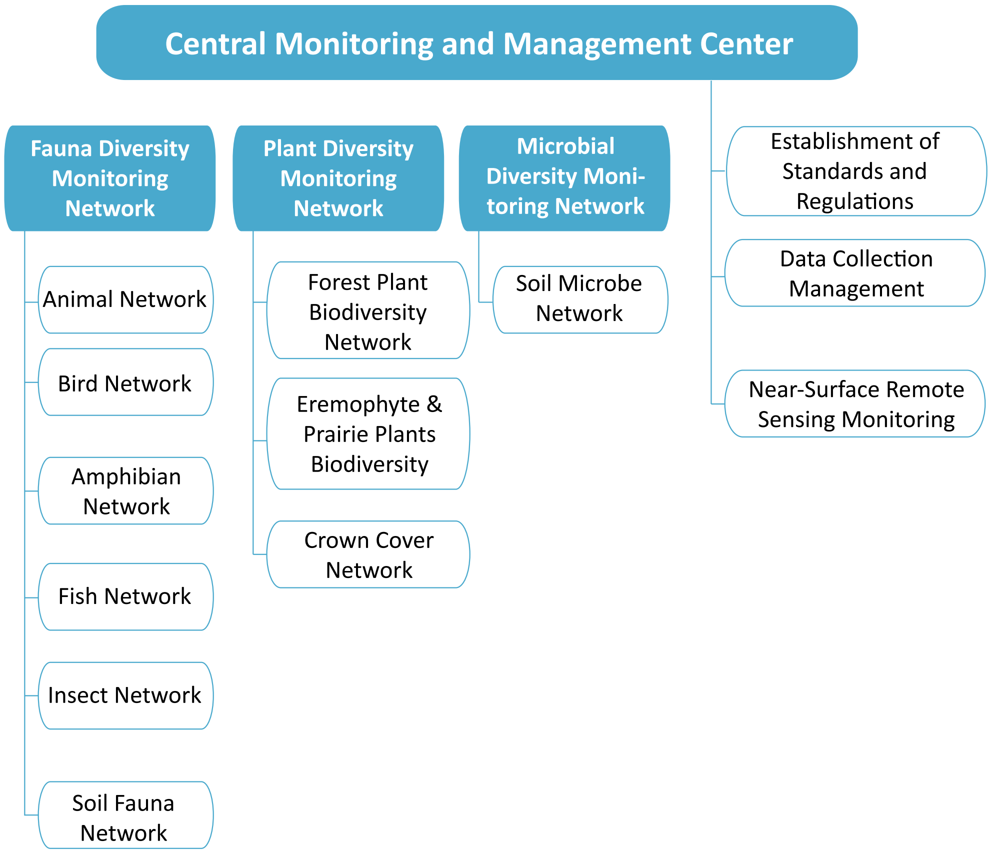


Figure. 3 Framework of Sino BIO-China Biodiversity Observation and Research Network. *Source: Adapted from Ma,2015* [120]

The national biodiversity assessment, completed in 2012, is another important initiative that advances biodiversity monitoring in China. The assessment was conducted in 31 provinces and identified biodiversity hotspots and conservation gaps previously unknown to the government. A method for biodiversity assessment was established in an effort to standardize varying practices across provinces, and five indicators – species richness, diversity of ecosystem types, completeness of vertical stratification of vegetation, endemism, and extent of biological invasions – were developed. Like many online biodiversity databases in China, however, the website (http://www.biodiv.org.cn/) that supposedly publishes the results of the assessment is currently inaccessible.

The biodiversity assessment recognizes that missing data and unsystematic biodiversity monitoring methods across provinces are problems that prevent effective biodiversity evaluation in China. The data collection process is difficult, involving gathering scattered information from provincial surveys and journal articles. This assessment, however, is the first effort in China to collect extensive data on the distribution of and threats to 34,039 vascular plants and 3,865 wild vertebrates. The current report proposes to assess biodiversity at the county level,[121] and much more data will have to be acquired and organized to perform an assessment at such a small geographical unit.

Terrestrial and Marine Protected Areas

According to MEP's Fifth National Report on the Implementation of the CBD, China's terrestrial and marine protected areas had reached 14.8 percent and close to 3 percent of the country, respectively. The CBD's targets, meanwhile, task countries to protect 17 percent of terrestrial habitat and 10 percent of marine habitat. The MEP refers to various types of terrestrial and marine protected areas as a system of *in-situ conservation*, consisting mainly of nature reserves and complemented by scenic spots, forest parks, and special marine protected areas, among other land and seascapes. Information on various types of protected areas comes from multiple agencies. MEP's progress report finds insufficient data needed to track the nation's ecological diversity and effective management of protected areas.[122]

Better Trade Data to Aid Species Protection

China's notorious appetite for endangered species parts has seriously hurt global biodiversity. The consumption of shark fin as a symbol of power and wealth in China and other east Asian countries has contributed to an alarming 98 percent decline in some shark populations in the last 15 years.[123]

Once the largest market for shark fins, consuming 95 percent of the world's trade at peak consumption, China's fever for this luxurious delicacy cooled off dramatically, with a 50 to 70 percent drop in sales over the last two to three decades.[124] A combination of factors has driven down shark fin consumption, including bans of shark fins at state banquets, growing environmental awareness among younger generations, and an international movement against shark fin trade.

As shark fin consumption wanes, other species that have not received nearly as much attention are still heavily traded and consumed. Campaigns against shark fin consumption have not affected the trade of other endangered marine species at all. Harvest of sea cucumber, for instance, for human consumption is increasing with a corresponding expansion of aquaculture and insufficient public and regulatory concern.[125] While sale of shark fin is banned on Taobao, China's largest e-commerce website, a cursory search for sea cucumbers returns 100 pages of results. A 2015 study stresses the importance of improving trade data to allow China's to assess consumption trends and enhance species conservation.[126]

Fisheries

Policy Use

China's fishing industry has grown rapidly in the last 30 years, driven by global demand and national policies.[127] As of 2014, China is the world's largest fishing country by fishery products and exports.[128] Belying the boom in China's fisheries, a looming governance crisis fraught with policy incoherence is leading to collapses in fish populations.[129] Overfishing in domestic waters has resulted in resource depletion and severe environmental degradation. Fish depletion in local waters has driven rapid development of China's distant water fishing (DWF), raising international legal problems and contributed to a crisis of global fisheries collapse. Implementation of domestic and international sustainable fishing policies has been at best half-hearted, as increasing fisheries production and fishermen's income remain the government's overarching goals.[130]

China is a member of a handful of international fisheries institutions, albeit with weak coherence and cooperation.[131] In 1996, China ratified the United Nation Convention on the Law of the Sea (UNCLOS) that established exclusive economic zones (EEZs) to 200 nautical miles from a country's coastal baselines. Throughout its EEZ, a nation has exclusive economic jurisdiction over natural resources and the responsibility to protect these resources. In coherence with UNCLOS, China released a new law to establish an EEZ and signed bilateral fishing access agreements with Japan, South Korea, and Vietnam in the early 2000s. China signed but did not ratify the UN Fish Stock Agreement in 1995 that governs highly migratory stocks and fish that move between different countries' EEZs.

In the mid-1990s, faced with severe domestic resource depletion and a deteriorating marine environment, China launched a series of sustainable fishing policies governing its inshore waters, including a fishing ban in major marine areas (Bohai, the Yellow Sea, the East China

Sea and South China Sea) and, in 2003, the Zero Growth Policy. The Zero Growth Policy was created to control overfishing, establishing mandatory limits set to reduce China's total marine catch. In 2000, China made amendments to its Fisheries Law, incorporating UNCLOS' EEZ regime. Amendments to the Fisheries Law were also influenced by FAO's Code of Conduct for Responsible Fisheries, a non-binding agreement that came into effect in 1995. The 2000 amendments to the Fisheries Law also created a new total allowable catch (TAC) system and updated several conservation measures, including ones that were initiated before UNCLOS.

Despite efforts to curb overfishing in China's inshore waters, offshore fishing and DWF have expanded almost unabated. Official data shows zero or even negative growth since the introduction of the Zero Growth Policy since the late 1990s, but fisheries experts strongly suspect that China's marine catch is perennially underreported due to the omission of illegal, unreported, and unregulated (IUU) fishing activities.[132] Despite participating in numerous international fisheries agreements, China funds high seas exploratory programs and heavily subsidizes DWF, which engages in IUU fishing in other countries' EEZs. [133]

Due to growing global demand for seafood and fisheries' importance for China's food security, China's expansive fishing operations are unlikely to slow in the near term. This trend is evident in China's 12th Five-Year plan for the fishing industry (Fisheries Plan), which sets meeting global demand as the nation's primary objective and places emphasis on fisheries output value, aquatic product export volume, and similar indicators.[134] The Plan also prioritizes domestic fisheries, fishermen welfare, and the expansion of China's global fisheries in coherence with China's "going out" policy.[135]

A common practice in developed countries, strong fisheries subsidies encourage China's seaward expansion and work against establishing sustainable fisheries. In line with Japan's $4.7 billion, China's fisheries subsidies amounted to $4.5 billion in 2009, making it the world's second largest fisheries subsidizer.[136] Among China's three forms of subsidies – basic infrastructure projects, specialized financing programs, and fuel subsidies[137] – 95 percent of the expenditures were deemed harmful to the environment.[138]

Fuel subsidies catalyzed the growth of China's fishing vessel building industry, which greatly increased the size and power of China's marine fishing fleet from 2004 to 2013.[139] Fuel subsidies and financial support from the Zero Growth Policy encouraged fishermen to build larger and more powerful ships and maximize the subsidies' benefits of RMB 1,250 ($192.30) per Kilowatt per year.[140] China's fishing vessel building industry boomed, with its price index increasing 20-fold from 2006 to 2012.[141] The increase in fishing capacity and fisherman-friendly policies motivated Chinese fishing fleets to go far into the distant ocean and reach deeper waters.

Data Availability and Gaps

Accurate fisheries stock assessment is very challenging, and most catch data are self-reported.[142] China's fishery data, in particular, has caused serious concerns, with many experts suspecting the country of over-reporting domestic catch and under-reporting DWF catch. China reports its fisheries data to both international and national agencies. At the international level, China reports annual species-aggregated data on inland and marine capture and aquaculture to the FAO. China's data quality varies across categories. Aquaculture production statistics are generally the highest quality data, reported with the best species breakdown and the lowest rates of unidentified production. Marine capture data has fairly good species breakdown, whereas inland capture is much less detailed and has a large portion of species unidentified.

At the national level, three kinds of data are reported monthly, annually, and biannually to different institutions. Once a year, the Bureau of Fisheries (BOF) under the Ministry of Agriculture publishes the *China Fisheries Yearbook*, with fishery and aquaculture data compiled and analyzed from submissions of 31 local administrative units.[143-144] Data categories include production, sector structure, and investment in fisheries, among others.[145]

Problems surrounding China's national fisheries data emerge early in the collection process. Under China's Statistical Law, BOF is responsible for designing, compiling, and distributing the fishing log-sheet that are sent to enumerators in the field for investigations of fishing operations.[146] In several pilot sample-based surveys fishermen exhibited low compliance with the designed log-sheet scheme. The low compliance is due in part to the fact that enumerators often do not adhere to the scheme themselves and only require fishermen to record catch values but not production-related data. Enumerators estimate fishery production values and average fish price from catch data provided by fishermen, which compromises the quality of data reported to high-level national institutions such as BOF and NBS.[147] Enumerators are poorly paid, making it challenging for them to maintain adequate technical competency for fishery statistical tasks. Fisheries log-sheets are filled in manually and there is no monitoring system to verify data quality. These issues collectively contribute to the unreliability of China's fisheries data.

China has likely over-reported its domestic catch, causing international agencies to overestimate fish catches in global fisheries datasets. International attention focused on China's fish catch reporting when, in 2001, researchers at University of British Columbia (UBC) wrote in *Nature* about China's suspiciously high marine catches that may have contributed to erroneous global marine fisheries estimates.[148] UBC researchers believe that China over-reported its marine capture fisheries production from 1995 to 1999 by more than 5 tonnes/ km^2 per year compared with their model's predicted numbers. The difference between the modeled global catch and that predicted by China's reported totals was 10.1 million tonnes in 1999.[149]

Chinese mid-level officials may have exaggerated actual numbers to gain professional promotions, which are associated with high fish catches.[150] The cause for false reporting seems trivial, but China's overreporting was no small issue for global fisheries. China is responsible for one-third of the world's reported fish production and two-thirds of global aquaculture production,[151] meaning that any error in its fisheries data reporting impacts estimates of global fisheries trends and the world's fishing industry's impact on the environment. China's overreporting resulted in rising FAO statistics in a time when catches in many places were declining, a contradiction that puzzled the international scientific community. Given FAO statistics' broad reach, overestimated catches spread the false impression that the world's fisheries were healthy and not collapsing.[152] Accurate reporting of fisheries data is crucial to timely implementation of sustainable fisheries measures and the conservation of endangered fish species including swordfish, tuna, and shark. [153]

China's BOF General Director dismissed the overreporting issue, responding that China's statistics were "basically right" and China's fisheries "have its own characteristics." FAO meanwhile expressed grave concern, as the only international organization that manages global fisheries data. FAO pointed out that scientists have raised similar red flags concerning China's fisheries data in the past. China is supported by FAO's "Strategy for improving information on status and trends of capture fisheries" (Strategy STF) project and the China Fishery Society's (CFS) efforts to improve fisheries data monitoring. Launched in late 2004, Strategy STF aims to develop frameworks and strategies for countries to enhance fisheries knowledge for better policymaking. In collaboration with a handful of Chinese organizations, Strategy STF helped perform a review of China's fisheries information and data collection system in 2008 as a part of a global inventory. This was the first comprehensive fisheries data review in China and has yet to be updated from its 2008 version.

Distant Water Fishing (DWF) [154]

A nearly 50 percent collapse in China's domestic fish stocks and large international demand spurred the rapid expansion of the country's DWF fleet. [155] China today has the world's largest DWF fleet, with 3,400 ships reported in over 93 countries' EEZs. Africa's west coast is a prominent destination.[156-157] By comparison, the United States, with around 200 ships, has the world's third largest DWF fleet.[158] China's DWF consists of high seas fishing and fishing in other countries' EEZs.[159] Under the UNCLOS, through access agreements and compensation, DWF fleets can catch surplus fish in the EEZs of countries that do not have sufficient capacity to fully exploit their resources. In 2012, high seas fisheries accounted for 58 percent of China's DWF, with the remainder in other countries' EEZs, and many of these incursions' legitimacy is highly questionable.[160]

Data gaps regarding China's DWF activities create uncertainty around China's involvement in illegal fishing. China does not disclose any information on the countries with which it has established bilateral fishing agreements.[161] The European Union (EU), in contrast, provides a public law database (http://eur-lex.europa.eu) with information relating to fishing access agreements established among its countries. A complete absence of transparency in China's DWF activities raises suspicions that much of the country's fishing is illegal.[162]

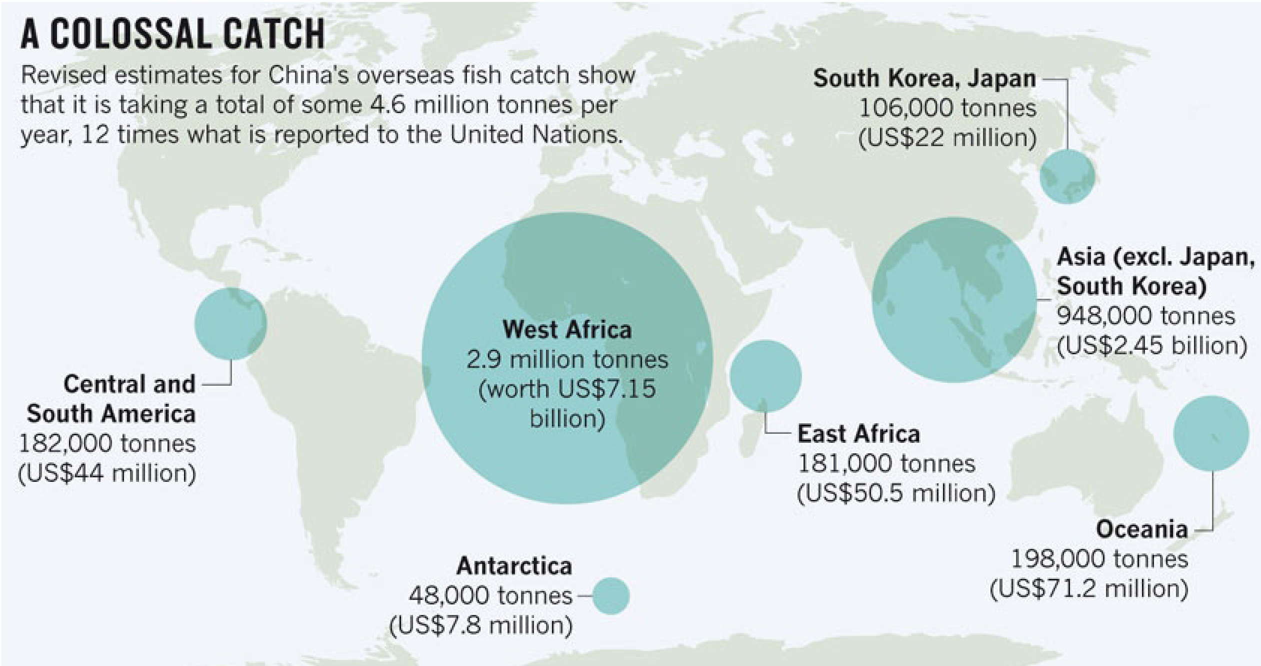


Figure 4. Source: A Pew Charitable Trusts report shows estimates of China's foreign fishing operations. *Source: Pew, 2013* [163]

Multiple studies have found that China severely under-reports its DWF catches, likely due to international pressure to halt its violations of maritime law.[164] Estimates from UBC researchers show that China's actual DWF catch from 2000 to 2011 averaged 4.6 million tonnes per year, more than 10 times the figure that China reported to FAO.[165] A 2012 study from the European Union uses two approaches to compare its estimates of China's DWF catch with the country's official statistics. The first approach makes a direct comparison, finding that China's reported DWF catch of around 1.1 million tonnes per year is less than a quarter of the study's estimate. The second approach focuses on China's DWF catch in Africa's waters, finding that around 2.5 million tonnes of the estimated 3.1 million tonnes of fish per year goes unreported.[166] Researchers derived this estimate by subtracting China's catch reported to FAO and the country's total share as reported by African countries.[167] Part of African countries' reported 'national' catches were deemed Chinese catches under joint-venture/charter/reflagged arrangements, and these were included in the estimation.

The privatization of large, state-owned fisheries enterprises in recent years has hindered reliable reporting. China National Fisheries Corporation (CNFC) is the biggest fisheries enterprise in China and owns about one-third of China's DWF fleet. CNFC operates widely throughout the three navigable oceans and was the first Chinese company to expand its operations into West African waters in the mid-1980s.[168] CNFC has gradually shifted its ownership status from state-owned to private, bringing a corresponding drop in reporting transparency.[169] In late 2010, the Chinese government announced that state observers would be dispatched to monitor companies' DWF operations, an essential action for implementing international conventions and establishing China's image as a responsible fishing country.[170] Fishing companies, however, still have trouble recording accurate fishing activities and observer data, properly identifying bycatch, and correctly attributing catch amounts to the country of origin.[171] Language barrier is a key challenge that these companies face. The creation of a common statistical system for fishing catch data is crucial for China to manage its catches, improve knowledge of fisheries' working conditions, and report accurate totals to the international community.[172]

Forests

Policy Use

Extensive unsustainable logging in the 1980s resulted in massive deforestation and soil erosion in China. In 1998, a severe flood of the Yangtze and Yellow Rivers spurred the creation of the "Six Key National Forestry Programs," intended to transition the nation's forest sector from its sole focus on extractive timber production to a system of forest restoration and sustainable management.[173] Among the six programs, the 2000-2010 National Forest Protection Program (NFPP) was the Chinese government's largest response to combat deforestation.[174] The NFPP's objectives were to conserve 90 million hectares of natural forest and to afforest or reforest an additional 31 million hectares by 2010.[175] With implementation beginning in 2000, the NFPP enacted logging bans, harvesting reductions, and encouraged forest management in 17 provinces, covering 68.2 million hectares of forest land, including 56.4 million hectares of natural forest that composed 53 percent of China's natural forests. In 2010, the program was extended to 2020 (Phase II) and included 11 more counties with a total capital investment of over 240 billion RMB (Figure 5). Phase II aims to add 5.2 million hectares (78 million mu) of forest area, 1.1 billion m^3 of forest stock volume, and 416 million tons of forest carbon sink.[176] In the *Outlines on Promoting Ecological Civilization (2013-2020)*, SFA proposed to increase forest coverage to over 23 percent and forest stock volume to over 15 billion m^3. [177]

Source: SFA.[4]

Figure 5. Phase I (2000-2010) and Phase II (2010-2010) of the National Forest Protection Program. *Source: Sun et al. 2016* [178]

Initiated in 2014, a commercial logging ban in several Heilongjiang state-owned forests demonstrated China's dedication to forest restoration. The province with the most natural forests and a reputation of overharvesting, Heilongjiang had been the powerhouse of China's forest industry.[179] As of 2013, however, the amount of wood harvested in Heilongjiang amounted to 0.89 million m^3, down 78 percent from the 4.1 million m^3 before NFPP Phase II was launched.[180] The logging ban is expected to expand to all state-owned natural forests in 2016 and eliminate logging activities on privately owned land by the end of 2017, decreasing harvest by 50 million m^3 annually, equivalent to a 30 percent reduction.[181]

Along with national policies restricting logging and promoting harvesting activities that increase forest cover, China created nature reserves and forest parks in line with the CBD's 2020 Aichi Targets. Destructive logging and deforestation activities including reclamation, quarrying, and mining are strictly prohibited in these areas.[182-183] By the end of 2013, China had established 2,697 nature reserves that cover an area of 146.3 million hectare – 14.8% of China's total land area. The nature reserves protect 25 percent of the country's primary forests, along with 90 percent of terrestrial ecosystem types and 65 percent of plant biota. [184]

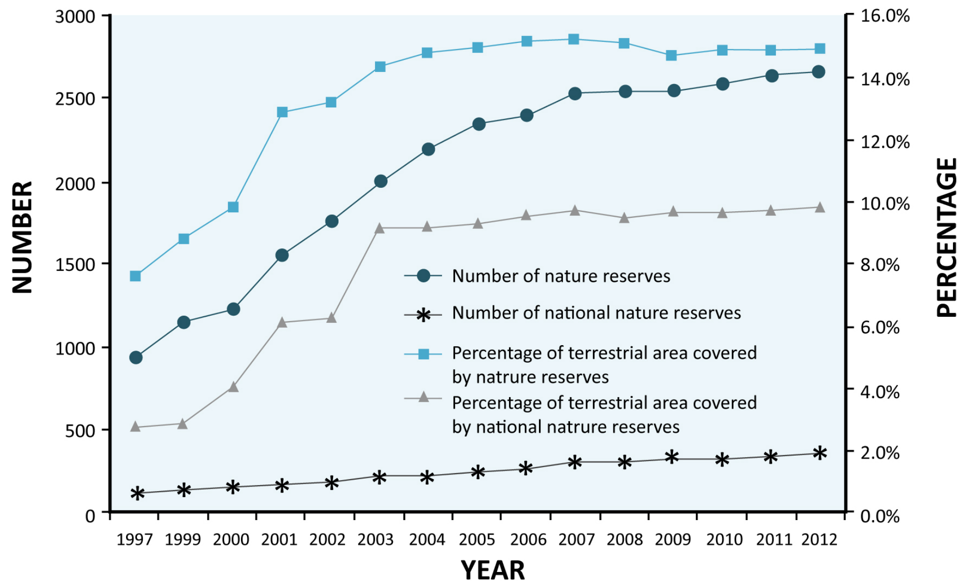


Figure 6. Number of Nature Reserves and Percentage of terrestrial area covered from 1997 to 2012.
Source: China's Fifth National Report on the Implementation of the Convention on Biological Diversity [185]

The number of forest parks increased steadily over the years. By SFA's definition, forest parks are large in scale, have beautiful scenery and natural and cultural landscapes where people can visit for scientific research or cultural, educational, and recreational purposes.[186] As of 2013, there were 2,855 forest parks covering an area of 17.4 million hectare, including 764 national forest parks and 1,315 provincial forest parks.[187] The official classification of forest parks, however, is vague, and these parks are not formally designated as nature reserves by national or international standards.[188]

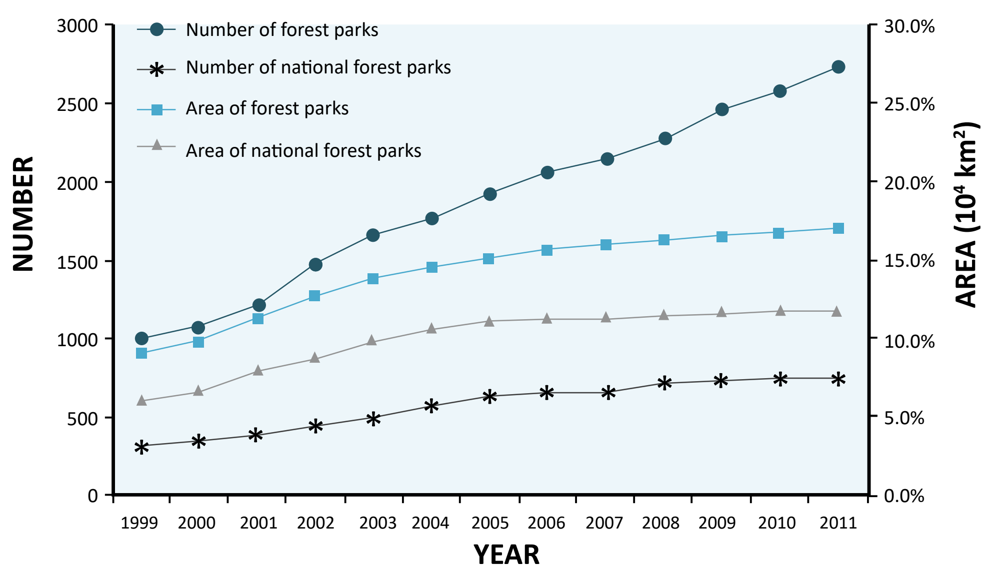


Figure 7. The number of forest parks has increased in China in the last decade.
Source: China's Fifth National Report on the Implementation of the Convention on Biological Diversity [189]

Grain for Green: China's Conversion of Cropland to Forest Program

China launched the Conversion of Cropland to Forest Program (CCFP), the world's largest Payments for Ecosystem Services (PES) program, in the 1990s to reduce soil erosion and flooding through afforestation. Through CCFP, rural households are paid to retire and grow trees or other vegetation on marginal cropland and continuously maintain the trees and grasses they planted.[190] The amount and duration of subsidies depend on the region and the type of vegetation planted. As of 2014, CCFP had converted 27.55 million hectares of cleared land into tree plantations.[191]

NFPP and CCFP and other forest protection programs have been highly effective in promoting increases of forest cover and growing stock in China in the past decade.[192] SFA's 2009-2013 national forest inventory (NFI) finds that China's total forest area is 207.69 million hectares, the relative forest cover is estimated at 21.63%, and the total growing stock volume is 15.14 billion m^3.[193] Forest area, forest cover, and growing stock volumes show nearly continuous increase in most NFIs (Table 1). SFA's data may be unreliable, as no methodology was disclosed and these data are frequently used to praise NFCP's success. Still, rigorous study from independent researchers at Michigan State University shows a 1.6 percent increase (60,739.7 square miles) in forest cover in China from 2000 to 2010, primarily in areas that suffered serious deforestation in the 1990s. Deforestation was minimal by comparison, with a 0.38 percent of the land experiencing significant forest cover loss.[194]

Table 1. Eight National Forest Inventories show near continuous growth in forest area, forest cover, and growing stock volume in China. *Source:Zeng et al. 2015* [195]

NFIs	Forest area (million ha)	Forest cover percent(%)	Growing stock volume (billion ha)
NFI1	121.86	12.69	8.66
NFI2	115.28	12.01	9.03
NFI3	124.65	12.98	9.14
NFI4	133.70	13.92	10.14
NFI5	158.94	16.55	11.27
NFI5	174.91	18.21	12.46
NFI7	195.45	20.36	13.72

Importing Timber and Exporting Environmental Harm

With strong domestic forest protection, China has shifted to relying heavily on imported timber to maintain its place as the one of the world's largest producers of wood furniture and wood products.[196] China's imports of timber products have grown rapidly in the past two decades and now account for more than half of China's timber supply. In 2014, China's imports of logs and sawwood totaled to 88 million m^3 roundwood (RWE), surpassing domestic commercial timber total of 82 million m^3. [197]

China's massive timber imports have exacerbated forest degradation in other regions including Southeast Asia, Africa, and Northern Eurasia.[198] China has reportedly been involved in illegal logging operations that harm local economies in other countries. In Mozambique, for instance, 76 percent of timber exports were considered illegal in 2013, of which China's share accounted for a staggering 93 percent. Mozambique, the second least developed country in the world, lost $146 USD million in tax revenues in the same year due to illegal logging activities. If illegal logging continues at such scale, it is likely to deplete Mozambique's commercial timber stocks within 15 years.[199]

The positive carbon sequestration effects from China's forest conservation policies could be cancelled out by its promotion of unsustainable and illegal logging overseas.[200] To counteract the timber trade deficit, SFA has planned to plant 14.7 million hectares of trees in China in the coming years.[201]

Data Availability and Gaps

Lack of disaggregated data by forest type has created a deceptive image of forest prosperity in China. The word "forest" in China is a broad term that includes uncut primary forest, regenerating natural forest, and monoculture plantations of non-native trees. Despite growth in China's forest cover resulting from strong policy support,[202] monoculture plantations of non-native trees account for most of this growth rather than regrowth from natural forest regeneration. As NFIs have shown, plantation area and volume proportions increased from 20 million hectares and 2 percent, respectively, in the first 1973-1976 NFI1 to 36 million hectares and 17 percent in the 2009-2013 NFI8.[203]

Negative environmental impacts resulting from plantation monocultures, including groundwater depletion and lack of organic inputs for soil fauna and flora, often outweigh benefits. Monoculture plantations have lowered pest resistance in China's forests and degraded 90 percent of the country's grasslands to various extents.[204] Rather than planting exotic trees, the best way to restore damaged forests is to implement "assisted" natural regeneration with simple measures such as weeding, fertilizing, preventing fire, or removing cattle.[205] Since 2008, China's forest tenure reform has prompted many smallholders to convert natural forests to monoculture plantations for long-term investment.[206-207] The reform aimed to devolve the use rights of formerly collectively owned forests and largely encouraged privatization of more than 100 million hectares of public forests.

Officially reported forest statistics are inadequate for effective management. The SFA's annual forestry development reports do not provide separate data on the area of natural forests and plantations nor do they report on the amount of restored forestland. The only available official data that is disaggregated by natural forests and plantation by province come from SFA's NFIs are conducted every five years. Forest cover is a widely used indicator, yet it says less about forest health than quantity. Emphasizing this one indicator could cause policymakers to miss the benefits of other strategies that improve forest health. A 2015 comparative study in southwest China shows that protected areas in China have a minimal impact on forest cover growth, yet these protections are more effective for conserving old-growth forests than no protection at all.

Leveraging Big Data and Remote-Sensing to fill Forestry Data Gaps

The forestry sector in China was among the first sectors to use big data applications to fill data gaps. The SFA's national forestry big data network has quickly taken shape since its launch in 2015. The total data volume at the big data center exceeded 1 petabyte (1 million gigabytes) as of late 2015.[208] The U.S. National Centers for Environmental Information (NCEI), by comparison, is the world's largest active archive of environmental data and hosts more than 20 petabytes of various data in 2015.[209] SFA's big data network has expanded to Beijing-Tianjing-Hebei, Yangtze River Economic Zone, and regions covered in the "One Belt One Road" national initiative, including Gansu, Qinghai, and Ningxia Province.[210] In early 2016, SFA formally launched a three-year plan to complete the forestry big data network by 2018. The network aims to accumulate a large volume of data using innovative technologies including satellite remote sensing and continuous monitoring systems.[211]

SFA launched an online forestry data platform in 2015 that fills some data gaps,[212] supplying annual forest cover data disaggregated by natural forest and plantation for years 2012 and 2013, but gaps in several important forestry indicators remain. Without official tree loss data, it is difficult to detect forest health trends using indicators like tree cover loss in natural forests.[213] Many reports available online are incomplete or presented in scanned PDFs, which are difficult to read and process.

Figure 8. Interface of China's Forestry online platform. *Source: State Forestry Administration*

SFA also does not separate natural forests from plantations when providing annual timber production data. Observing and recording trends among timber production sources is important because an increase in timber production from plantations can reduce logging in natural forests, aiding regeneration and reducing degradation.

Remote sensing has great potential to help China upgrade its forestry data. China has in the past applied remote sensing widely in all 31 provinces as a supplement to SFA's National Forest Inventories.[214] China's recent advancements in remote sensing could help fill gaps in forestry data and improve overall information quality. China is no longer heavily dependent on international data and can now generate 80 percent of satellite data with resolution as high as 0.8 meter by 0.8 meter.[215]

Technical limitations to remote sensing, however, cannot be overlooked. Current satellite-based monitoring systems, for instance, do not distinguish between natural forests and plantations, which makes it difficult to detect changes in forest types.[216] Due to set satellite orbits and limited time series, forests that have slower growth and regeneration cycles may be identified incorrectly as "loss." Due to these limitations, China has used a mix of inventory methods to achieve best results.[217]

Climate Change and Energy

Policy Use

China has developed climate change and energy policies since the landmark 2009 Copenhagen climate negotiations where China, for the first time, pledged to reduce its carbon intensity. This pledge was officially adopted into binding national law in China's 12th Five Year Plan (2011-2015), considered the "greenest" Five-Year Plan. The 12th FYP included 2020 targets to reduce both energy and carbon intensity, increase the share of non-fossil fuels in its energy portfolio, and increase forest stock volume.

China announced a bilateral agreement with the United States in November 2014 including its commitment to a peak emissions year by 2030 or "as soon as possible."[218] Prior to the UN Climate Conference in Paris (COP-21) in December 2015, China announced 2030 targets for its *Intended Nationally Determined Contributions (INDC)* under the Paris Agreement on Climate Change, including a goal to lower carbon dioxide emissions per unit of GDP by 60 to 65 percent from the 2005 level; to increase the share of non-fossil fuels in primary energy consumption to around 20 percent; and to increase the forest stock volume by around 4.5 billion cubic meters from the 2005 level.

Recent policy developments require improvements in China's carbon emissions monitoring. During the second Summit between Presidents Obama and Xi in September 2015, China reaffirmed its plans for a national carbon emissions trading program by 2017.[219] Challenges to adapting U.S. EPA's SO_2 trading program and other local trading systems in China demonstrate the necessity of enhancing data quality and establishing measurements for future programs.[220-221] Monitoring and measurement, reporting, and verification (MRV) systems, however, have not been harmonized in China's seven pilot emissions trading schemes, which cover around 7.4 percent of the country's total annual emissions. Lacking a standardized monitoring system means that China's trading schemes could lose monitoring efficiency and the ability to link to international markets.[222]

Particular measurement challenges may arise in the case of non-CO_2 greenhouse gases. China's subnational pilots only cover CO_2, whereas China's national ETS plans to cover six GHGs. There is very little measurement and virtually no available data on non-CO_2 GHGs in China, which is discussed later in the next section. Because each pilot has its own purview to develop distinct MRV protocols, measurements may be difficult to aggregate and reconcile, particularly given that inventories are self-reported. Firms have varying capacities or incentives to accurately measure and report their data, requiring most pilots to seek third-party verification - a relatively new concept in China. To establish the national ETS, the government will need to bring in additional third-party organizations to develop adequate verification capacity throughout China.

Monitoring and reporting emissions data will be key at the sub-national level. Twenty-three cities in China have made joint commitments to peak their carbon emissions by 2030.[223] Cities that committed to early peaking are also dedicated to regular reporting of GHG emissions, establishment of concrete climate actions plans, and enhancement of bilateral collaborations.[224] As the first city to commit to peak early, in 2025, Chengdu was able to complete its GHG inventory in 2012 with help from the World Resources Institute.[225]

Data Availability and Gaps

There is no timely greenhouse gas emissions data or other relevant climate information at the provincial and national levels in China. Information about greenhouse gas emissions in China at the national and local scales and across sectors must come from the country's official reporting on related topics, including energy and environmental pollution, and policy plans for future monitoring systems that are accurate and robust.

Policies that mandated a national greenhouse-gas statistical monitoring system in 2007 have not been realized, and there is currently no up-to-date, official carbon emission data disclosed in China. The Chinese government most recently reported its carbon emissions in November 2012 in its Second National Communication on Climate Change to the UNFCCC, which included data only from 2005.[226] Although few results have been disclosed, China has devoted several programs to emission monitoring. The NBS, for example, has developed carbon dioxide monitoring requirements for China in the past five years, borrowing from guidelines used by the U.S. EPA and institutions in Europe.[227] China is likely to adopt U.S. EPA's continuous emissions monitoring (CEMs) for coal-fired power plants. [228]

In 2011, the NDRC mandated the completion of national major emission sources and sinks (e.g., forests, soils) monitoring and planned on making results public.[229] By October 2015, at least 160 cities, most of which are part of NDRC's low carbon pilot program, had started or completed the compilation of GHG emission sources.[230] Under the NDRC, the National Center for Climate Change Strategy and International Cooperation (NCSC) is continuously updating, revising, and improving the nation's GHG emission accounting and reporting standards. Regional environmental protection departments manage compilation and reporting of local emissions data and issue environmental certificates for local enterprises and construction projects. Corruption charges, however, among local officials and reporting enterprises further complicate data availability and accuracy. [231]

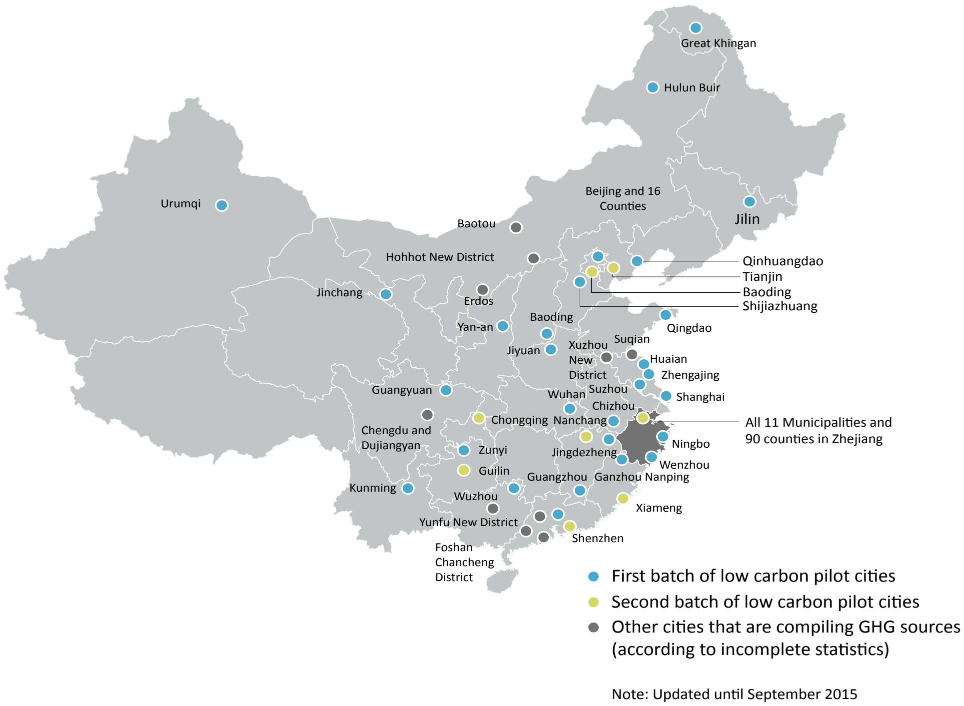


Figure 1.160 Chinese cities are in the process of compiling greenhouse gas emissions sources.
Source: Adapted from: WRI [232]

Several structural issues further hinder consistent and regular reporting. Companies that vary in size and sector, for example, often report to different sub-national agencies at various, irregular intervals. For example, the 5,000 enterprises with revenue greater than 5 million RMB (~$800,000 USD) report energy data directly to the NBS, while those below report to local bureaus of statistics.233 Power companies report electricity usage to China's Electricity Council; whereas coal or oil companies may report to local statistical bureaus. This fragmentation makes it challenging to compile a comprehensive picture of emissions sources in China, let alone calculate emissions from relevant fuel or activity data. Further, independent programs that promote energy efficiency collect their own data and don't often report to official agencies. Seligsohn (2010) notes that making a comprehensive list of the number of energy savings and climate or low-carbon related programs in China is nearly impossible.234 These multiple reporting levels and overlaps between programs results in similar challenges of institutional coordination, resulting data gaps, and persistent data mismatches described in air and water pollution data in China, which environmental protection bureaus manage.235 Such challenges will need to be reconciled if China is to develop accurate systems for measuring and managing its carbon emissions.

Frequent Revisions in Energy Data

Official reporting of energy data from NBS focuses on energy production and consumption,[236] with indicators that include annual national aggregates of total and per capita energy production and consumption, total energy import and export volumes, and consumption of energy by sector.[237] NBS data and analysis on energy consumption is heavily used in China for emission estimates, a common practice in many other countries.[238] Due to frequent data revisions and uncertainty in coal consumption, however, NBS energy consumption data's transparency and reliability often come into question. Following China's first economic census in 2005 and the second in 2009, government energy consumption data from 1999 to 2008 was adjusted upward several times with no official explanation (Table 2). The resulting data discrepancies are significant. The 2000 energy consumption data in the first census is 6.28 percent higher than the original data. The decline in energy consumption from 1997 and 2001 was then eliminated after revisions (Figure 11).[239]

Table 2. Data revisions following the first and the second economic census adjusted primary energy consumption upward. *Source: Carnegie Endowment for International Peace* [240]

Year	Energy Statistical Yearbooks 2002-2004	Energy Statistical Yearbook 2005(1st census)	Energy Statistical Yearbook 2009 (2nd census)	Difference between first census revision and second census revision(%)	Difference between primary statistics and 2nd census revision(%)
1999	1248	1284	1351	5.2	8.3
2000	1246	1325	1394	5.2	11.9
2001	1284	1358	1430	5.3	11.4
2002	1406	1442	1518	5.3	8.0
2003	1632	1673	1761	5.3	7.9
2004		1940	2042	5.3	

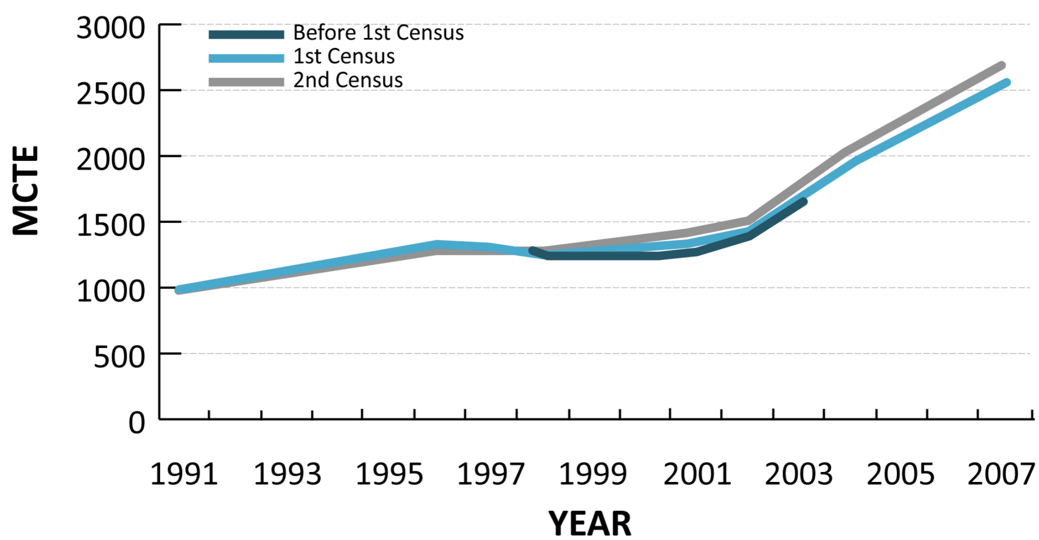


Figure 11. The supposed decline in energy use after 1996 shown in original data was eliminated after two census revisions. *Source: Carnegie Endowment for International Peace*[241]

Among all energy sources, coal production and consumption data is the least reliable and adjusted most heavily following each census. 2001 coal production data was, for instance, adjusted upward from about one billion to 1.5 billion tons of coal, possibly because local bureaus of statistics had initially failed to report output from small coal mines. This revision demonstrates one reason why it is difficult to obtain accurate coal production data in China: there are thousands of coal mines spread across more than 1,100 counties.[242] Quality of coal output reporting varies between different coal mining companies, with highly questionable reporting from local and Town and Village Enterprises (TVES).[243] Coal consumption data is likewise commonly revised upward. Coal consumption data revisions in the *China Energy Statistical Yearbook 2014* indicate that nearly a billion tonnes more CO_2 was emitted compared to initial calculations.[244] Because coal production and consumption dominate China's aggregate energy data, this information's unreliability has major implications for China's ability accurately track progress towards energy consumption and climate pledges.

NBS is fortunately making efforts to improve data quality. In 2007, NBS established a Statistics Indicators, Monitoring and Evaluation System (SME) with a three-part goal: to implement a statistical monitoring, verification, and indicators system to assess energy intensity. SME has incorporated data on energy products from large enterprises and small enterprises that had been omitted.[245] Under the SME, the top 10,000 industrial enterprises and those with revenue over 5 million RMB (~$800,000 USD) are obligated to submit statistics on energy production and consumption for all fuel types. The SME's verification system could help address irregularities found in official energy data that have spurred researchers' concerns over the accuracy and consistency of China's energy and climate data.[246]

Non-CO_2 greenhouse gases

Non-CO_2 greenhouse gases do not receive adequate policy attention in China. Non-CO_2 greenhouse gases include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF_3). Emissions of these gases contribute significantly to the global greenhouse effect. China's non-CO_2 greenhouse gas emissions in 2012 were estimated at 1.66 gigatonnes of CO_2 equivalent (GtCO2e), higher than the total GHG emissions of Japan, Germany, Canada, and Mexico in the same year.[247] Research indicates that, without policy for emission control, non-CO_2 GHG emissions in China could almost double by 2030 from the 2005 levels.[248] There is currently no governmental monitoring of non-CO_2 greenhouse gases in China.

Despite the absence of a monitoring system and specific policies to address non-CO_2 greenhouse gases, China's existing emissions policies support mitigation of non-CO_2 greenhouse gases indirectly. The 13th Five-Year Plan mentions the "control [of] non-CO_2 greenhouse gas emissions" in a chapter that addresses climate change, but does not specify a concrete action plan. Introduced in 2008 with the objective to eradicate waste, China's Circular Economy Promotion Law indirectly restricts CH_4 emissions by stipulating power generation from low-concentration methane and coal gangue, a low-calorific and highly polluting waste product from coal mining and processing still used in China's power plants. [249-250] With sufficient funds, China would be able to mitigate non-CO_2 greenhouse gases, as technologies to control emissions from these gases have been proven effective in other countries.[251]

Endnotes

1 Hsu, A. (2016). The 2016 Environmental Performance Index. Yale University, New Haven, CT. http://www.epi.yale.edu.

2 Mol, A.P.J. (2009). Environmental governance through information: China and Vietnam. Singapore Journal of Tropical Geography, 30:114–129; Hsu, A., A. de Sherbinin, H. Shi. 2012. Seeking truth from facts: the challenge of environmental indicator development in China. Environmental Development, 3:39-51.

3 Sinton, J. (2001). Accuracy and reliability of China's energy statistics. China Economic Review, 12:373- 383; The Economist. 2008. An aberrant abacus. http://www.economist.com/finance/displaystory.cfm?story_id=11290833.

4 Rawski, T.G. (2001). What is happening to China's GDP statistics? China Economic Review. 12:347–354.

5 Sinton, 2001; Zhang, Q., D.G. Streets, K. He, Y. Wang, A. Richter, J.P. Burrows, I. Uno, C.J. Jang, D. Chen, Z. Yao, and Y. Lei. 2007. NOx emission trends for China, 1995-2004: the view from the ground and the view from space. Journal of Geophysical Research. Vol. H2; Yardley, J. 2008. Consultant Questions Beijing's Claim of Cleaner Air. NY Times. 10 January. Available: http://www.nytimes.com/2008/01/10/world/asia/10china.html. Last accessed: January 25, 2013; Guan, D., Z. Liu, Y. Geng, S. Lindner, and K. Hubacek. 2012. The gigatonne gap in China's carbon dioxide inventories. Nature Climate Change, 2:672-675.

6 Hornby, L. (2014). China admits widespread soil pollution in 'state secret' report. The Financial Times. 18 April. Available: http://www.ft.com/cms/s/0/c250bd4c-c6b4-11e3-9839-00144feabdc0.html#axzz4M00Wmpda.

7 孙秀艳, & 刘毅. (2016, March 9). "十三五"规划纲要草案中资源环境指标增至10项. 人民网. Retrieved from http://finance.people.com.cn/n1/2016/0309/c1004-28183208.html

8 Hsu, A., de Sherbinin, A., & Shi, H. (2012). Seeking truth from facts: The challenge of environmental indicator development in China. *Environmental Development*, *3*, 39–51. https://doi.org/10.1016/j.envdev.2012.05.001

9 Deborah Seligsohn, Angel Hsu. ChinaFile.2016. How China's 13th Five-Year Plan Addresses Energy and the Environment. Retrieved from: https://www.chinafile.com/reporting-opinion/environment/how-chinas-13th-five-year-plan-addresses-energy-and-environment

10 Deborah Seligsohn, Angel Hsu. ChinaFile.2016. How China's 13th Five-Year Plan Addresses Energy and the Environment. Retrieved from: https://www.chinafile.com/reporting-opinion/environment/how-chinas-13th-five-year-plan-addresses-energy-and-environment

11 国务院. (2016). 中华人民共和国国民经济和社会发展 第十三个五年规划纲要, p. 10. Retrieved from http://www.ndrc.gov.cn/xgtj/201603/P020160318573832811637.pdf

12 Deborah Seligsohn, Angel Hsu. ChinaFile.2016

13 张淼淼. (2008). 北京：黄标车禁行政策出台. Retrieved October 5, 2016, from http://news.xinhuanet.com/newscenter/2008-12/30/content_10582521.htm

14 新华网. (2014). 国务院将审议落实"大气十条"22项措施. Retrieved October 4, 2016, from http://news.xinhuanet.com/politics/2014-02/11/c_119283211.htm

15 新华网. (2014). 国务院将审议落实"大气十条"22项措施. Retrieved October 4, 2016, from http://news.xinhuanet.com/politics/2014-02/11/c_119283211.htm

16 Wong, E. and V. Pao. (2016). *When China Wants Better Air Readings, Cotton Does the Trick. The New York Times,* from http://www.nytimes.com/2016/10/29/world/asia/china-xian-air-pollution-data.html?_r=0

17 A pollution reading below 50 is classed as "excellent," 51 to 100 "fairly good," 101 to 200 "slightly polluted," 201 to 300 "poor" and over 301 is "hazardous," according to the Beijing Municipal Bureau of Environmental Protection.

18 中国清洁空气联盟秘书处. (2013). 大气污染防治行动计划-英文版, p.1 . Retrieved October 5, 2016, from http://www.cleanairchina.org/product/6349.html

19 中国清洁空气联盟秘书处. (2013). 大气污染防治行动计划-英文版, p.2 . Retrieved October 5, 2016, from http://www.cleanairchina.org/product/6349.html

20 中国清洁空气联盟秘书处. (2013). 大气污染防治行动计划-英文版, p.1,2,6,7 . Retrieved October 5, 2016, from http://www.cleanairchina.org/product/6349.html

21 中国清洁空气联盟秘书处. (2013). 大气污染防治行动计划-英文版, p.3 . Retrieved October 5, 2016, from http://www.cleanairchina.org/product/6349.html

22 Fu, L., Wan, W., & Zhang, W. (2015). *Air Pollution Prevention and Control Progress in Chinese Cities*. Clean Air Asia. Retrieved from http://cleanairasia.org/wp-content/uploads/2016/03/ChinaAir2015-report.pdf

23 Fu, L., Wan, W., & Zhang, W. (2015). *Air Pollution Prevention and Control Progress in Chinese Cities*. Clean Air Asia. Retrieved from http://cleanairasia.org/wp-content/uploads/2016/03/ChinaAir2015-report.pdf

24 Ministry of Environmental Protection, & General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China. (2012). New Ambient Air Quality Standard(GB3095-2012). Retrieved from http://210.72.1.216:8080/gzaqi/Document/gjzlbz.pdf

25 Fu, L., Wan, W., & Zhang, W. (2015). *Air Pollution Prevention and Control Progress in Chinese Cities*. Clean Air Asia. Retrieved from http://cleanairasia.org/wp-content/uploads/2016/03/ChinaAir2015-report.pdf

26 陈阳. (2015, November 27). "大气十条"实施两年有余，得失几何？. 中国经济导报. Retrieved from http://www.ceh.com.cn/ztbd/jnjpzk/878668.shtml

27 Indoor air pollution database for China. (n.d.). Retrieved October 5, 2016, from http://www.who.int/indoorair/health_impacts/databases_china/en/

28 Andrews, S. Q. (2008). Inconsistencies in air quality metrics:"Blue Sky"days and PM10 concentrations in Beijing. *Environmental Research Letters*, *3*(3), 34009.

29 Ghanem, D., & Zhang, J. (2014). "Effortless Perfection: Do Chinese cities manipulate air pollution data? *Journal of Environmental Economics and Management*, *68*(2), 203–225.

30 Andrews, S. Q. (2008). Inconsistencies in air quality metrics:"Blue Sky"days and PM10 concentrations in Beijing. *Environmental Research Letters*, *3*(3), 34009.
from http://iopscience.iop.org/article/10.1088/1748-9326/3/3/034009/pdf

31 Andrews, S.Q. (2008). Inconsistencies in air quality metrics: 'Blue Sky' days and PM10 concentrations in Beijing. Environmental Research Letters 3(3): 1-14. From http://iopscience.iop.org/article/10.1088/1748-9326/3/3/034009/pdf

32 Ghanem, D., & Zhang, J. (2014). "Effortless Perfection: Do Chinese cities manipulate air pollution data? *Journal of Environmental Economics and Management*, *68*(2), 203–225.
http://www.sciencedirect.com/science/article/pii/S0095069614000400

33 Hsu, A. (2013). Limitations and Challenges of Provincial Environmental Protection Bureaus in China's Environmental Monitoring, Reporting, and Verification. Environmental Practice, 15(3): 280-292.

34 Fu, L., Wan, W., & Zhang, W. (2015). *Air Pollution Prevention and Control Progress in Chinese Cities*. Clean Air Asia. Retrieved from http://cleanairasia.org/wp-content/uploads/2016/03/ChinaAir2015-report.pdf

35 CNEMC. (2016). Monthly air quality reports. Retrieved from http://www.cnemc.cn/publish/totalWebSite/0666/newList_1.html.

36 北京地区大气环境监测超级站. (n.d.). Retrieved October 5, 2016, from http://atmrs.net/menuPage/map.html?lg=0

37 Fu, L., Wan, W., & Zhang, W. (2015). *Air Pollution Prevention and Control Progress in Chinese Cities*. Clean Air Asia. Retrieved from http://cleanairasia.org/wp-content/uploads/2016/03/ChinaAir2015-report.pdf

38 Shanghai Qingyue Open Data Center. Air Quality Data. Retrieved from https://wat.epmap.org/air/nations.

39 Institute for Public and Environmental Affairs. (2016). Pollution Map. Retrieved from http://www.ipe.org.cn/en/pollution/quality.aspx

40 Roberts, D. (2015). Opinion: How the US Embassy Tweeted to Clear Beijing's Air. Retrieved October 5, 2016, from https://www.wired.com/2015/03/opinion-us-embassy-beijing-tweeted-clear-air/

41 World Air Quality Indicator Project. (2016). Available: http://aqicn.org/city/beijing/

42 关于公布《"十二五"主要污染物总量减排目标责任书》要求2015年完成的减排项目的公告. (2015). Retrieved October 5, 2016, from http://www.mep.gov.cn/gkml/hbb/bgg/201504/t20150430_299867.htm

43 China Ministry of Environmental Protection. (2016). Nitrogen oxides control. Retrieved from http://datacenter.mep.gov.cn/main/template-view.action?templateId_=8ae5e4b74d96f8f9014d9988d8f40059&dataSource=

44 China Ministry of Environmental Protection. (2016). Nitrogen oxides control in power industries. Retrieved from http://datacenter.mep.gov.cn/main/template-view.action?templateId_=8ae5e4b74d96f8f9014d9988d8f40059&dataSource=

45 China Ministry of Environmental Protection. (2016). Nitrogen oxides control in cement industries. Retrieved from: http://www.mep.gov.cn/gkml/hbb/bgg/201407/t20140711_278584.htm

46 室内空气质量标准. (2002). 国家质量监督检验检疫总局. Retrieved from http://www.nbepb.gov.cn/UploadFiles/lan2/200575164539953.pdf

47 室内空气质量标准. (2002). 国家质量监督检验检疫总局. Retrieved from http://www.nbepb.gov.cn/UploadFiles/lan2/200575164539953.pdf

48 IPEN. (2016). *Lead in Enamel Decorative Paints in China*. Retrieved from http://ipen.org/sites/default/files/documents/Lead_in_Enamel_Decorative_Paints_in_China_EN.pdf

49 Every breath we take – transforming the health of China's office space. (n.d.). Retrieved October 5, 2016, from http://www.jll.com/china/en-gb/research/221/indoor-air-quality

50 Wu, Q., & Sally, A. (2010). China's 13th Five Year Plan: Environment. Retrieved October 5, 2016, from http://www.kwm.com/en/us/knowledge/insights/china-13th-5-year-plan-environment-sustainability-initiatives-20160414

51 Seligsohn, D., & Hsu, A. (2016, March 10). How China's 13th Five-Year Plan Addresses Energy and the Environment. Retrieved October 5, 2016, from https://www.chinafile.com/reporting-opinion/environment/how-chinas-13th-five-year-plan-addresses-energy-and-environment

52 New "Water Ten Plan" to Safeguard China's Waters | China Water Risk. (n.d.). Retrieved from http://chinawaterrisk.org/notices/new-water-ten-plan-to-safeguard-chinas-waters/

53 Lingyu, K. (2015, May 10). Inside China's grand plan to fight water pollution. Retrieved October 5, 2016, from http://www.marketwatch.com/story/inside-chinas-grand-plan-for-water-pollution-2015-05-04

54 国务院印发《水污染防治行动计划》. (2015). Retrieved October 5, 2016, from http://www.mep.gov.cn/gkml/hbb/qt/201504/t20150416_299173.htm

55 Liu, Q. (2016). Clear as mud: how poor data is thwarting China's water clean-up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/8922-Clear-as-mud-how-poor-data-is-thwarting-China-s-water-clean-up

56 Liu, Q. (2016). Clear as mud: how poor data is thwarting China's water clean-up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/8922-Clear-as-mud-how-poor-data-is-thwarting-China-s-water-clean-up

57 Liu, Q. (2016). Clear as mud: how poor data is thwarting China's water clean-up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/8922-Clear-as-mud-how-poor-data-is-thwarting-China-s-water-clean-up

58 Yue, J., & Tan, C. (2016). 国家级地下水监测网： 十年"联姻"，五年规划，再等两年. Retrieved October 4, 2016, from http://www.infzm.com/content/116618

59 Link to the Surface Water Quality Real-time Monitoring Data Automatic Publishing System: http://online.watertest.com.cn/

60 环境保护部. (2016). *2015* 中国环境状况公报. Retrieved from http://www.mep.gov.cn/hjzl/zghjzkgb/lnzghjzkgb/201606/P020160602333160471955.pdf

61 Yue, J., & Tan, C. (2016). 国家级地下水监测网： 十年"联姻"，五年规划，再等两年. Retrieved October 4, 2016, from http://www.infzm.com/content/116618

62 Yue, J., & Tan, C. (2016). 国家级地下水监测网： 十年"联姻"，五年规划，再等两年. Retrieved October 4, 2016, from http://www.infzm.com/content/116618

63 Ministry of Environmental Protection. (2016). Surface Water Quality Real-time Monitoring Data Automatic Publishing System. Retrieved from: http://online.watertest.com.cn/

64 Ministry of Environmental Protection. (2016). Weekly Water Quality Monitoring Info for Major River Basins in China. Retrieved from http://datacenter.mep.gov.cn/report/getCountGraph.do?type=runQianWater

65 Ministry of Environmental Protection. (2016). Environmental Data Center. Retrived from http://datacenter.mep.gov.cn/report/hjtj/water/water_timeAnalys.jsp

66 Ministry of Environmental Protection. (2016). Black and Foul Water Treatment Information System. Retrieved from: http://www.hcstzz.com/ .

67 Chinese Academy of Sciences. (2016). Thematic database for human-earth system. Retrieved from: http://www.data.ac.cn/

68 Institute of Public & Environmental Affairs. (2016). Retrieved from: http://www.ipe.org.cn/en/pollution/index.aspx

69 IPE. Pollution Map. (2016). Retrieved from: http://www.ipe.org.cn/en/pollution/status.aspx .

70 Ministry of Water Resources. (2016). Groundwater Monthly Update. Retrieved from: http://www.mwr.gov.cn/zwzc/hygb/dxsdtyb/201604/P020160405539942030096.pdf

71 China report sounds alarm on groundwater pollution. (2016, April). Retrieved October 4, 2016, from http://phys.org/news/2016-04-china-alarm-groundwater-pollution.html

72 水利部. 2016. 我国地下水饮用水水源地水质总体良好. Retrieved from: http://www.mwr.gov.cn/slzx/slyw/201604/t20160411_739358.html

73 财经. 2014. 水利部官员：约一亿农村人口存在用水安全问题. Retrieved from: http://ndfinance.oeeee.com/html/201403/23/900128.html.

74 刘晓慧. (2016). 国土资源部发布《2015中国国土资源公报》. Retrieved October 5, 2016, from http://www.mlr.gov.cn/xwdt/jrxw/201604/t20160425_1403460.htm

75 Ministry of Environment Protection. 2015. 2014 State of Environment Report. Retrieved from: http://www.mep.gov.cn/gkml/hbb/qt/201506/W020150605384146647135.pdf

76 Liu, Q. (2016). Clear as mud: how poor data is thwarting China's water clean-up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/8922-Clear-as-mud-how-poor-data-is-thwarting-China-s-water-clean-up

77 国家环境保护总局. 2008. 全国饮用水水源地基础环境调查及评估工作方案. Retrieved from: http://www.mep.gov.cn/gkml/zj/bgt/200910/W020080310507324810498.pdf

78 The Ministry of Housing and Urban-Rural Development surveyed national drinking water quality in 2009.

79 Liu, Q. (2016). Clear as mud: how poor data is thwarting China's water clean-up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/8922-Clear-as-mud-how-poor-data-is-thwarting-China-s-water-clean-up

80 Liu, Q. (2016). Clear as mud: how poor data is thwarting China's water clean-up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/8922-Clear-as-mud-how-poor-data-is-thwarting-China-s-water-clean-up

81 Liu, H. (2015). Who is responsible for China's water? Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/7839-Who-is-responsible-for-China-s-water-

82 Liu, H. (2015). Who is responsible for China's water? Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/7839-Who-is-responsible-for-China-s-water-

83 学者称中国水质情况很糟糕 但多糟是国家机密. (2014). Retrieved October 4, 2016, from http://news.sciencenet.cn/htmlnews/2014/4/292969.shtm

84 Link to Shanghai Qingyue's Open Environmental Data Center : https://data.epmap.org/

85 Link to Qingyue's reports of drinking water data transparency of 12 cities: http://www.epmap.org/ngo/page/report

86 Danger Maps. (2016). 又一个长江经济带省份公开水源地水质. Retrieved October 4, 2016, from http://mp.weixin.qq.com/s?__biz=MzI2MTA1NTAwNA==&mid=2651532628&idx=1&sn=379f6ac1577dd43af5df6899907fd6e4&scene=4#wechat_redirect

87 曾鼎. 凤凰周刊. 2016. 大陆城市地表水水源地水质"达标"疑云. Retrieved from: http://weibo.com/ttarticle/p/show?id=2309403961689916760733

88 Zhang, C. (2013). Why should soil pollution data be kept a "state secret"? China Dialogue. Retrieved October 4, 2016 from: https://www.chinadialogue.net/blog/5758-Why-should-soil-pollution-data-be-kept-a-state-secret-/ch

89 China's tainted soil initiative lacks pay plan. (2016, June 20). Retrieved October 5, 2016, from https://www.chinadialogue.net/article/show/single/en/9028-China-s-tainted-soil-initiative-lacks-pay-plan

90 Kong, A., & Wang, J. (2016). Is China's new plan to tackle soil pollution too little, too late? Retrieved October 5, 2016, from http://www.greenpeace.org/eastasia/news/blog/is-chinas-new-plan-to-tackle-soil-pollution-t/blog/56643/

91 Zhang, C. (2016). Lack of data, openness could obstruct soil clean up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/9009-Lack-of-data-openness-could-obstruct-soil-clean-up

92 Kong, A., & Wang, J. (2016). Is China's new plan to tackle soil pollution too little, too late? Retrieved October 5, 2016, from http://www.greenpeace.org/eastasia/news/blog/is-chinas-new-plan-to-tackle-soil-pollution-t/blog/56643/

93 Li, X. (2016). China working on law to tackle soil pollution. *Xinhua*. Retrieved from http://news.xinhuanet.com/english/2016-03/10/c_135174596.htm

94 环境保护部和国土资源部. (2014). 全国土地污染状况调查公报. Retrieved from http://www.zhb.gov.cn/gkml/hbb/qt/201404/W020140417558995804588.pdf

95 Miao, W., & Hsu, A. (2014). Soil Pollution in China Still a State Secret Despite Recent Survey. Retrieved October 5, 2016, from https://blogs.scientificamerican.com/guest-blog/soil-pollution-in-china-still-a-state-secret-infographic/

96 Miao, W., & Hsu, A. (2014). Soil Pollution in China Still a State Secret Despite Recent Survey. Retrieved October 5, 2016, from https://blogs.scientificamerican.com/guest-blog/soil-pollution-in-china-still-a-state-secret-infographic/

97 Ministry of Land and Resources. (2015). *2015 National Land and Resources Report*. Retrieved from http://www.mlr.gov.cn/zwgk/tjxx/201604/P020160421532279160618.pdf

98 Ministry of Land and Resources. (2015). *2015 National Land and Resources Report*. Retrieved from http://www.mlr.gov.cn/zwgk/tjxx/201604/P020160421532279160618.pdf

99 Gong, J. (2011). Heavy Metals Tainting China's Rice Bowls. *Caixin Online*. Retrieved from http://english.caixin.com/2011-02-16/100226177.html?p2

100 环境保护部有关负责人答记者问. (2016). Retrieved October 6, 2016, from http://www.mep.gov.cn/gkml/hbb/qt/201605/t20160531_352670.htm

101 新华社. (2016). 坚决守住土壤环境质量底线——环境保护部有关负责人解读“土十条”_解读_中国政府网. Retrieved October 6, 2016, from http://www.gov.cn/zhengce/2016-06/01/content_5078554.htm

102 Li, J. (2016). Are you at risk from China's polluted soil? Check this map. Retrieved October 6, 2016, from http://www.scmp.com/news/china/policies-politics/article/1940108/are-you-risk-chinas-polluted-soil-check-map

103 蔚蓝地图. (2016). 马军专访 | 你身在污土之上吗？. Retrieved October 6, 2016, from http://www.weixinla.com/document/12514107.html

104 Zhang, C. (2016). Lack of data, openness could obstruct soil clean up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/9009-Lack-of-data-openness-could-obstruct-soil-clean-up

105 蔚蓝地图. (2016). IPE发布首张土壤污染风险源地图. [Online Image] Retrieved October 6, 2016, from http://www.weixinla.com/document/2846237/

106 Zhang, C. (2016). Lack of data, openness could obstruct soil clean up. Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/9009-Lack-of-data-openness-could-obstruct-soil-clean-up

107 China-Country Profile. (n.d.). Retrieved October 6, 2016, from https://www.cbd.int/countries/profile/default.shtml?country=cn#measures

108 China National Biodiversity Conservation Strategy and Action Plan (2011-2030). (2010). Retrieved from https://www.cbd.int/doc/world/cn/cn-nbsap-v2-en.pdf

109 China-Country Profile. (n.d.). Retrieved October 6, 2016, from https://www.cbd.int/countries/profile/default.shtml?country=cn#measures

110 China-Country Profile. (n.d.). Retrieved October 6, 2016, from https://www.cbd.int/countries/profile/default.shtml?country=cn#measures

111 Ministry of Environmetal Protection. (2014). *China's Fifth National Report on the Implementation of the Convention on Biological Diversity*. Retrieved from https://www.cbd.int/doc/world/cn/cn-nr-05-en.pdf

112 Yeh, E. (2014). Do China's nature reserves only exist on paper? Retrieved October 4, 2016, from https://www.chinadialogue.net/article/show/single/en/6696-Do-China-s-nature-reserves-only-exist-on-paper-

113 China-Country Profile. (n.d.). Retrieved October 6, 2016, from https://www.cbd.int/countries/profile/default.shtml?country=cn#measures

114 Forestry Council. (2016). Forest Resources Inventory. Retrieved from: http://211.167.243.162:8085/8/book/jiankuang/index.html

115 Ministry of Forestry. (2014). Forestry Statistical Yearbook. Retrieved from: http://cfdb.forestry.gov.cn/lysjk/indexJump.do?url=view/moudle/searchData/showDetail&keyid=1004576

116 Ministry of Forestry. (2016. Wetland Resources and Biodiversity databases. Retrieved from: http://data.forestry.gov.cn/lysjk/indexJump.do?url=view/moudle/index

117 China National Biodiversity Conservation Strategy and Action Plan (2011-2030). (2010). Retrieved from https://www.cbd.int/doc/world/cn/cn-nbsap-v2-en.pdf

118 The "China Biodiversity Observation and Research Network" (Sino BON) working meeting was held in Beijing. (n.d.). Retrieved October 5, 2016, from http://www.abcdn.org/news/2888

119 Ma, K. (2015). Biodiversity monitoring in China: from CForBio to Sino BON. *Biodiversity Science*, *23*, 1–2.

120 Ma, K. (2015). Biodiversity monitoring in China: from CForBio to Sino BON. *Biodiversity Science*, *23*, 1–2.

121 Wan, B., Xu, H., Ding, H., Liu, Z., & Wang, J. (2007). Methodology of comprehensive biodiversity assessment. *Biodiversity Science*, *15*(1), 97. https://doi.org/10.1360/biodiv.060132

122 Ministry of Environmetal Protection. (2014). *China's Fifth National Report on the Implementation of the Convention on Biological Diversity*. Retrieved from https://www.cbd.int/doc/world/cn/cn-nr-05-en.pdf

123 Duggan, J. (2014, August 7). Sales of shark fin in China drop by up to 70%. *The Guardian*. Retrieved from https://www.theguardian.com/environment/chinas-choice/2014/aug/08/sales-of-shark-fin-china-drop-70

124 WildAid. (2014). *Evidence of Declines in Shark Fin Demand | China*. Retrieved from http://wildaid.org/sites/default/files/resources/SharkReport_Evidence%20of%20Declines%20in%20Shark%20Fin%20Demand_China.pdf

125 Eriksson, H., & Clarke, S. (2015). Chinese market responses to overexploitation of sharks and sea cucumbers. *Biological Conservation*, *184*, 163–173. https://doi.org/10.1016/j.biocon.2015.01.018

126 Eriksson, H., & Clarke, S. (2015). Chinese market responses to overexploitation of sharks and sea cucumbers. *Biological Conservation*, *184*, 163–173. https://doi.org/10.1016/j.biocon.2015.01.018

127 Hongzhou, Z. (2015). China's Fishing Industry: Current Status, Government Policies, and Future Prospects,[a paper for the China as a "Maritime Power" conference].

128 Food and Agriculture Organization of the United Nations. (2016). *2014 Fishery and Aquaculture Statistics*. Retrieved from http://www.fao.org/3/a-i5716t.pdf

129 Mallory, T. G. (2016). Fisheries subsidies in China: Quantitative and qualitative assessment of policy coherence and effectiveness. *Marine Policy*, *68*, 74–82. https://doi.org/10.1016/j.marpol.2016.01.028

130 Hongzhou, Z. (2015). China's Fishing Industry: Current Status, Government Policies, and Future Prospects,[a paper for the China as a "Maritime Power" conference].

131 John Hopkins School of Advanced International Studies. (2013). China's Fisheries Management Policy: An Interview with Tabitha Mallory. SAIS Review of International Affairs, 33(2).
. Retrieved October 3, 2016, from http://www.academia.edu/5405442/China_s_Fisheries_Management_Policy_An_Interview_with_Tabitha_Mallory

132 Hongzhou, Z. (2015). China's Fishing Industry: Current Status, Government Policies, and Future Prospects,[a paper for the China as a "Maritime Power" conference].

133 Hongzhou, Z. (2015). China's Fishing Industry: Current Status, Government Policies, and Future Prospects,[a paper for the China as a "Maritime Power" conference].

134 国务院. (2006). 国务院关于印发中国水生生物资源养护行动纲要的通知. Retrieved October 6, 2016, from http://www.gov.cn/zwgk/2006-02/27/content_212335.htm

135 国务院. (2006). 国务院关于印发中国水生生物资源养护行动纲要的通知. Retrieved October 6, 2016, from http://www.gov.cn/zwgk/2006-02/27/content_212335.htm
http://www.gov.cn/zwgk/2006-02/27/content_ 212335.htm (accessed 30.09.15) (Chinese).

136 Sumalia, U. R., Lam, V., Le Manach, F., & Swartz, W. (2013). *Global Fisheries Subsidies*. European parliament, Directorate-General for Internal Policies. Retrieved from http://www.europarl.europa.eu/RegData/etudes/note/join/2013/513978/IPOL-PECH_NT(2013)513978_EN.pdf

137 Mallory, T. G. (2016). Fisheries subsidies in China: Quantitative and qualitative assessment of policy coherence and effectiveness. *Marine Policy*, *68*, 74–82. https://doi.org/10.1016/j.marpol.2016.01.028

138 Mallory, T. G. (2016). Fisheries subsidies in China: Quantitative and qualitative assessment of policy coherence and effectiveness. *Marine Policy*, *68*, 74–82. https://doi.org/10.1016/j.marpol.2016.01.028

139 Bureau of Fisheries, Ministry of Agriculture of China. (Multiple years). China FIsheries Yearbook.

140 China's Fishing Industry: Current Status, Government Policies, and Future Prospects https://www.cna.org/cna_files/pdf/China-Fishing-Industry.pdf

141 Shi, C. (2013, December 17). Fisherman has no fish to catch, but fishing vessel horsepower index increased 20 times in 7 years. *Qianjiang Evening News*.

142 Mallory, T. G. (2016). Fisheries subsidies in China: Quantitative and qualitative assessment of policy coherence and effectiveness. *Marine Policy*, *68*, 74–82. https://doi.org/10.1016/j.marpol.2016.01.028

143 Zhijie, G., Yingliang, X., Xiangguo, Z., Yong, W., Zhang, D., & Sugiyama, S. (2008). Review of fishery information and data collection systems in China. *FAO Fisheries Circular*, (1029), 46.

144 Bureau of Fisheries, Ministry of Agriculture of China. (2000-2014). China FIsheries Yearbook.

145 Zhijie, G., Yingliang, X., Xiangguo, Z., Yong, W., Zhang, D., & Sugiyama, S. (2008). Review of fishery information and data collection systems in China. *FAO Fisheries Circular*, (1029), 46.

146 Zhijie, G., Yingliang, X., Xiangguo, Z., Yong, W., Zhang, D., & Sugiyama, S. (2008). Review of fishery information and data collection systems in China. *FAO Fisheries Circular*, (1029), 46.

147 Zhijie, G., Yingliang, X., Xiangguo, Z., Yong, W., Zhang, D., & Sugiyama, S. (2008). Review of fishery information and data collection systems in China. *FAO Fisheries Circular*, (1029), 46.

148 Watson, R., & Pauly, D. (2001). Systematic distortions in world fisheries catch trends. *Nature*, *414*(6863), 534–536.

149 Watson, R., & Pauly, D. (2001). Systematic distortions in world fisheries catch trends. *Nature*, *414*(6863), 534–536.

150 VOA. (2001). Study: China Over-Reporting Fish Catches - 2001-12-05. Retrieved October 6, 2016, from http://www.voanews.com/a/a-13-a-2001-12-05-20-study-66948557/377799.html

151 FAO Fisheries & Aquaculture - Fishery and Aquaculture Country Profiles - The People's Republic of China. (n.d.). Retrieved October 6, 2016, from http://www.fao.org/fishery/facp/CHN/en

152 VOA. (2001). Study: China Over-Reporting Fish Catches - 2001-12-05. Retrieved October 6, 2016, from http://www.voanews.com/a/a-13-a-2001-12-05-20-study-66948557/377799.html

153 VOA. (2001). Study: China Over-Reporting Fish Catches - 2001-12-05. Retrieved October 6, 2016, from http://www.voanews.com/a/a-13-a-2001-12-05-20-study-66948557/377799.html

154 China defines DWF as citizens, legal entities, and other organizations of China engaging in marine fishing and its processing, supply, and product transportation activities on the high seas and in the sea areas under the jurisdiction of other countries, but does not include fishing activities in the Yellow Sea, East China Sea, or South China Sea. Source: Fisheries Law of the People's Republic of China.

155 Lebling, K. (2013). Fishing For Answers: Understanding Drivers and environmental Impacts of China's Distant Water Fishing Fleet. *Washington, DC: Wilson Center*.

156 Lebling, K. (2013). Fishing For Answers: Understanding Drivers and environmental Impacts of China's Distant Water Fishing Fleet. *Washington, DC: Wilson Center*.

157 Rogers, C. (2016, June 2). The dark side of China's foreign fishing boom. Retrieved October 6, 2016, from https://news.mongabay.com/2016/06/the-dark-side-of-chinas-foreign-fishing-boom/

158 Lebling, K. (2013). Fishing For Answers: Understanding Drivers and environmental Impacts of China's Distant Water Fishing Fleet. *Washington, DC: Wilson Center*.

159 Mallory, T. G. (2016). Fisheries subsidies in China: Quantitative and qualitative assessment of policy coherence and effectiveness. *Marine Policy*, *68*, 74–82. https://doi.org/10.1016/j.marpol.2016.01.028

160 Bureau of Fisheries, Ministry of Agriculture of China. (2013). China FIsheries Yearbook.

161 Lebling, K. (2013). Fishing For Answers: Understanding Drivers and environmental Impacts of China's Distant Water Fishing Fleet. *Washington, DC: Wilson Center*.

162 Lebling, K. (2013). Fishing For Answers: Understanding Drivers and environmental Impacts of China's Distant Water Fishing Fleet. *Washington, DC: Wilson Center*.

163 Pew Charitable Trusts. (April 2013). "China's Foreign Fishing is Largely Unreported." [Online Image]. Available: http://news.ubc.ca/wp-content/uploads/2013/05/Research-Summary.pdf

164 Watson, R., & Pauly, D. (2001). Systematic distortions in world fisheries catch trends. *Nature*, *414*(6863), 534–536.

165 Pauly, D., & Le Manach, F. (2015). Tentative adjustments of China's marine fisheries catches (1950-2010). Retrieved October 3, 2016, from http://www.seaaroundus.org/doc/publications/wp/2015/Pauly-and-LeMenach-China.pdf

166 Blomeyer, R., Goulding, I., Pauly, D., Sanz, A., & Stobberup, K. (2012). The role of China in world fisheries. *Directorate General for Internal Policies. Policy Department B: Structural and Cohesion Policies. European Parliament*.

167 Blomeyer, R., Goulding, I., Pauly, D., Sanz, A., & Stobberup, K. (2012). The role of China in world fisheries. *Directorate General for Internal Policies. Policy Department B: Structural and Cohesion Policies. European Parliament*.

168 Lebling, K. (2013). Fishing For Answers: Understanding Drivers and environmental Impacts of China's Distant Water Fishing Fleet. *Washington, DC: Wilson Center*.

169 Mallory, G., & Panel, V. (2012). China as a distant water fishing nation. *US-China Economics and Security Review Commission, John Hopkins School of Advanced International Studies*.

170 Mallory, T. G. (2013). China's distant water fishing industry: Evolving policies and implications. *Marine Policy*, *38*, 99–108.

171 Mallory, T. G. (2013). China's distant water fishing industry: Evolving policies and implications. *Marine Policy*, *38*, 99–108.

172 China's distant water fishing industry: Evolving policies and implications Tabitha Grace Mallory Johns Hopkins University School of Advanced International Studies (SAIS), 1619 Massachusetts Avenue NW, Washington DC 20036, USA

173 Démurger, S., Yuanzhao, H., & Weiyong, Y. (2009). Forest management policies and resource balance in China an assessment of the current situation. *The Journal of Environment & Development*, *18*(1), 17–41.

174 Sun, X., Canby, K., & Liu, L. (2016). *China's Logging Ban in Natural Forests :Impacts of Extended Policy at Home and Abroad*. Forest Trends. Retrieved from http://www.forest-trends.org/documents/index.php?pubID=5145

175 Stage, J., Edström, F., & Nillson, H. (2012). The Natural Forest Protection Program in China: A contingent valuation study in Heilongjiang province. *Journal of Environmental Science and Engineering B*, *1*, 426–432.

176 *China's Report on the Implementation of the Forest Instrument*. (n.d.). Retrieved from http://www.un.org/esa/forests/wp-content/uploads/bsk-pdf-manager/157_CHINA.PDF

177 *China's Report on the Implementation of the Forest Instrument*. (n.d.). Retrieved from http://www.un.org/esa/forests/wp-content/uploads/bsk-pdf-manager/157_CHINA.PDF

178 Sun, X., Canby, K., & Liu, L. (2016). *China's Logging Ban in Natural Forests :Impacts of Extended Policy at Home and Abroad*. Forest Trends. [Image] Retrieved from http://www.forest-trends.org/documents/index.php?pubID=5145

179 Sun, X., Canby, K., & Liu, L. (2016). *China's Logging Ban in Natural Forests :Impacts of Extended Policy at Home and Abroad*. Forest Trends. Retrieved from http://www.forest-trends.org/documents/index.php?pubID=5145

180 Sun, X., Canby, K., & Liu, L. (2016). *China's Logging Ban in Natural Forests :Impacts of Extended Policy at Home and Abroad*. Forest Trends. Retrieved from http://www.forest-trends.org/documents/index.php?pubID=5145

181 Zhang, Y. (2016). China Introduces Series of Logging Bans, Forestry Official Says. Retrieved October 4, 2016, from http://english.caixin.com/2015-06-10/100817889.html

182 State Forestry Administration. (1993). Forest Park Regulations. Retrieved from http://www.forestry.gov.cn/main/3962/content-689952.html

183 State Council. (1994). 中华人民共和国自然保护区条例. Retrieved from http://www.gov.cn/flfg/2005-09/27/content_70636.htm

184 Ministry of Environmental Protection. (2014). *China's Fifth National Report on the Implementation of the Convention on Biological Diversity*. Retrieved from https://www.cbd.int/doc/world/cn/cn-nr-05-en.pdf

185 Ministry of Environmental Protection. (2014). *China's Fifth National Report on the Implementation of the Convention on Biological Diversity*. Retrieved from https://www.cbd.int/doc/world/cn/cn-nr-05-en.pdf

186 State Forestry Administration. (1993). Forest Park Regulations. Retrieved from http://www.forestry.gov.cn/main/3962/content-689952.html

This project is funded by Climateworks Foundation.