Climate Change Impacts on China' s Medium- and Long-Term Development: Analysis and Policy Recommendations (Postprint)

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Abstract

Global warming will inflict severe, pervasive, and irreversible impacts upon human society and ecosystems. Multilateral negotiations on carbon emission reductions, from the Kyoto Protocol to the Paris Agreement, have consistently advanced amid considerable difficulties. In early June 2017, the United States announced its withdrawal from the Paris Agreement, casting an additional shadow over the already unpromising prospects for global emission reductions. As the world' s largest developing nation with a vast population and complex, diverse topography, China is exceptionally vulnerable to the adverse effects of climate change, with systemic risks to society posed by climate warming continuously escalating. At present, as China stands at a critical historical juncture of domestic economic transformation and the implementation of the Belt and Road Initiative, it must approach climate change mitigation from the perspective of safeguarding national security and fully leverage its leadership within the global climate governance architecture. This constitutes not only China' s responsibility and commitment to extensive participation in global governance and the construction of a community with a shared future for mankind, but also represents an intrinsic requirement for achieving sustainable development, promoting green and low-carbon transformation, and enhancing China' s comprehensive competitiveness.

Full Text

Impact Analysis and Countermeasures for Climate Change on China' s Long-term Development

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Global warming is causing serious, widespread, and irreversible impacts on human societies and ecosystems. From the Kyoto Protocol to the Paris Agreement, multilateral negotiations on carbon emission reductions have progressed with great difficulty. In early June 2017, the United States announced its withdrawal from the Paris Agreement, casting a further shadow over the already uncertain prospects for global emission reductions. As the world' s largest developing country, China—with its vast population and complex, diverse topography—is extremely vulnerable to the adverse effects of climate change. The social system risks posed by climate warming continue to increase. Currently, China is in a critical historical period of domestic economic transformation and implementation of the "Belt and Road" Initiative. We must approach climate change from the perspective of safeguarding national security and fully exert China' s leadership in the global climate governance system. This is not only China' s responsibility for broadly participating in global governance and building a community with a shared future for mankind, but also an inherent requirement for achieving sustainable development, promoting green and low-carbon transformation, and enhancing China' s comprehensive competitiveness.

Keywords: climate change, Paris Agreement, Belt and Road Initiative, green transformation
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The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) indicates that greenhouse gas emissions from fossil fuel combustion are very likely the primary cause of global climate warming since the mid-20th century. Over the past 130 years, global surface temperature has risen by 0.8°C, and sea level has increased by 19 cm. Polar ice mass loss has accelerated, with an average annual reduction of 362 billion tons in recent years. Concentrations of long-lived greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) have reached their highest levels in 800,000 years, increasing by 41%, 160%, and 20% respectively above pre-industrial levels. For China, climate change impacts are even more severe: the average temperature over land areas has risen by 0.9–1.5°C, exceeding the global average. Glaciers, permafrost, and sea ice areas have decreased, extreme weather events have become more frequent, and the rate of coastal sea level rise over the past 30 years has exceeded the global average.

Future Climate Trends and the Global Response

Climate scientists believe that if global average temperature rises more than 2°C above pre-industrial levels (the baseline when humans began using fossil fuels), catastrophic consequences will ensue. The *Proceedings of the National Academy of Sciences* (PNAS) has published research indicating that global warming will cause sea level rise, with East Asia facing the greatest risk. China will be the first to bear the brunt, with 145 million people in coastal areas under threat, though limiting warming to 2°C could reduce this number to 64 million. To achieve the goal of keeping temperature rise below 2°C, parties to the Paris

Agreement have committed to peaking greenhouse gas emissions as soon as possible. This implies that global CO_2 equivalent emissions should decrease from approximately 50 billion tons in 2010 to 40 billion tons by 2030, with atmospheric CO_2 concentrations controlled between 430–480 ppm. However, even if all countries achieve their nationally determined contributions, emissions in 2030 will still reach 55.2–55.9 billion tons, leaving a reduction gap of 15.2–15.9 billion tons [1]. At this rate, temperature rise will reach 2.7–3.4°C by the end of the 21st century, with significantly increased negative impacts and greater risks for humanity [2]. More seriously, if temperature rise reaches or exceeds 4°C, it will not only cause mass extinction of endangered species but also substantially increase the likelihood of extreme climate events with broad scope and major impacts [1].

The United States is the world' s second-largest energy consumer and greenhouse gas emitter after China. Following its withdrawal from the Paris Agreement, the World Resources Institute (WRI) predicts that U.S. annual carbon emissions will increase by 900 million tons beyond the targets set by the Obama administration' s Clean Energy Security Act—an increment exceeding Germany' s total emissions. On the other hand, the $100 billion in transfer payments from developed to developing countries stipulated in the Agreement will be difficult to realize. Without economic incentives, the effectiveness of energy conservation and emission reductions in developing countries may be substantially compromised. Consequently, as developing economies, including China, rapidly increase their carbon emissions, their obligations and pressures for emission reductions will continue to grow. Although the U.S. withdrawal has negatively impacted global confidence and efforts in emission reduction, the fundamental structure of developed versus developing countries and potential leadership in emission reductions remains unchanged under the principle of "common but differentiated responsibilities." In addition to fulfilling nationally determined contributions, we should consider going beyond the Paris Agreement to propose pathways for socio-economic transformation and green, low-carbon development, innovating development models and global climate governance patterns. In this process, China can play a more active role in promoting comprehensive international cooperation and establishing a responsibility-sharing mechanism based on long-term convergence of per capita emissions, providing more global public goods for addressing common crises.

Scientific Uncertainties in Climate Change Research

After 2000, global warming has slowed. Research indicates that natural climate cyclical changes have offset part of the global warming effect, causing temperatures to change slowly after 2008, which means natural factors influence at least 25% of temperature variation [3]. Although the ability of numerical models to predict climate system changes has improved significantly, considerable uncertainty remains. For example, the sensitivity of atmospheric temperature to CO_{2} concentration has not been conclusively determined. The predic-

tion that a doubling of CO_{2} concentration will cause a 2–2.5°C temperature increase represents only the average of most model projections and requires further scientific verification [4,5]. The complexity of climate system changes means scientific understanding can only be based on bounded rationality. Additionally, scholars studying this field come from different disciplines, leading to inevitable differences in understanding many aspects of climate change [6].

Climate Change Impacts on China' s Medium- and Long-Term Development

Accelerated Warming and Increasing Extreme Weather Events

Global climate change has accelerated warming in China' s land regions and increased the frequency of extreme weather events. (1) Over the past century, both the average temperature increase over China' s land area and the rate of coastal sea level rise have exceeded global averages. The *Third National Assessment Report on Climate Change* shows that from 1909–2011, China' s land area average temperature increased by 0.9–1.5°C, higher than the global level, and may increase by 1.3–5.0°C by the end of the 21st century [8]. China' s coastal sea level rose at a rate of 2.9 mm/year during 1980–2012, exceeding the global average, reaching its highest level since 1980 in 2012 [7]. (2) The frequency, intensity, and affected area of persistent high-temperature events in China have increased significantly since the 1990s after previously showing a slight decreasing trend. In 2013, daily maximum temperatures exceeded 40°C in 43 cities and counties nationwide, with 53 cities and counties experiencing extreme high temperatures [9]. Extreme heavy precipitation days, average extreme precipitation intensity, and extreme precipitation values have all shown increasing trends, with extreme precipitation events becoming more frequent, particularly in the 1990s when the proportion of extreme precipitation increased. In 2016, the national average temperature was 0.6°C higher than normal, and precipitation was 55% above normal. (3) Glacier, permafrost, and sea ice areas have further decreased. From the 1960s–70s to the early 21st century, China' s glacier area retreated by 10.1% [7], with higher retreat rates concentrated in the Ili River basin of the Tianshan Mountains, the Junggar interior drainage system, the Ob River basin of the Altai Mountains, and the Hexi interior drainage system of the Qilian Mountains. Approximately 92% of glaciated areas show varying degrees of vulnerability, with intensity and extreme intensity vulnerable zones accounting for 41% of the total study area. From the 1970s to 2006, China' s permafrost area decreased by about 18.6%, from 2.15×10^{6} km^{2} to 1.75×10^{6} km^{2}, and may have been only 1.59×10^{6} km^{2} in 2012 [7].

Threats to Agriculture, Water Resources, Major Projects, Ecosystems, and Economic-Social Development

As climate warms, China' s agriculture, water resources, major engineering projects, ecosystems, coastal cities and zones, human health, and economic and social development will face severe threats, with climate security risks continu-

ously increasing. (1) Climate warming has led to reduced yield and quality of some crops, declining farmland quality, increased fertilizer and water costs, and aggravated agricultural disasters, posing challenges to food production security. From the 1980s to the early 21st century, climate change caused yield declines in wheat, corn, and soybeans, with yield reductions of 1.27%, 1.73%, and 0.14% respectively. Compared with the climate baseline period of 1961–1990, a 2°C average temperature increase would reduce wheat, corn, and rice yields by about 10% without considering CO_{2} fertilization effects. Climate warming accelerates pest development and increases reproductive capacity. It is estimated that a 1°C increase in annual average temperature would increase the area of crops affected by pests in China by 96×10^{6} hectares. Climate warming would reduce China' s grain self-sufficiency rate target of 95% by 0.4%. However, if adaptive agricultural technological progress is considered, China' s grain self-sufficiency rate could reach 99.2%, basically achieving self-sufficiency, though the cost of agricultural production adapting to climate change would increase substantially, making food security more difficult to guarantee [7]. (2) Water areas have further shrunk, with increased annual average evaporation in river basins. The adjustable water volume of the middle route of the South-to-North Water Diversion Project has decreased compared with planning projections. Permafrost degradation has caused subgrade deterioration of the Qinghai-Tibet Railway and premature aging of afforestation in the "Three North" Shelterbelt Program. The adjustable water volume of the South-to-North Water Diversion Project' s middle route has decreased from planned levels. The probability of synchronous abundant and dry periods in the Han River basin and Hai River basin has slightly increased by 3–5% in 2010–2039, 2040–2069, and 2070–2099 compared with 1960–2000. In the 21st century, precipitation in the Three Gorges Reservoir area shows an increasing trend of 6.1–9.7% per century. From the 1970s–90s, permafrost temperatures along the Qinghai-Tibet Railway increased by 0.1–0.3°C annually due to climate warming [10]. If temperatures rise by 1–2°C in the next 50 years and the average ground temperature exceeds 0.51°C, the subgrade in permafrost areas of the Qinghai-Tibet Railway will experience settlement deformation of up to 30 cm, significantly impacting railway safety. (3) Global climate warming has exacerbated problems in natural and marine ecosystems, such as shortened freezing periods for rivers and lakes, extended growing seasons in mid- and high-latitude regions, expanded distribution ranges of flora and fauna toward polar and high-altitude regions, reduced populations of some species, and earlier flowering periods for some plants. Coastal erosion has occurred: the Yellow River Delta area decreased by an average of 26 km^{2}/year during 1986–1996; the intertidal wetland area of Shanghai' s Chongming Island east beach decreased at a rate of 0.09–0.13 km^{2}/year during 2005–2010; and coastal wetlands in Guangdong have decreased by more than 50% since 1980 [7]. (4) Sea level rise has further caused loss of some coastal territories and intensified urban waterlogging disasters. In recent years, major Chinese cities have experienced severe urban waterlogging, with disasters showing complexity, diversity, and amplification characteristics. During 2008–2010, 62% of cities nationwide experienced urban waterlogging disasters, with 137 cities suffering

more than three waterlogging events, of which 57 cities had maximum water accumulation lasting over 12 hours. In the summer of 2016, floods affected 29 provinces, impacting 80 million people and causing direct economic losses of approximately 144 billion yuan [11]. (5) Heatwaves and high temperatures from climate warming can make pathogens and parasites more active, damaging human immunity and disease resistance while increasing the incidence and mortality of heart and respiratory diseases related to heatwaves. Although cardiovascular and cerebrovascular disease incidence may decrease due to warmer winter temperatures, summer heatwaves increase comorbidity trends. Medical research literature indicates that the respiratory system is most severely affected by climate warming, with the most obvious impacts on asthma, allergic diseases, and infectious diseases. Scholars have proposed the concept of a "heat threshold" —when temperature rises exceed this threshold, mortality increases significantly. Research on Shanghai shows that high temperature is the main factor increasing summer mortality. In 1998 alone, Shanghai experienced four severe heatwaves (July 8–20, August 1–3, August 7–17, and August 21–23), during which total deaths reached 2–3 times that of non-heatwave periods [12]. (6) Direct economic losses from global climate warming show a clear upward trend. Since the 21st century, direct economic losses from meteorological disasters in China have averaged about 1% of GDP, eight times the global average level. Annual average direct economic losses from meteorological disasters during 1990–2013 increased 2.6 times compared with 1965–1989 [1].

Geopolitical Implications and Global Strategy Impacts

Climate warming will affect geopolitical patterns and China' s global strategy. (1) Climate change increases uncertainty and difficulty in implementing China' s "Belt and Road" Initiative. According to international disaster databases, major infrastructure construction and regional sustainable development along the "Belt and Road" face significant natural disaster threats. The high mountain areas have active geological structures, large elevation differences, and clear climate differentiation, making them active zones for earthquakes, landslides, debris flows, floods, ice and snow disasters, and droughts. Disaster losses in these areas are more than twice the global average. From 1995–2015, 7 of the top 10 countries most affected by meteorological disasters were among the 65 "Belt and Road" countries. From 1980–2015, many global natural disasters occurred in "Belt and Road" countries, with 235 severe natural disasters (defined as causing at least 10 deaths or economic losses exceeding 10 million yuan) in the region in 2000 alone [2]. (2) Climate warming is gradually melting Arctic glaciers, and new summer shipping routes may shift the focus of world trade. This will profoundly affect China' s future maritime transport, particularly trade with North America and Europe. Combined with large untapped mineral fuel resources in the Arctic, competition among major global powers for Arctic resources has frequently made headlines, and competition for Arctic resources will become a new focus. (3) Increased climate risks may bring food security, energy security, and water security issues, exacerbating regional tensions and affecting regional economic development and social stability. Climate change-induced population

migration in neighboring countries may lead to food shortages, trigger conflicts, regional riots, and invasions from neighboring countries, posing challenges to national security and political stability.

Opportunities for Green Low-Carbon Development and Enhanced International Status

Although addressing climate change first arises from China's objective needs and has synergistic effects with pollution control, the Paris Agreement also provides external constraints for China to accelerate green and low-carbon transformation, facilitating the use of domestic and international resources to explore innovative paths for green, low-carbon development and energy transition. China' s carbon emissions and environmental pollution share the same root causes. If China can reduce CO_{2} emissions by 1.469 billion tons by 2030, it will generate health-related economic benefits exceeding US$10 billion. New technology investments can create new employment opportunities. From 2005–2020, green investments in China' s major industries will have cumulatively created 35.3 million jobs [7]. Even though the U.S. announced its withdrawal from the Paris Agreement, this will not significantly affect China' s low-carbon development. Low-carbon development represents the trend of energy and technological progress, and China will not change its strategy due to shifts in the U.S. government' s attitude toward climate change. According to the National Energy Administration' s *Biomass Energy Development 13th Five-Year Plan*, investment in the biomass energy industry alone will add about 196 billion yuan by 2020, enabling it to achieve basically commercialized and large-scale utilization. China will also formulate a 2050 energy transition roadmap to better resolve energy crises and ensure energy security.

Strategic Recommendations

Recognize Climate Security as Part of Overall National Security

Relevant research shows that climate change is having widespread impacts on China' s national security, posing challenges to security development in multiple areas [15]. Currently, addressing climate change has become an essential component of national security strategy. We need to more firmly establish the concept that climate change affects China' s national security on the basis of existing national climate change strategies and institutional mechanisms. From the perspective of building a community with a shared future for mankind and maintaining overall national security, we should examine climate change issues, coordinate policies across different departments, improve climate security protection levels, and achieve the dual goals of actively and effectively addressing climate change while reducing greenhouse gas emissions, transforming the energy structure, and forming future competitive advantages.

Develop a Green Belt and Road Initiative

Conduct impact analyses of climate change along the Belt and Road routes, strengthen risk assessments of climate change impacts on infrastructure con-

struction projects, and select regions with strong foundations, good regional representativeness, and distinctive industrial development characteristics to build a batch of international demonstration zones for green and low-carbon agriculture, transportation, and infrastructure. Provide key support for new technology research, development, and promotion in green energy, environmental governance, ecological restoration, energy conservation and emission reduction, low-carbon buildings, and green low-carbon infrastructure. Actively promote green and low-carbon technology innovation and cross-border transfer among Belt and Road countries, establish green technology trading platforms, and strengthen the transfer of advanced green technologies to developing countries along the routes. Carry out practical inter-regional technology cooperation on green Belt and Road initiatives, promote green technology investment and trade, and foster a new situation of win-win development between green technology and environmental protection, forming a new pattern of coordinated economic, social, and ecological development driven by technology.

Optimize Capital Allocation and Build a Sound Climate Investment and Financing Mechanism

Coordinate multiple departments including economy, finance, environmental protection, and science and technology to formulate supporting policies for mitigation and adaptation. Establish special adaptation funds or adaptation financing to support basic and applied research on climate change adaptation and related disaster relief and poverty alleviation activities. Create specialized climate investment and financing functional departments and cultivate professional talent in climate investment and financing. Establish authoritative industry standards and scientific evaluation systems to strictly control climate investment and financing projects. Actively participate in and deploy international climate funding mechanism rules, lead and improve multilateral climate financing mechanisms. Use green finance as an entry point to promote global cooperation in climate investment and financing, advance green trade and investment, and improve the green financial system. Establish a unified climate financing management functional department responsible for approving, reviewing, and managing climate financing projects and formulating related policies under unified management.

Promote Green Low-Carbon Transformation and Enhance Comprehensive Competitiveness

Use climate change response as an opportunity to promote green development models and accelerate the transformation of economic development modes. Deeply understand and implement General Secretary Xi Jinping' s emphasis on placing ecological civilization in a prominent position in overall work, adhering to the basic national policy of resource conservation and environmental protection, and forming spatial patterns, industrial structures, production methods, and lifestyles that conserve resources and protect the environment to achieve coordinated progress in economic and social development and ecological and environmental protection [16]. Integrate the formulation of technological innovation policies with climate change countermeasures, utilize China' s

natural resource conditions, focus on developing major clean and renewable energy conversion and utilization technologies and intelligent management technologies, encourage substitution of traditional energy and raw materials, formulate low-carbon standard systems, innovate business models and financing models, seize the commanding heights of core technologies, generate future driving forces and competitive advantages for China' s low-carbon transformation, and increase employment in related new technologies and industries.

Exercise Leadership in Global Climate Governance and Appropriately Host UN Climate Change Conferences

We should clearly recognize that exercising climate leadership is an important opportunity and breakthrough for China to influence the global governance pattern. Currently, China' s greenhouse gas emissions have not yet peaked, and it faces arduous emission reduction tasks. We need to re-examine China' s goal of peaking carbon emissions around 2030, prioritize implementing national determined contributions and creating models, and strive to peak emissions as early as possible. Only in this way can China exert genuine global leadership. Changing ourselves to influence and lead the world is China' s best path to effectively playing its role in global climate governance. Simultaneously, China should follow the "bottom-up" approach that made the Paris Agreement successful, carry out multi-faceted cooperation with major parties, promote the establishment of a global united front among state and non-state actors to address climate change, form multi-level platforms and alliances, explore diversified pathways and models for green low-carbon transformation, and strive to host a UN Framework Convention on Climate Change conference in 2020 to effectively exercise leadership.

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Note: Figure translations are in progress. See original paper for figures.