Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/forestsystems
doi: http://dx.doi.org/10.5424/fs/2014231-04705

Forest Systems 2014 23(1): 183-186
ISSN: 2171-5068
eISSN: 2171-9845

Short Communication. Forestry solutions for mitigating climate change in China

Guanglei Gao, Guodong Ding*, Yuanyuan Zhao, Yanfeng Bao, Minghan Yu

College of Soil & Water Conservation. Beijing Forestry University. No. 35 Qinghua East Road. Haidian District. 100083, Beijing, P. R. China

Abstract

Aim of study: Forests have vital functions in global carbon cycle, and thus are of prime importance in efforts to curb climate change. This study intends to guide effective forestry solutions to combat climate change in China.

Area of study: China, not only a major emitter of greenhouse gases, but also one of the five most-forest richest countries with the largest plantations in the world.

Material and methods: We summarize and recommend carbon sequestration forestry by considering two Kyoto Protocol activities: afforestation/reforestation and forest management.

Main results: Afforestation has a top priority of carbon sequestration forestry in China. However, the tree-based solution will reach its limits to growth in a predictable near future. Forest management contributes to break the deadlock. When scientifically and sustainably managed, forests still have a central role in climate change mitigation.

Research highlights: China's efforts on carbon sequestration forestry should shift the focus from afforestation to forest management.

Key words: climate change; carbon sequestration forestry; afforestation; forest management.

Introduction

Climate change is a serious and urgent issue. Although global temperatures have fluctuated, the trend of climate warming is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global sea level (IPCC, 2008). Climate change over the past decades have produced numerous shifts span an array of ecosystems and organizational hierarchies resulting in changes of industrial structure and citizen's lifestyle, unintended extreme natural disasters, and extinction from the species to the community levels, etc (Walther *et al*., 2002; Helmer and Hilhorst, 2006). Therefore, global climate change has profound impacts on the survival and development of the mankind. It has been a major challenge facing all countries.

Societies can respond to climate change by adapting to its impacts (adaption) and by reducing greenhouse gases (GHGs) emissions (mitigation) (IPCC, 2008). Of the many ways to reduce GHGs emissions and atmospheric concentrations, the most familiars are increasing energy efficiency, and using cleaner and alternative energy sources (Robert *et al*., 2008). However, these solutions always need powerful support by national policy, sufficient finance and advanced interdisciplinary studies in a large-scale area (Bouwer and Aerts, 2006). Further, it can sometimes lead to a serious shock on national economic pattern and structure (Mideksa, 2010). In contrast, unique among all possible remedies, forests can both prevent and reduce GHGs emissions while simultaneously providing essential environmental and social benefits, including clean water, wildlife habitat, recreation, forest products, and other values and uses (Robert *et al*., 2008). Carbon sequestration Forestry has attracted strong attention of global eager eyes under the condition of climate change scenario.

China, as the largest developing country and the most populous country, has become a major emitter of GHGs (Piao *et al*., 2010). The CO_2 equivalent in China keeps growth steadily with a baseline of 3.65 Gt in 1994; and the annual CO_2 emissions grew by around 4.0 Gt between 1992 and 2007 (Minx *et al*., 2011). Further, China's cumulative carbon emissions from fossil fuel combustion separately between 2006

*Corresponding author: dingguodong@bjfu.edu.cn
Recibido: 05-07-13 . Aceptado: 24-10-13.

Table 1. Six Key Forestry Programs in China

Item	Program	Region	Period	Goal	Afforestation area (10^6 ha)
1	Natural Forest Protection	Yangtze & Yellow River basin, Northeastern China, Inner Mongolia, Hainan, Xinjiang (17 Provinces)	2000-2010	Natural forest rehabilitation	8.7
2	Land Conversion from Farmland to Forestland	Except Southeastern China (25 Provinces)	2001-2010	Soil and water conservation	32.0
3	Sandstorm Source Control	Beijing-Tianjin Region (5 Provinces)	2001-2010	Desertification control	26.3
4	Shelterbelt Forest Development in Three-north Regions (IV)	Northern China (13 Provinces)	2001-2010	Desertification control	9.5
5	Wildlife Protection and Nature Reserve Developmentand	China	2001-2010	Wildlife protection nature reserves development	—
6	Fast-growing and High-yielding Timber Base Development	Eastern China (18 Provinces)	2002-2015	Timber plantations cultivation	13.3

and 2020 will be more than 32 Gt (Yin *et al*., 2010). With the urgent truth and increasing scientific and political interest, there is a strong impetus to better understand of carbon offsets of China (Piao *et al*., 2009). Therefore, in this manuscript, we synopsize and recommend scientific and technical options to guide effective climate change mitigation in China by considering two Kyoto Protocol activities: afforestation/reforestation and forest management, and attempt to lead a sagacious road to sustainability in climate change.

Afforestation: tree-based carbon sequestration

Over the latest past few decades, China has been implementing unprecedented and grand greening efforts to protect the fragile and fragmented environments, simultaneously reduce GHGs emissions and combat climate change (Table 1) (David *et al*., 2001). To date, the total forest area in China is 0.20 billion ha with 7.8 Gt carbon stock covering 20.36% of the terrestrial land. Among the forests, the new plantations (61.68 million ha) make prominent contributions to reduce carbon footprints for both China and the world. While an ambitious goal, Chinese government has promised that China will continue to energetically increase forest carbon sinks by planting trees in a large scale area. Concretely, China will endeavor to increase forest coverage by another 40 million ha and forest stock by 1.3 billion m^3 over the 15 year period (2006-2020). Considering the steadfast determination and recent efforts of accelerated tree planting, it is not hard for us to infer that the 40 million ha and 1.3 billion m^3 target represents only a modest, and indeed conservative, gain; and it will be successfully completed on schedule (Yin *et al*., 2010). Therefore, this tree-based carbon sequestration has been a strategic solution for China to deal with climate change. However, what about the future, after the 40 million ha or another 40 million ha? Afforestation is not a panacea. Taking into consideration forestlands, afforestation cannot reach a sustainable growth in carbon sequestration. In China, the implementation regulations of Forest Law set the national forest coverage target at 30%. Accordingly, new plantations absorb GHGs, but diminishing area to the forest-suitable lands with a baseline of 20.36% in 2010. Further, afforestation costs are expected to rise sharply due to the difficulties in tree planting. So, for the foreseeable future, the tree-based carbon sequestration solution will reach its limits to growth. Planning ahead, it is time for change when it is needed the most.

Table 2. Forest area and carbon stock in living forest biomass (2000-2010)

Country	Forest area		Carbon stock in living forest biomass	
	2010 (ha)	Annual change (ha)	2010 (t)	Annual change (t)
China	207×10^6	2986×10^3	6203×10^6	91×10^3
U.S.	304×10^6	383×10^3	19308×10^6	131×10^3
Total World	4033×10^6	-5211×10^3	—	—

Forest management for carbon sequestration

Forest management is the other forest's function in carbon stock increasing which is addressed by Kyoto Protocol. In China, the average forest carbon stock was only 40.4t/ha accounting for 56.4% of the global level. Although there were large variabilities due to the differences in climate, physiognomy, soil, and vegetations, forests in the northwest of China normally do not support a high stocking level due to climate and precipitation, those in the northeast and much of the south regions can support high stocking levels (Yin *et al*., 2010). If the country can increase the existing forest carbon stock by 10% through forest management activities between 2010 and 2020, the cumulated carbon sinks will be much larger than 683 Mt of the Chinese official afforestation target (Gao *et al*., 2011). For instance, if China follows forest management activities of the U.S., the increasing forest productivity will boost China's forest carbon sequestration from 96 to 152 Tg C/yr without requiring additional forestland area (Shao *et al*., 2011). Obviously, Chinese forests have huge potential for CO_2 absorption in the method of forest management, but needs to explore (Table 2). Meanwhile, forest management can contribute to climate change not only through increasing carbon stocking, but avoiding carbon emissions by deforestation. Further, forest management also helps to eliminate the threat of environmental and socio-economic impacts of large-scale afforestation (Wang and Cao, 2011; Gao *et al*., 2012), and restore mono-culture plantations (Gao *et al*., 2013).

Discussions

Climate change has been not an isolated or regional event, but a global subject that closely linked to ecological environment and human society. China has taken and will continue to take determined and practical steps to tackle climate change. This includes highlighted forestry solutions for GHGs emissions reduction. However, outstanding achievements and severe challenges always walk side by side. China's past efforts are successful, but not perfect. Moreover, facing the entangled issues, the country also has a lot of things to do in the future. Not only natural and technological, but also socioeconomic forces have affected China's GHGs emissions reduction separately and comprehensively. For instance, difficulties in quantifying forest carbon stock limited the uptake of forestry activities in climate policies. Furthermore, carbon sequestration forestry needs participatory plan to tackle carbon emissions reduction and sociometric prosperity together to succeed. China's forestry solutions for mitigating climate change need to grow in a more scientific, technological and sustainable way. This needs the support of interdisciplinary studies, policy and financial designs at the local, national and global scales. Fortunately, China is on the way.

Acknowledgements

This work was supported by Commonweal Project of State Forestry Administration of P. R. China (200804022A).

References

Bouwer LM, Aerts J, 2006. Financing climate change adaption. Disaster 30: 49-63.

David GS, Jiang K, Hu X, Jonathan ES, Zhang X, Xu D, Mark ZJ, James EH, 2001. Recent reductions in China's greenhouse gas emissions. Science 294: 1835-1837.

Gao GL, Ding GD, Wang HY, Zang YT, Liang WJ, 2011. China needs forest management rather than reforestation for carbon sequestration. Environ. Sci. Technol. 45: 10292-10293.

Gao GL, Ding GD, Wang HY, Zang YT, Zhang JY, Liang WJ, 2012. Environmental restoration efforts should not make residents struggle for survival. Environ. Sci. Technol. 46: 3054-3055.

Gao G, Ding G, Wang H, Zang Y, Liang W, An Y, He Y, 2013. Short communication. Restoring monoculture plantation using stand spatial structure analysis. Forest Syst. 22: 147-151.

Helmer M and Hilhorst D, 2006. Natural disasters and climate change. Disasters 30: 1-4.

IPCC, 2008. Climate change 2007: synthesis report. Geneva, Switzerland. 52 pp.

Mideksa TK, 2010. Economic and distributional impacts of climate change: The case of Ethiopia. Global Environ. Change 20: 278-286.

Minx JC, Baiocchi G, Peters GP, Weber CL, Guan DB, Hubacek K, 2011. A "carbonizing dragon": China's fast growing CO2 emissions revisited. Environ. Sci. Technol. 45: 9144-9153.

Piao S, Fang J, Ciais P, Peylin P, Huang Y, Sitch S, Wang T, 2009. The carbon balance of terrestrial ecosystems in China. Nature 458: 1009-1013.

Piao S, Ciais P, Huang Y, Shen Z, Peng S, Li J, Zhou L, Liu H, Ma Y, Ding Y, Friedlingstein P, Liu C, Tan K, Yu Y, Zhang T, Fang J, 2010. The impacts of climate change on water resources and agriculture in China. Nature 467: 43-51.

Robert WM, Patrick H, Steve B, Douglas C, Fred D, Christopher G, Edmund G, John AH, Nathan M, Michael M, Steve R, Matthew S, John S, 2008. Forest management solutions for mitigating climate change in the United States. J. Forest. 106: 115-173.

Shao G. F, Dai LM, Duke, JS, Jackson RB, Tang LN, Zhao JZ, 2011. Increasing forest carbon sequestration through cooperation and shared strategies between China and the United States. Environ. Sci. Technol. 45: 2033-2034.

Walther G, Post E, Convey P, Menzel A, Parmesan C, Beebee T, Fromentin J, Hoegh-Guldberg O, Bairlein F, 2002. Ecological responses to recent climate change. Nature 416: 389-395.

Wang Y, Cao S, 2011. Carbon Sequestration May Have Negative Impacts on Ecosystem Health. Environ. Sci. Technol. 45: 1759-1760.

Yin R, Sedjo R, Liu P, 2010. The potential and challenges of sequestering carbon and generating other services in China's forest ecosystems. Environ. Sci. Technol. 44: 5687-5688.