



Short communication

Challenges facing socioeconomic development as a result of China's environmental problems, and future prospects

Chunyan Luo^{a,b}, Li Chen^c, Hui Zhao^d, Suoyan Guo^d, Guosheng Wang^{e,*}^a Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, PR China^b Institute of Soil and Fertilizer, Sichuan Academy of Agricultural Sciences, Chengdu 610066, PR China^c Water and Soil Conservation Institute of Yan'an City, Yan'an, Shaanxi 716000, PR China^d Monitoring Center of Soil and Water Conservation, Ministry of Water Resources, No. 27, Nanbinhe Road, Xicheng District, Beijing 100055, PR China^e China Law Society, Beijing 100038, PR China

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ABSTRACT

China's policymakers are being forced to balance socioeconomic development with the need for environmental protection. In this paper, we have briefly discussed the main characteristics of the environmental problems that China will face in the 21st century and the challenges that must be met in order to develop policies that will support environmental management. As our discussion in this paper shows, the negative effects of China's economic development on its environment will continue to rise for some time, despite strong efforts to reverse the situation. It will also be necessary to change China's resource-intensive mode of economic development, change the economic development philosophy to one in which controlling pollution is as important as economic development, and raise public awareness of the need for environmental protection.

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1. Introduction

China has experienced explosive economic growth in recent decades, but this is creating severe pressure on the environmental services required to support its people and its economy. Increasing urbanization is another important environmental pressure, since this phenomenon has been one of the most spectacular responses to China's 1978 economic reforms, which became the driving forces behind China's economic growth. Both the economic growth and increasing urbanization have had serious impacts on China's environment, since neither was planned for nor anticipated (Abramson, 2006; Cao et al., 2009c). As a result, these changes have caused consumption of natural resources (including arable land) and generation of pollutants at an increasingly unsustainable rate, in part due to a labor-intensive economic model that uses resources inefficiently (Streets, 2006; Cao et al., 2011).

Government statistics show that China's population grew at an annual average rate of 1.83% from 1952 to 1990, and an average annual rate of 0.22% from 1990 to 2010. This has been

accompanied by average capita income growth rates of 6.7 and 19.7%, respectively, and increases in annual per capita income of 4.9 and 7.1%, respectively (Cao, 2012a). As a result, total energy consumption and coal consumption increased by 15.1% from 1952 to 1990, and by 22.9% from 1990 to 2010. Emissions of industrial pollutants are increased by 14.9% annually from 1952 to 1990 and by 12.2% annually from 1990 to 2010. This has led to severe environmental problems. Unfortunately, the emissions of industrial pollutants grew even faster than China's economy (Zheng and Cao, 2011). The proportion of total pollution emitted by industries was 42.6% from 1952 to 1990 and 43.6% from 1990 to 2010, suggesting that pollution is increasing slowly as a result of technological and industrial development. In 1980, China's emissions of industrial pollution began to decline while the total income growth rate remained high (around 10.0% annually), but the environmental quality continued to deteriorate (CSB, 2012).

The deterioration of environmental quality and increasing pollution of the environment have been important negative side-effects of China's rapid economic development, rapid urbanization, and large population. A large part of the problem has been that China's environmental policy developed belatedly in response to the consequences of economic growth rather than being integrated with the country's economic development policy right from the start. In this paper, we offer an overview of these changes that

* Corresponding author. Tel.: +86 10 6618 3012; fax: +86 10 6233 7674.

E-mail addresses: lcy407@163.com (C. Luo), lichen1969@126.com (L. Chen), 7166zhaohui@163.com (H. Zhao), Guo_sy@263.net (S. Guo), gshwang@126.com (G. Wang).

has hitherto been lacking, in the hope that this will help both the Chinese government and the international community to develop more effective policy responses that integrate the need for socioeconomic development with the need to reduce pollution emissions and thereby better protect the environment. We believe that this discussion is relevant to readers of *Ecological Engineering* because many developing countries are seeking to emulate China's economic success, and monitoring will be necessary to detect whether following China's path will adversely affect their ecosystems (i.e., so that measures can be taken to solve the problems before they become serious). In addition, all natural ecosystems are increasingly sustaining impacts from socioeconomic systems, and it's important for researchers and managers to understand the context that produces these impacts; without that understanding, it is impossible to protect endangered ecosystems.

2. Economic development and environmental policy

Environmental degradation is clearly costing China dearly, although the magnitude of this cost has been estimated using a range of techniques that produce different outcomes. For example, the aggregate annual cost of China's environmental damage has been estimated at between 4.5 and 18% of GDP (CSB, 2012). Water pollution alone is estimated to cost between 0.6 and 4.5% of GDP, with estimates averaging around 1.7%, and the cost of air pollution is similar (CSB, 2012). This is an important predicament for policy-makers and environmental managers because it is difficult to focus resources and policies on the correct problems when the problems are not clearly understood. The obstacles that pollution creates for China's rapid economic growth and social development have forced the government to recognize the need for increased investment in environmental protection. The 12th Five-Year Plan (2011–2015) was approved by the National People's Congress, China's top legislature, in March 2011. The central government committed US\$600 billion to growing sectors such as information technology, clean energy, environmental protection, and scientific research and innovation (He et al., 2012). From 2003 to 2008, China invested 1636 billion RMB in environmental conservation (ca. US\$240 billion based on the approximate rate of exchange in 2010). For its Three Lakes (Taihu, Chaohu, and Dianchi) and Three Rivers (Huaihe, Liaohe, and Haihe) programs to restore polluted bodies of water, China invested 96 billion RMB (ca. US\$14 billion) over a 6-year period (Cao et al., 2011). The Chinese government has taken several important additional steps toward pollution control. For example, the government will now punish violators of state environmental regulations who cause serious pollution of the land, the water, or the atmosphere. The penalty is up to 3 years of imprisonment and a large fine; up to 7 years of imprisonment can be imposed in the most serious cases (MEP, 2009).

The concept of sustainable development has been gaining in popularity across many sectors of the Chinese economy and throughout much of China's society (Cao, 2012b). To increase protection of a rapidly degrading environment, the National Environmental Protection Agency (formed in 1987) was elevated to the rank of a full ministry in 2008, and was renamed the Ministry of Environmental Protection (MEP, 2009). Though China's environmental policy is still a work in progress, it is aiming in the right direction (that is, the situation would have been much worse in the absence of this policy) and it has already achieved some successes, including strong investments in renewable energy and significant reductions in the emission of pollutants per unit GDP (Chen and Cao, 2013). Unfortunately, some of the environmental policy has not been effective or has suffered from an implementation gap

(Fang et al., 2009). Part of the problem is that the structure of China's environmental organizations forms a complex grid that is composed of many vertical and horizontal linkages (Guan et al., 2011). In the vertical portion of the hierarchy, each level of government below the national MEP, continuing down to provincial and even municipal levels, has its own Environmental Protection Bureau. The relationship between these Environmental Protection Bureaus and other government authorities is also structured horizontally (Cao, 2010). A good example is the Ministry of Forests, which competes with MEP for budgetary money at a national level and which has policies that sometimes conflict with MEP policies, and similar horizontal relationships and conflicts exist with Environmental Protection Bureaus at progressively more local levels. At all levels, these agencies rely heavily on the corresponding level of government for funding and other forms of support, such as the authority to implement changes or overrule the actions of other agencies (Liu, 2010).

3. The challenge of balancing environmental needs with socioeconomic development

China's struggle against environmental degradation has resulted from the need to simultaneously alleviate poverty and control population growth. Despite China's explosive economic growth, 28.2 million of its people still suffered from extreme poverty in 2009 (Liu, 2010). Because much of China's industry has traditionally been labor-intensive, with low energy efficiency and (until recently) low technological inputs, the current high energy consumption and the high emission of pollutants caused both by energy consumption and industrial processes have led to some of the most severe environmental problems faced by any major country, and these problems are worsening because of the increasing resource requirements to support the country's rapid industrial and urban development (Liu, 2010). The social and economic forces associated with this growth have had a range of effects, from positive (e.g., the recent growth of a software development industry) to negative (e.g., continuing reliance on coal for energy), and the effects have ranged from direct (e.g., discharge of untreated urban wastewater into rivers) to indirect (e.g., increasing depths to the water table in many areas).

China is simultaneously facing severe problems due to desertification that has resulted from a combination of climate change and unsustainable uses of environmentally fragile areas. The government has implemented huge programs to mitigate these problems, but although some of these programs have achieved impressive results, the consequences have not all been positive. For example, although forest cover has increased to about 18% of China's land area as a result of aggressive afforestation programs, timber yield and quality remain lower than elsewhere in the world (Cao, 2011). The estimated mean timber volume in China was 67.2 m³/ha in 2005, versus an average of 81 m³/ha for East Asia, because much of the planting has occurred in regions with insufficient water to sustain tree growth (Yin et al., 2010). Extensive efforts to plant trees in arid and semiarid regions have also caused environmental deterioration when the trees consumed too much of the limited soil moisture; this has led to plantation failures, reduced overall vegetation cover, and increased severity of wind and water erosion (Cao, 2008; Cao et al., 2010a). There is therefore a great need to develop decision-support tools to guide the managers of China's re-vegetation programs to solutions that are more suitable for local environmental conditions (e.g., McVicar, 2007; Wang and Cao, 2011). Better site selection and the consideration of "evolutionary" re-vegetation schemes that account for limits on plant

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