China's progress towards sustainable land development and ecological civilization

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The 2012 Rio+20 Summit committed to developing integrated Sustainable Development Goals (SDGs) for achieving a harmonious relationship among economic development, social inclusion, and environmental sustainability by 2030 (Sachs et al. 2016; Gao and Bryan 2017). Seventeen of the SDGs were adopted by all the signatories by 2015. During recent decades, China, as one of the signatories, has designed and implemented a number of national sustainability

policies to promote 'ecological civilization' and 'beautiful China'. The co-authors of this editorial have recently published a synthesis describing how a wide range of sustainability programs have been implemented in China (Bryan et al. 2018). This synthesis aimed to help improve future sustainable development programs and policies in China, as well as to provide examples and lessons for other countries that seek to achieve the SDGs for themselves and for

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global sustainability. In this editorial, we encapsulate the main findings of this comprehensive study, and highlight several key ideas for advancing future sustainability policies and landscape sustainability science in China and worldwide.

China's sustainability programs in response to severe land degradation

Many of China's ecological and environmental problems are caused by long-term unsustainable land management. Agricultural production over millennia had put China's rural land ecosystems in a relatively stable but fragile balance. However, after the founding of the People's Republic of China, farmland was expanded unsustainably to meet the need for food, leading to a significant reduction in areas of wetlands and natural woodlands, as well as the continuous decline in ecosystem stability, massive erosion, and soil productivity loss. Although China successively launched six sustainability programs after the economic reform and opening up in 1978, such as the *Three-North Shelterbelt Program* and the *National Key Construction Program for Soil and Water*, the implementation of these did not offset the growing

pressures on the environment from the rapid urbanization and industrialization during this period.

By the end of the 1990s, repeated ecological disasters, such as the floods of the Yangtze River, the drying up of the Yellow River, and dust storms hitting Beijing, caused the Chinese government to launch seven new sustainability programs, such as the *Grain for Green Program* and *Natural Forest Conservation Program*, in a very short period of time. Together with three later programs, a total of 16 major sustainability programs were implemented (Fig. 1).

These programs covered many activities, such as soil erosion control, biodiversity conservation, natural forest conservation and cultivation, forest management, desertification control, grassland protection, promotion of agricultural production and food security, governance of rocky desertification-prone areas, and improvement of rural livelihood (Fig. 2). They are mainly designed to be regionally sensitive, accounting for the diverse environments in China, from the continental arid and semi-arid climates in the Northwest to the temperate monsoon climate in the southeast. Programs such as the *Partnership to Combat Land Degradation in Dryland Ecosystems* and the *Grassland Ecological Protection Program* were designed for conditions in northwest China, the *Three-North Shelterbelt Development Program* for

Fig. 1 Chronology of key political, socio-economic and policy events (red markers), human-environmental disasters (blue markers), and the 16 major sustainability program responses

(green markers) in China from 1949 to 2015. The trajectories of population and economic development (Gross Domestic Product) are shown in the lower graph

Fig. 2 Word cloud illustrating the major aims of the 16 sustainability programs reviewed. The size of the words reflects how frequently they occur in the stated aims of the programs

northern China, the *Grain for Green Program* for the middle and upper reaches of rivers, the *Shelterbelt Development Program-Five Regions* for the middle and lower reaches of rivers and coastal areas, the *Rocky Desertification Treatment Program* for the Southwest Limestone region, the *National Key Construction Program for Soil and Water* for impoverished mountain regions, and the *Cultivated Land Quality Program* for central-eastern China (Fig. 3).

Major achievements and keys to success

Bryan et al. (2018) found that, over the past 20 years, China has invested more than USD 370 billion across

6.2 million km² (65% of the country's total area) of land through these programs (Fig. 4). More than 500 million people have participated in them. Their implementation has resulted in very positive impacts: for example, forests now cover over 22% of China, grasslands have expanded and regenerated, and soil erosion and sedimentation have been significantly reduced. The sediment load of the Yellow River has dropped by 90%, agricultural productivity has grown by 5% annually on average, and millions of farmers have been lifted out of poverty. China's government has developed programs that promote ecological protection and environmental management in ways that include complementary programs focused on economic growth.

However, many ecosystems in China still face serious problems. Program implementation was imperfect and these programs have also had some negative effects, such as planting of unsuitable trees which has caused the depletion of water resources in some areas and led to large-scale planting failures. Biodiversity is still in decline, partly due to the prevalence of non-native, single-species plantations. There is also concern about the affordability of continuing incentive payments that could be required to sustain progress in some areas.

Of particular global relevance is the way the research also mapped each program's investment against the 17 SDGs and found that these 16 sustainability programs have made a significant contribution to 14 of the 17 goals (Fig. 5), especially to five goals: SDG15 (*protecting, restoring and promoting sustainable use of terrestrial ecosystems*), SDG2 (*ending hunger and promoting sustainable agriculture*), SDG1 (*ending poverty*), SDG13 (*combating climate change*) and SDG11 (*making human settlements inclusive and sustainable*).

Fig. 3 Photographic examples of some of the major sustainability issues facing China, and some of the responses. **a** Engineered, high-quality, irrigation rice paddy and maize achieved under the National Land Consolidation Program in Haitang, Changshou District, Chongqing, 2014. Photograph courtesy of Guangyin Chen. **b** The sediment-rich Yangtze River at the Three Gorges, Hubei. Photograph courtesy of David Favis-Mortlock, <http://soilerosion.net/doc/off-site.html> (accessed May 5, 2018). **c** The plateau wetland in Lugu Lake natural reserve supported by the Wildlife Conservation and Nature Reserve Protection Program, Sichuan Province, 2014. Photograph courtesy of Xiufeng Sun. **d** Conversion of low-yielding farmland via levelling and widening to enable agricultural mechanisation under the Comprehensive Agricultural Development Program, near Da Yang township, Gansu Province, 2013. Photograph courtesy of the People's Government of Zhangjiachuan Hui Autonomous County, http://www.zjc.gov.cn/html/czjj/2013-11/6/10_11_43_808.html (accessed Nov 26, 2017). **e** Economic forest (date trees) restoration in the Fo Tang Yan village, Zizhou County, Loess Plateau, 2010. Photograph courtesy of Jim Richardson, <http://jimrichardson.photoshelter.com/image/I0000vmXfDUOxqwc> (accessed May 5, 2018). **f** Field experiment assessing the ability of organic fertiliser to improve soil fertility and health, reduce pollution, and improve the quality of cultivated land under the Cultivated Land Quality Protection and Promotion Program in Tongdao County, Hunan Province, 2015. Photograph courtesy of Huaihua Agriculture Bureau Information Station, <http://www.farmers.org.cn/Article/ShowArticle.asp?ArticleID=574530> (accessed Feb 10, 2018). **g** Mountain pasture supported by the Grassland Ecological Protection Program in Aba Autonomous Prefecture of Sichuan Province, 2012. Photo courtesy of Xiufeng Sun. **h** Karst landscape subject to rocky desertification planted to dragon fruit (*Hylocereus undatus*), conserving soil and water and increasing the income of poor farm households in Pingguo County of Baise, Guangxi Zhuang Autonomous Region, 2015. Photograph courtesy of Xiufeng Sun. **i** Forest recovery in areas that had previously been cut down by logging companies promoted by the Natural Forest Conservation Program in Changbai Mountains, Jilin Province, 2017. Photograph courtesy of Lei Gao

What stands out in this analysis is the way that there has been mutual complementarity among various programs, in the spirit of integration encouraged by

the SDGs. For example, the trade-offs associated with programs that limit deforestation and encourage forest establishment to achieve water quality goals were reduced by simultaneous initiatives that encourage timber supply and agricultural production. At the same time, China pays attention to the combination of long-term planning and short-term goals in these programs, and most of the programs aimed to deliver multiple objectives through various measures. This process resonates with the concept of organic wholeness and treatment based on syndrome differentiation in traditional Chinese medicine theory. Of course, the technical standards and methods of these programs are also constantly revised and evolved in a process of adaptive management in implementation. In the face of environmental problems, pragmatic and on-ground implementation has been key to China's progress in sustainability.

Although China still faces severe ecological and environmental problems during its development, this research analyzes how environmental issues have emerged in China from the perspective of historical development, and has shown how China has tackled some big problems in the land sector. It presents the first comprehensive effort to collect, sort and review data on the 16 major sustainability programs in China focused on the land sector, as well as combining information documenting policies, investments, environmental assessments, and human welfare measures in a comprehensive, rigorous and impartial manner. Reviewers commented that this work is an “*ambitious, complicated, timely, and comprehensive*” effort “*to synthesize the available research to show the achievements of China's efforts on sustainability, which deserve greater recognition and provide useful lessons to other countries*”.

Fig. 4 Total investment under the 16 sustainability programs in China from 1978 to 2015

Fig. 5 mapping of China's sustainability investment against the 17 UN Sustainable Development Goals

Lessons and implications

Bryan et al. (2018) show that China has evolved its priorities from “economic and social goals as the center” to “economic, social and ecological coordinated development as the center” in the implementation of national land focused ecological programs since the 1980s. In implementing the programs, it has been vitally important to take a comprehensive view of agriculture, rural areas, and farmers' problems, which have long plagued sustainable development in China's rural areas.

China's experience also provides valuable lessons for all nations as they pursue the UN SDGs. The interlinkages among goals and the integrated nature of the SDGs are of crucial importance in ensuring that the purpose of the new agenda is realized. For China, the goals of each program are partial, so it is particularly important to evaluate the impact of these programs as a sum in total. Although scholars have previously evaluated individual programs, this study is the first to review 16 major sustainability programs in China together and judge their integrated contribution to sustainable development as expressed by the SDGs. This provides an opportunity to analyze policy intent, investment inputs, ecosystem services and human well-being in a coordinated way.

From this analysis, wider lessons can be learned. The set of national ecological programs needs to be considered in terms of top-level design, multiple co-governance systems, national and local economic diversification fund guarantee mechanisms to reduce pressure on land by reducing economic dependency, local participation and the promotion of new technology and knowledge sharing and extension. The globally relevant finding is that nations can launch

different sustainable development programs to match different environment and developmental levels, and individual programs should choose different management modes according to local historical experience and cultural differences, avoiding “one size fits all”. All levels (national, provincial and local) have an important influence on sustainable development programs, and how policy tools and market mechanisms affect individual decision-making plays a crucial role in successful implementation. Decision-makers need to monitor and evaluate the whole process, to ensure program goals are realized; this continues to be necessary in China.

A number of key conclusions for the future can be drawn from this work. In order to achieve the UN SDGs by 2030, the integration of science and policy is of vital importance. A deep understanding of how humans interact with their environments is needed to integrate economic, social and ecological outcomes at the national scale into a global perspective. To effectively take strong action on global issues such as climate change and biodiversity conservation it will be crucial to take complementary action on poverty eradication, rural development, urban renewal in a way that acknowledges that links between socio-economic and environmental issues. This understanding can aid other countries to can plan, research, and formulate policies suited to their national conditions but in ways that contribute to a global goal of sustainability.

Of course, additional comprehensive assessment and synthesis like the work presented in this paper can contribute to achieving these global sustainability goals but research alone is not enough. Large investment, integrated environmental and socio-economics policy initiatives, specific technologies and

quantitative monitoring, evaluation and adaptive learning processes are also needed, and there is also a growing literature on these for China.

The science community and readership of this journal have a key role to play in many ways. For example, in the area of sustainable landscape management and optimization, recent research has shown that enhanced management practices can achieve a win-win outcome with regard to crop production and environmental management over large areas (Cui et al. 2018), and that appropriate farmland management measures are critical for the sustainable utilization of cultivated land (Zuo et al. 2018). Remote sensing and landscape models have been valuable tools for assessing the effectiveness of large-scale ecological protection and construction projects to reduce land degradation risk (Li et al. 2016; Yu et al. 2018; Tong et al. 2018). In addition, landscape sustainability science can guide our transition toward sustainability, particularly on scales ranging from local ecosystems to regional landscapes (Wu 2013; Opdam et al. 2018). It is important that studies from these diverse perspectives on sustainable development continue, and that there continue to be syntheses like Bryan et al (2018) to bring them together.

As China's great acceleration in sustainability investment continues with new development strategies launched, such as "Beautiful China" and "rural vitalization strategy", it is important that the science community continues to contribute overall syntheses of the impacts and effectiveness of multiple programs and support future planning (Delang and Yuan 2014; Rodríguez et al. 2016). Future syntheses are needed globally at regional, national and transnational levels, combining diverse analyses (including case studies, systematic reviews, and meta-analyses of individual program impacts). From the policy formulation point of view, portfolio-wide planning is essential to efficiently and effectively achieve multiple SDGs (Gao and Bryan 2017), thereby reducing the overall costs of meeting the Chinese dream and global ambitions of ecological civilization for China and the world.

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