frontiers | Frontiers in Environmental Science

EDITORIAL
published: 08 July 2022
doi: 10.3389/fenvs.2022.874963

Editorial: Desertification and Rehabilitation

Xian Xue[1], *Atsushi Tsunekawa*[2] *and Caroline King-Okumu*[3,4]*

[1]Northwest Institute of Eco-Environment Resources, Chinese Academy of Sciences (CAS), Beijing, China, [2]Arid Land Research Center, Tottori University, Tottori, Japan, [3]The Borders Institute (TBI), Africa, Nairobi, Kenya, [4]GeoData Institute, School of Geography and Environmental Science, Faculty of Environmental and Life Sciences, University of Southampton, Southampton, United Kingdom

Keywords: climate change, human activities, degradation, restoration, rehabilitation, sustainable development

Editorial on the Research Topic

Desertification and Rehabilitation

INTRODUCTION

Desertification, resulting from climatic variability and irrational human activities, is currently one of the most important environmental problems. Because desertification has brought poverty, famine, and displacement, hindering the improvement of eco-environment and social-economy in the developing countries and regions, it has attracted the attention of the whole world. Since 1994, when the United Nations Convention to Combat Desertification (UNCCD) was established, all kinds of battles against desertification have been conducted worldwide with hopes to bring about a positive change.

Nevertheless, a large number of questions concerning desertification still remain, depending on the different contexts and objectives of national strategies (Xue et al., 2015; Muñoz-Rojas et al., 2021). The large gap between sciences and policies concerning the rehabilitation of the desertified land requires urgent attention in many countries. To design effective land restoration and rehabilitation strategies and achieve the global goals for sustainable development, including Land Degradation Neutrality, a systemic and comprehensive understanding of desertification and rehabilitation is necessary (see discussions in: Wang et al., 2015; Kong et al., 2021; Xue, 2022). Following a brief conceptual overview and an introduction to the context and planning of Chinese national investments in land rehabilitation, this Editorial introduces fifteen collected contributions to this debate from interested scientists in China.

Due to the scale of the land degradation, desertification and drought challenges in China, it accounts for a large portion of the total area of degraded land globally (Alexander et al., 2019)[1]. The achievement of the global target for land degradation neutrality and the objectives of the UN Decade on Ecosystem Restoration will depend on significant progress to be made in China. The Chinese Government is investing heavily in the achievement of its ecological objectives, and reporting substantial achievements (PRC, 2021). For example, from 2015 to 2018, the net area of land restored in China was calculated to account for about one fifth of the global total. On this basis, the 2021 Chinese Voluntary National Review stated that China had restored more land than any other country (PRC, 2021 p28). The role of Chinese scientists, and their commentaries on this achievement should

[1]See: https://knowledge.unccd.int/glo/global-land-outlook-glo.

OPEN ACCESS

Edited by:
Ioan Cristian Ioja,
University of Bucharest, Romania

Reviewed by:
Alexandru-Ionut Petrisor,
Ion Mincu University of Architecture and Urbanism, Romania
Mihai Razvan Nita,
University of Bucharest, Romania

****Correspondence:***
Caroline King-Okumu
caroking@yahoo.com

Specialty section:
This article was submitted to Land Use Dynamics, a section of the journal Frontiers in Environmental Science

Received: *13 February 2022*
Accepted: *02 May 2022*
Published: *08 July 2022*

Citation:
Xue X, Tsunekawa A and King-Okumu C (2022) Editorial: Desertification and Rehabilitation. Front. Environ. Sci. 10:874963. doi: 10.3389/fenvs.2022.874963

therefore be of considerable interest to the international-science-policy community (Kong et al., 2021).

CONCEPTUAL FRAMINGS OF DESERTIFICATION, DEGRADATION, REHABILITATION AND RESTORATION

According to the UNCCD, "desertification" means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities; "land" means the terrestrial bio-productive system (that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system); and "land degradation" means reduction or loss of the biological or economic productivity and complexity in that terrestrial system. More recently, the millennium ecosystem assessment has defined measures of productivity (or loss of productivity) in terms of ecosystem services. The Paris Agreement has captured emerging understanding of the complexity of food-related aspects of the terrestrial system.

According to the United Nations Convention for Combatting Desertification (Article 1b)[2], "Combating desertification" includes activities which are part of the integrated development of land for sustainable development which are aimed at: (i) prevention and/or reduction of land degradation; (ii) rehabilitation of partly degraded land; and (iii) reclamation of desertified land. Rehabilitation aims to improve to some degree a degraded site by re-establishing associated ecosystem functions such as trophic interactions, water, and nutrient cycles (Gurr et al., 2014). The goals are determined by what society wants and needs, the level of degradation, and the economic, political, and social environment (Gurr et al., 2014). Dryland ecologists observe a distinction between the limited objectives of ecosystem rehabilitation versus the more ambitious agenda for ecological restoration (Aronson et al., 1999; Alexander et al., 2016).

Rehabilitation is used to refer to restoration activities that may fall short of fully restoring the biotic community to its pre-degradation state, including natural regeneration and emergent ecosystems (Fisher et al., 2018 p6). The Society for Ecological Restoration (SER) defines standards for rehabilitation as follows (Gann et al., 2019):

Rehabilitation–management actions that aim to reinstate a level of ecosystem functioning on degraded sites, where the goal is renewed and ongoing provision of ecosystem services rather than the biodiversity and integrity of a designated native reference ecosystem.

Alexander et al. (2016) observe the focus of rehabilitation activities on functionality and the delivery of targeted services more than on reinstating the pre-disturbance system condition in all its biological complexity (as restoration does). They maintain that rehabilitation may in fact be the only option in situations where degradation has passed a point of no return, where species have become extinct, or where seed and soil biota have all been lost. Furthermore, rehabilitation is more in line with the immediate aspirations of the public and decision-makers.

Globally, it appears that there will be some challenges to be faced over the coming years in order for policy-makers to be able to monitor and report successes achieved in relation to land restoration targets. Rehabilitation is more feasible to monitor than restoration. This can be done in terms of emerging economic environmental accounts that capture the stocks and flows of ecosystem services of value to the human population, including provisioning services and selected supporting and regulating services that are measurable in many parts of the developing world through the emerging systems for water accounting alongside other aspects of natural capital accounting (UNEP, 2021a; UNEP, 2021b).

A range of case studies of successful rehabilitation are available from the Intergovernmental Panel on Biodiversity and Ecosystem Services, whereas the case studies of success in restoration were fewer (IPBES, 2019). The Hunshandak Sandland, Inner Mongolia, China, was one of the few case study examples of restoration success presented in this assessment.

Dryland ecologists have frequently observed that for the most degraded areas, rehabilitation is a more feasible objective and a necessary first step toward restoration (Aronson et al., 1999). According to Le Floc'h et al. (1999):

"The main objective of ecological rehabilitation is to pilot trajectories of disturbed ecosystems so that they may recover their main functions, including productivity, via intensive interventions of relatively short duration. Rehabilitated ecosystems should become autonomous and have sufficient resilience to recover after moderate disturbances."

Aronson et al. (1999) observed that thereafter, it could be possible either to proceed toward full restoration or else to "pilot" the systems in question in other directions according to local needs and priorities and, of course, the potentialities of local climate and soils. But until that first level of reparation is achieved, nothing else, longterm, is realistically possible. They argued that this, in a nutshell, was the situation of almost all the populous dryland regions in the world by the early 1990s.

In 2020, the international community has launched a UN Decade for Ecosystem Restoration in pursuit of the ambitious agenda of Ecosystem Restoration and are calling upon governments to invest commensurately (UNEP, 2021b). To track progress of efforts to restore degraded ecosystems for the United Nations Decade on Ecosystem Restoration, a Framework for Ecosystem Restoration Monitoring has been established[3]. Already, all governments have made a commitment to achieve a universal global goal to neutralize land degradation. Many governments have published targets and strategies for achievement of this within their countries, and a number have voluntarily reviewed their progress so far (Sewell et al., 2020)[4].

[2]Available in all 5 UN Languages including Chinese and English from: https://www.unccd.int/convention/about-convention.

[3]https://www.fao.org/national-forest-monitoring/ferm/en/.

[4]See: https://knowledge.unccd.int/ldn/ldn-monitoring/sdg-indicator-1531 and also https://landportal.org/book/sdgs/1531/sdgs-indicator-1531 and https://trends.earth/docs/en/ and all VNRs at: https://sustainabledevelopment.un.org/vnrs/.

For decades, whereas, ecological restoration has been recognized as a challenging objective, requiring massive investment over a long period of time, scientists have considered that rehabilitation is a feasible and realistic first step that can be taken toward it and which can be pursued across a wider area (Aronson et al., 1999; Wang et al., 2015). For example, they have argued that 100 million hectares could be rehabilitated immediately for the same cost or less than what it would take to fully restore 1,000 ha (see p316 in Aronson et al., 1999).

From both ecological and economic perspectives, rehabilitation is still recognized as often the most pragmatic response to be taken in cases where all stakeholders can agree that land degradation has occurred (Alexander et al., 2016). Rehabilitation is also still considered the first step that can be taken and achieved rapidly toward full-scale restoration to follow over the longer term. Scientists across the developing world remain aware of the relevance and value of the differentiated objective of ecological rehabilitation (Tlili et al., 2018; Tlili et al., 2020), as a contribution to the global agenda for ecosystem restoration. Not only does it positively support and move beyond the agenda for land degradation neutrality, but it also builds in greater feasibility, measurability and achievability for decision-makers who are also committed to the achievement of ecological restoration, recovery and the creation of a new green economy.

A further differentiation of terms between restoration, rehabilitation and reclamation has been highlighted recently by the SER (Gerwing et al., 2021) which observes that when rehabilitation occurs on mined lands or post-industrial sites, it is sometimes, but not always, called reclamation; suggesting that reclamation could be considered as conceptually nested within rehabilitation. In practice, the delineation between these two terms, as well as their relationship to ecological restoration, is unclear.

BACKGROUND TO DESERTIFICATION AND REHABILITATION DEBATES IN CHINA

According to the Chinese Voluntary National Review of the Sustainable Development Goals/SDGs (PRC, 2021 p28), in China:

"Desertification has been checked across 10 million hectares, leading to a drop in both area and intensity of desertification in three consecutive monitoring periods. Compared with 2011, the area of rocky desertification has shrunk by 1.932 million hectares; the sediment in the Yangtze River basin is down by more than 40%; 61.4% of the rocky desertification areas are covered by vegetation. From 2015 to 2018, net restored land in China accounted for about one fifth of the global total, ranking first in the world."

Reported positive changes are particularly concentrated in the North-Central part of China and Northeast (**Figure 1**).

On August 15, 2005, Xi Jinping, then secretary of the CPC Zhejiang Provincial Committee shared his vision that "Lucid waters and lush mountains are as good as mountains of gold and silver." In 2017, this vision was written into the report of the 19th CPC National Congress and the revised CPC Constitution as a guiding principle for coordinated development and conservation. It also informed a report on the national targets for land degradation neutrality in China (PRC, 2017). Also in 2017, to advance global efforts to control desertification, China hosted CoP 13 of the United Nations Convention to Combat Desertification. This was the first CoP China has ever hosted in the UN environmental field. Through this and subsequent CoPs, the Chinese experience and solutions were shared with other Parties.

In 2021, the Chinese government has issued policies on accelerating the establishment of a sound, green, low carbon and circular economic system and on establishing a mechanism for realizing the value of ecosystem products, as part of the effort to put in place a policy system to promote green development. The Chinese VNR (PRC, 2021) also highlights China's *14th Five-year Plan for National Economic and Social Development and Vision 2035 which* covers the immediate next 5 years and also outlines a medium-term vision. It is essentially compatible with the SDGs which integrate economic, social and environmental dimensions and cover five key elements: People, Planet, Prosperity, Peace and Partnership. During the 14th Five-year Plan period, China will strive to achieve high-quality development, balanced social progress and harmony between man and nature through economic growth, innovation, improvement in people's well-being and ecological conservation.

The role of science in enabling effective monitoring and understanding of processes taking place in the rehabilitated ecosystems is critical (Xue et al., 2015; Xue, 2022). Chinese scientists have raised many questions about the feasibility of extensive afforestation in arid and semi-arid areas and the negative effects of afforestation on soil water, groundwater levels, and surface runoff. As increased drought has been considered to contribute to the degradation of the water environment, scientists have investigated the increasing demands for water that are created by the expansion of the afforestation area. A second question that is, frequently raised concerns the impact of grazing exclusion and ecological migration on the stability and diversity of rangeland ecosystems and the local cultural traditions: Can the no-grazing-induced increase in the vegetation cover be considered to signify the reversal of degraded rangeland?

Alongside these, a new battle against deserts (not desertification) is raging in modern China. This involves a struggle to transform the natural or semi-natural land such as dune fields by planting tree species where nature did not intend that they should grow. However, scientists have observed that this can be counter-productive—resulting in increased erosion rather than stablization of mobile sand dunes (Wang et al., 2015). These three issues directly affect the sustainability of desertification control in China.

There is a need for decision-makers to maintain the balance of the coupled human-environmental system while making full use of their human capability as leaders to formulate policies and measures. Although land degradation and restoration are chronic long-term processes, government planning horizons must plan and budget in shorter-term phases. Where designed and implemented effectively, these can support a rapid recovery in vegetation cover and biomass. In light of this, a recent commentary by researchers at the Chinese Academy of Sciences (Xue, 2022) focuses on goals and principles that could guide and inform better policy and planning, by improving the available understanding of the concepts, assessment criteria, and causes of desertification in China. Until they do this, the target for Zero Net Land Degradation (ZNLD) cannot be achieved in China or globally.

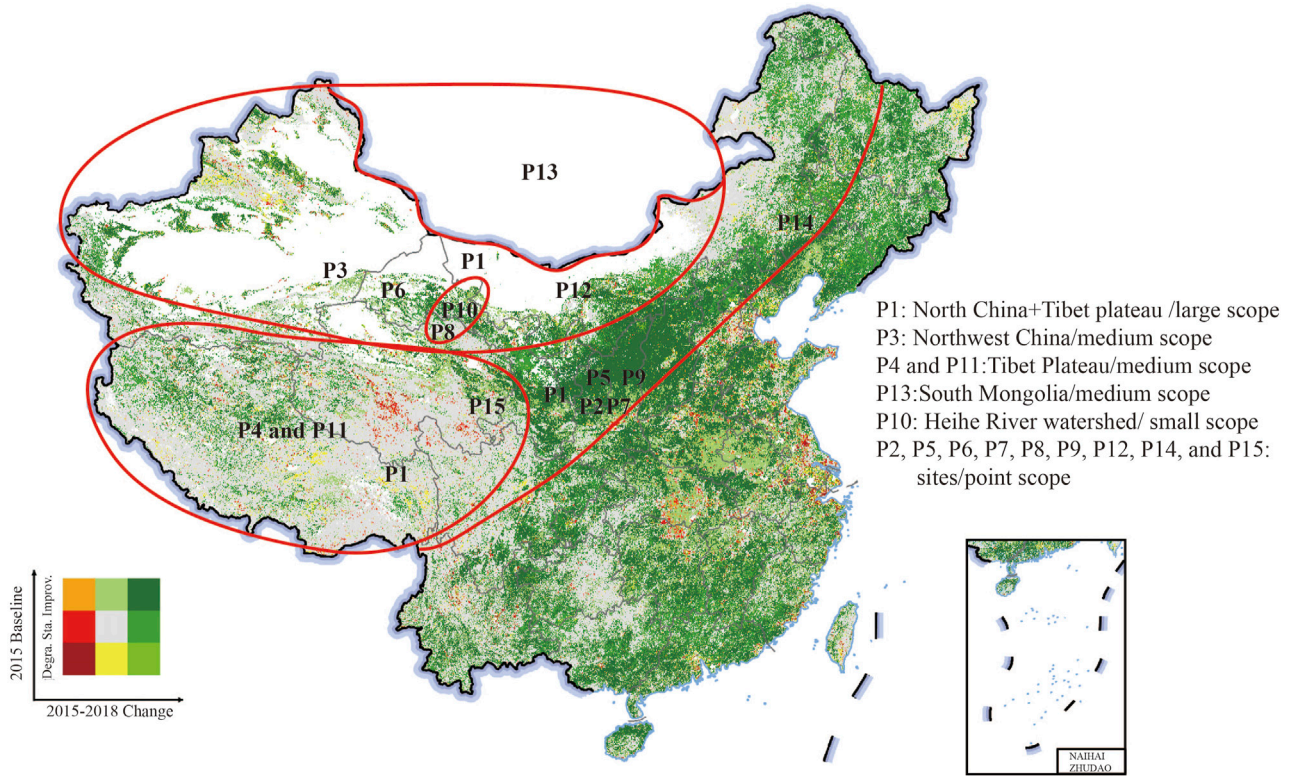

FIGURE 1 | Reported dynamics of land restoration in China (2018) and location of papers in this issue (prepared by Xian Xue from original map provided by Li et al. (2021), and presented in PRC (2021)).

TABLE 1 | Overview of papers included in this Special Issue.

Author name	Climate/ecological conditions	Landcover/land use/Ecosystems	Features under observation	Methods of observation
Wang et al.	Arid, semi arid and sub-humid	All vegetation	NDVI	RS
Zou et al.	Semi-arid	Forest	Methods approach	Field observation, and experiment
Guojing et al.	Arid and semi-arid	Forest	Plants	data and documents analysis
Huang et al.	Alpine	Grassland	Plant and soil	Field observation
Zhang et al.	Semi-Arid	Sandy land	Fungi	Field observation
Cui et al.	Arid	Sandy land and Gobi	Soil water	Field observation
Gu et al.	Semi-Arid	Agro-pastoral ecotone	Plant and soil	Field observation
Wang et al.	Arid	Oasis and desert	Soil water	Field observation
Li et al.	Semi-Arid	Sandy land	Erosion	Experiment
Song et al.	Arid	Oasis and desert	Land cover	RS
Zhang and Sun	Alpine	Grassland	Plant	Field observation
Qu et al.	Arid	Grassland	Litter	Field observation
Kim et al.	Arid	Gobi desert	Erosion	RS
Wang et al.	Sub-humid	Agro-pasture ecotone	Cellulose decomposer	experiment
Zhu and Wang	Alpine	Grassland	Plant	Field observation

OVERVIEW OF THE SPECIAL ISSUE CONTRIBUTIONS

Researchers from the Chinese Academy of Sciences have led the preparation of this Special Issue in Frontiers in Earth Science to share with international scientific community some of the high-quality research from different fields of research that is, ongoing in China on desertification and restoration (**Figure 1**; **Table 1**).

The papers range from broadscale overviews of the effectiveness of land restoration practices, as observed using remote sensing techniques, to finer scaled studies conducted at the field level and in the laboratories of the Chinese Academy of Sciences. Some of the studies involve experiments designed and conducted to increase the available knowledge of plants, soils and hydrological responses under the effects of rehabilitation or degradation processes.

The contributions help the scientific community to better understand the dynamics of land degradation, desertification and rehabilitation. Insights address current issues and solutions to improve the ongoing national investments in land restoration and rehabilitation to enable economic growth, innovation, improvement in people's well-being and ecological conservation.

They contribute to understanding China's policies and measures for neutralizing land degradation and raise questions for the future. For example, one of the papers analyses over half a century (7 decades) of investments in afforestation in Northwest China. They also highlight questions relating to the effects on ecosystems and livelihoods that have been achieved through fencing and grazing prohibition measures adopted in the North-eastern grasslands of the Qinghai-Tibet Plateau. Such measures have been carried out in Northern China, especially Inner Mongolia. However, as yet, these could not be fully evaluated. Furthermore, the papers reflect on questions concerning the effects of land restoration policies on hydrological conditions in the drier regions. For example, the article on the dynamics of soil-water content in the desert-oasis ecotone shows that some of the practices currently being implemented for ecological restoration purposes may in fact be exacerbating soil-water deficits and drought risks.

We conclude that further research on these questions will require close collaboration between geographers, ecologists, and social scientists to ensure a multi-angle analysis of sustainable degraded land restoration policies. This learning could help to achieve the anticipated transitions through ongoing investments in land rehabilitation and restoration.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

REFERENCES

Alexander, S., Aronson, J., Whaley, O., and Lamb, D. (2016). The Relationship between Ecological Restoration and the Ecosystem Services Concept. *Ecol. Soc.* 21, 34. doi:10.5751/es-08288-210134

Aronson, J., Dhillion, S., and Floc'H, E. L. (1999). Dryland Restoration and Rehabilitation. *Arid Soil Res. Rehabilitation* 13, 315–317. doi:10.1080/089030699263203

Fisher, J., Montanarella, L., and Scholes, R. (2018). "Chapter 1: Benefits to People from Avoiding Land Degradation and Restoring Degraded Land," in *The IPBES Assessment Report on Land Degradation and Restoration*. Editors L. Montanarella, R. Scholes, and A. Brainich (Bonn, Germany: Secretariat of the Intergovernmental Panel on Biodiversity and Ecosystem Services IPBES).

Gann, G. D., Mcdonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J., et al. (2019). International Principles and Standards for the Practice of Ecological Restoration. Second Edition. *Restor. Ecol.* 27, S1–S46. doi:10.1111/rec.13035

Gerwing, T. G., Hawkes, V. C., Gann, G. D., and Murphy, S. D. (2021). Restoration, Reclamation, and Rehabilitation: on the Need for, and Positing a Definition of, Ecological Reclamation. *Restor. Ecol.*, e13461. doi:10.1111/rec.13461

Gurr, G. M., Johnson, A. C., and Liu, J. (2014). "Land Use: Restoration and Rehabilitation," in *Encyclopedia of Agriculture and Food Systems*, Vol. 4, 139–147.

IPBES (2019). *Assessment Report on Land Degradation and Restoration*. Nairobi, Kenya: Intergovernmental Panel on Biodiversity and Ecosystem Services.

Kong, Z. H., Stringer, L. C., Paavola, J., and Lu, Q. (2021). Situating China in the Global Effort to Combat Desertification. *Land* 10 (7), 702. doi:10.3390/land10070702

Le Floc'h, E., Neffati, M., Chaieb, M., Floret, C., and Pontanier, R. (1999). Rehabilitation Experiment at Menzel Habib, Southern tunisia. *Arid Soil Res. Rehabilitation* 13, 357–368.

Li, X. S., Qi, L., and Xiaoxia, J. (2021). Harnessing Big Earth Data to Facilitate Land Degradation Neutrality Goals—Practices and Prospects. *Bull. Chin. Acad. Sci.* 36, 896–903. (in Chinese).

Muñoz-Rojas, M., Hueso-Gonzalez, P., Branquinho, C., and Baumgartl, T. (2021). Restoration and Rehabilitation of Degraded Land in Arid and Semiarid Environments: Editorial. *Land Degrad. Dev.* 32, 3–6. doi:10.1002/ldr.3640

PRC (2017). *China National Committee to Implement the UNCCD (CCICCD) China Final National Report of the Voluntary Land Degradation Neutrality (LDN) Target Setting Programme December 2017*. People's Republic of China.

PRC (2021). *China's VNR Report on Implementation of the 2030 Agenda for Sustainable Development*. Beijing: Ministry of Foreign Affairs of the People's Republic of China June 2021.

S. Alexander, U. Kang, and J. Xiosha (Editors) (2019). *The Global Land Outlook, Northeast Asia Thematic Report* (Bonn, Germany: United Nations Convention to Combat Desertification).

Sewell, A., Esch, S. V. D., and Löwenhardt, H. (2020). *Goals and Commitments for the Restoration Decade: A Global Overview of Countries' Restoration Commitments under the Rio Conventions and Other Pledges*. The Hague: PBL Netherlands Environmental Assessment Agency.

Tlili, A., Ghanmi, E., Ayeb, N., Louhaichi, M., Neffati, M., and Tarhouni, M. (2020). Revegetation of Marginal Saline Rangelands of Southern Tunisia Using Pastoral Halophytes. *Afr. J. Range Forage Sci.* 37, 151–157. doi:10.2989/10220119.2020.1720293

Tlili, A., Tarhouni, M., Cerdà, A., Louhaichi, M., and Neffati, M. (2018). Comparing Yield and Growth Characteristics of Four Pastoral Plant Species under Two Salinity Soil Levels. *Land Degrad. Dev.* 29, 3104–3111. doi:10.1002/ldr.3059

UNEP (2021a). "Ecosystem Restoration Playbook," in *UN Decade on Ecosystem Restoration*.

UNEP (2021b). *State of Finance for Nature 2021*. Nairobi: United Nations Environment Programme.

Wang, T., Xue, X., Zhou, L., and Guo, J. (2015). Combating Aeolian Desertification in Northern China. *Land Degrad. Dev.* 26, 118–132. doi:10.1002/ldr.2190

Xue, X. (2022). "Chapter 7 Goals and Principles for Combating Aeolian Desertification," in *Combating Aeolian Desertificaiton in Northeast Asia*. Editors T. Wang, A. Tsunekawa, X. Xue, and Y. Kurosaki (Singapore: SpringerNature).

Xue, X., Liao, J., Hsing, Y., Huang, C., and Liu, F. (2015). Policies, Land Use, and Water Resource Management in an Arid Oasis Ecosystem. *Environ. Manag.* 55, 1036–1051. doi:10.1007/s00267-015-0451-y

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.