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Drylands and climate change – confronting the social and ecological challenges

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Editorial

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[#]Contribution to Phase II of the Global Dryland Ecosystem Program (GDEP)

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Introduction

China's drylands are extensive, encompassing a broad range of environments and cultures. Yet China's drylands are at a critical juncture, beset with a broad range of climate change-related issues associated with higher temperatures and more variable rainfall (Li et al., 2024b). Changing climates are increasing susceptibility to erosion and soil degradation, reducing soil and landscape functionality, and placing greater pressure on water catchments and agricultural land uses (Li et al., 2024a). These biophysical effects are compounded by, and exacerbate social challenges related to increasing population pressure and competition for limited resources. Climatic extremes associated with climate change add another layer of complexity to those issues, currently experienced as increasing frequency, severity and duration of higher temperatures and drought, presenting huge challenges for governments (WBG and ADB 2021).

Managing the climate crisis requires genuine consultation with key stakeholders to determine their views and needs (Ng and Ren 2018; Ou and Song 2024). Such an approach builds trust that is important with applied research and provides an avenue for authentic communication. Thus, knowing what, where and how to mitigate the substantial effects of changing climates in drylands requires an assessment of stakeholder opinions, concerns, and their perceptions regarding both the challenges and solutions identified. Surveys that benchmark stakeholder needs are critical if China is to identify and meet the social and ecological challenges with which it is confronted over the next three decades (Fu et al., 2025).

The views of Chinese dryland scientists on climate change

We surveyed 29 dryland-focused academics and practitioners from Chinese research institutions to gauge their perceptions of the effects of climate change on drylands. Sixty-four percent of respondents identified as dryland experts, 39% as being familiar with natural resource management, 7% as socio-economic specialists, and 3% as general environmental experts. Respondents were asked to rank the importance of current and future climate change and their impacts on drylands, identify and prioritise adaptations to climate change impacts, and evaluate research and educational gaps in our understanding the effects of climate change in drylands. We used revised approaches that had been applied in previous studies (e.g., George et al., 2009). Our survey included a subset of questions to identify: (i) perceptions of the climate challenge, (ii) knowledge gaps required for better managing the climate risks; and (iii) potential barriers to adoption and actions to help overcome them. A weighted score system was used to obtain meaningful overall rankings (Webster 1995). Responses were collated into 1) key issues and perceptions, 2) an analysis of knowledge gaps, and 3) enablers and barriers to adaptation.

Dryland scientists perceive climate change adaptation as largely intractable

Predictably, the group of scientists identified increases in temperature as the greatest current and future climate-related issue, followed by changes in patterns of rainfall, the occurrence of heatwaves and drought, declining water security, and increased land degradation (80-90% agreement). These views are largely consistent with those of the general Chinese community (e.g., Stringer et al., 2021) and those such as herders, who are closely tied to the land and therefore understand the vagaries of their climate (Hou et al., 2012). Yet little is known about the view of Chinese scientists about climate-related issues. While all respondents accepted the scientific basis of climate change, some queried the projected rate of change, given diverging global opinion on different potential scenarios and the speculative, or low, probability of catastrophic events (*sensu* Lenton et al., 2019). Worryingly, most questioned whether adaptation would be possible, given the complexity of the climate crisis, the difficulty in curbing global greenhouse gas emissions, and the problems in with dealing with cross-sectoral impacts (Nordgren et al., 2021). Most respondents argued that increasing temperatures would compromise water security and therefore food security and human livelihoods, which are intimately linked. Water insecurity would also impact natural ecosystems and reduce the positive benefits of current restoration and reclamation

practices (Ramón Vallejo et al., 2012), actions that would be hampered by more frequent droughts (Jain et al., 2024).

Water security, ecosystem services and reclamation dominate structural needs

Perceptions of needs by respondents were strongly aligned with their experiences, interests and competencies. Participants identified the importance of improved knowledge of the impacts of climate change, probably because they represent educational and scientific sectors where knowledge is respected. Improved water security in drylands was identified as the greatest priority. Water security issues in China are complex, with China's water security agenda driven not only by water management concerns, but also by strategic considerations in relation to neighboring countries over transboundary river systems (Xie and Warner 2022). Land use mapping, identification of key biomes susceptible to climate change, and prioritizing areas for protection and intervention were seen as key challenges to reduce the impacts of changing climates. Yet, these actions are not new. Chinese scientists have focused over the past two decades on identifying 'hotspots' of change induced by changing climates, more recently in the Qinghai-Tibet Plateau (Xiang and Xiao 2022), which is seen not only as a critical water source for China, but a provider of ecosystem services such as soil retention, carbon sequestration, biodiversity conservation, and ecotourism (Guillot and Replumaz 2013).

Chinese scientists also raised the importance of reclamation and restoration, which while acknowledged as critical, were also recognized as costly, time-consuming, and actions that may temporarily displace people and disrupt routine practices and land management options (Li et al., 2024b). Government policy embodied in the "Grain to Green" program has led to substantial restoration of plant cover, and conversion of eroded farmland into forest or grassland during the past three decades in China's Loess Plateau (Zhou et al., 2019). Ecosystem modelling reveals that the Loess Plateau has transitioned from a net carbon source to net carbon sink between 2000 and 2008 following the initiation of the Grain to Green program (Feng et al., 2013). These examples demonstrate that restoration has a role in mitigating the negative effects of climate change in China's drylands (Lu et al., 2018) and that co-benefits will likely result from other initiatives that involve carbon-soil-biodiversity synergies (Hu et al., 2026). The importance of agricultural economics and ecosystem payments in helping decide what are wise trade-offs with resource allocations will only become more paramount as time proceeds (Jiang et al., 2023).

Governance and education are critical, but social needs are underrepresented in climate change mitigation in China

Issues raised most frequently by the dryland experts were the need for better climate change education across all sectors, improved skill development, consensus on how to curb emissions, better communication and understanding of climate variability and extremes, the importance of governance, and the role of monitoring and evaluation of progress towards sustainability in drylands. Many of these issues are highly interconnected. For example, China's climate change governance is highly tied to its centralized political system, and the need to manage an extensive land area and population size (Teng and Wang 2021). Effective governance however faces significant challenges due to low levels of public engagement and conflicts, and tradeoffs between central and local governments (Wu 2023).

In addressing social needs for drylands, respondents recognized that building capacity and improving leadership are essential to implement change. This could involve, for example, further developing curricula at high school level, balancing the needs of unique catchment groups that include downstream users to reconcile potential conflicts, and effective communication and education processes to solve 'real-life' problems such as potential displacement of people due to climate abatement programs (Qi et al., 2023). Climate change-related programs have increased in school curricula over the past two decades, and education has become an integral part of the country's climate change strategy (Han 2015). Evaluation of school-based programs suggests significant attitudinal changes among students, and a greater understanding of the role of government in climate change mitigation (Tang 2023). Socio-economic and hydrological watershed benefits, however, have been underrepresented in Chinese climate mitigation initiatives (Hu et al., 2026).

Monitoring, modelling and technological advances dominate structural needs

Respondents signaled that critical issues remain with monitoring, verification of climatic and climate change data sources, identification of alternative renewable energy sources, and improving the modelling of the trajectory of the changing climate. These views align closely with published lists of technology advances required to achieve structural reform in relation to climate mitigation (Wang et al., 2021). Key adaptation technologies include better early warning forecasting, monitoring of climate impacts, improving the modelling of climate dynamics and statistical downscaling. Aligned needs to improve technology required to maintain a sustainable agriculture and adequate water resources to create resilience to climate change include improved water delivery and irrigation systems, solar photovoltaic water lifting systems for irrigation, and exploration of unconventional water sources for use in agricultural production (Wang et al., 2021). There is also scope for better integrating climate forecasting with improved governance and safeguards to enhance local rules to aid decision-making that relates to agriculture, water management, and water sharing.

Conclusions and reflections

Climate-based environmental issues are global and extend beyond political boundaries and systems. China is a substantial economy that uses large quantities of energy and emits large quantities of greenhouse gases (Paltsev et al., 2012). China's role in mitigating the impacts of global climate change in the drylands is therefore considerable. Our study is based on the response of one small cohort of experts who met in Australia in early 2026 to plan Phase II of the Global Drylands Ecosystem Program (Fu et al., 2021, 2025). A larger and more varied sample that included key end-users such as herders and farmers who face the greatest risk to their livelihoods (Wu et al., 2021), would probably support and/or reinforce these findings as well as highlight other insights. This survey reinforces perspectives from the broader literature that define the key issues facing the world's drylands as climates become hotter and drier. These include improved water security through technological advances, landscape restoration without displacing people (as far as is humanly possible), greater public engagement with governance, building capacity and leadership through education, and additional and improved modeling and climate

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forecasting services. The immediate challenge confronting people living in drylands, however, is food and water insecurity (Squires et al., 2015). Feeding the world's most populous country will be a major challenge as the effects of climate change increase in severity. Dryland ecosystems will continue to evolve under climate change. The challenge will be to tailor specific actions addressing the uniqueness of each land system and catchment. Adaptation is essential, not optional, and will continue to be refined with authentic inputs from a collaboration of key stakeholders, end-users and scientists.

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