A farmland biodiversity strategy is needed for China

Nationwide citizen science data show the importance of farmland outside protected areas for China's avifauna. We urge the government of China to develop a national strategy for policy and research to protect biodiversity and traditional knowledge of sustainable agriculture to meet the post-2020 goal of the Convention on Biological Diversity.

Li Li, Ruocheng Hu, Jikun Huang, Matthias Bürgi, Ziyun Zhu, Jia Zhong and Zhi Lü

Agricultural lands take up to a third of the Earth's terrestrial surface. In recent decades, the expansion and intensification of agricultural land, triggered by the continuous increase in human population and dietary changes, has become one of the direct drivers of Anthropocene biodiversity loss[1]. The expansion of agricultural production, however, has neither always nor everywhere taken place at the expense of biodiversity. Instead, over the course of centuries of development of agricultural practices, a significant number of wild species have adapted or even become dependent on farmland habitats. The exact characteristics of agricultural development are, therefore, relevant to the fate of global biodiversity, and wildlife-friendly farmlands should be considered as valuable ecosystems. Half of the globe's agricultural lands are distributed in the 17 megadiverse countries, of which China possesses the largest share of the world's agricultural lands at 9.9% of the global total[2,3]. With its long cultivation history, China has accumulated rich knowledge with regard to sustainable intensive agricultural practices at small scales. The modernization of agriculture in China in recent decades, despite its remarkable success at feeding its large population, has led to the rapid extinction of diverse land-use practices, threatening the coupling of social and ecological systems[4]. Unfortunately, China's National Biodiversity Strategies and Action Plan (NBSAP) for the Convention on Biological Diversity (CBD) fails to recognize traditional agriculture as an asset for biodiversity conservation bearing its unique cultural heritage[5], nor the drastic change in agricultural practice as one of the causes of domestic biodiversity loss.

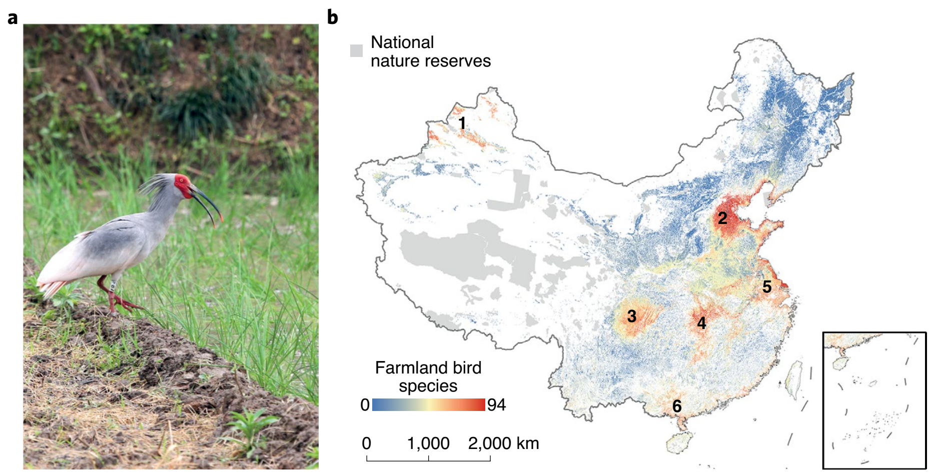

Fig. 1 | Farmland bird species in China. a, The crested ibis (*Nipponia nippon*) depends on rice paddy fields. Benefiting from the conservation measures of maintaining traditional land use and restricting agrochemicals, its numbers have increased from less than a dozen to over 2,000 in the past 30 years. **b**, Simulated distributions of the 220 farmland bird species in China. Six avian-diverse farming regions are numbered as follows: (1) northwest Xinjiang; (2) the Bohai Rim and parts of the North China Plain; (3) the Sichuan Basin; (4) the Poyang Lake plain and the plain of Hunan and Hubei; (5) the coastal areas and plains of the Yellow Sea; and (6) the West Guangdong and East Guangxi areas. (1) and (2) mainly consist of dry farming lands; (4) and (5) are paddy fields; (3) and (6) have both. Credit: Blickwinkel / Alamy Stock Photo (**a**).

Overlooked biodiversity value of farmlands

Typically, the value of farmland is considered with regard to food production. China's agricultural policies primarily target this production function of farmland. In China's national implementation reports for the CBD, biodiversity in the agricultural sector related to farmland is exclusively interpreted in terms of genetic resource conservation, invasive species and pest control. The term 'biodiversity' was not mentioned in the annual budget of the Ministry of Agriculture and Rural Affairs[6]. China's newly developed land-use planning scheme, 'Major Function-Oriented Zones', aimed at optimizing the state's spatial development pattern in a top-down approach by assigning the territorial space to four types based on development intensity: development-optimized areas, development-prioritized areas, development-restricted areas and development-prohibited areas[7]. Each area is assigned to one of the four major functions serving for industrial or urban development, food production, or ecosystem services provision[7]. Although biodiversity in development-restricted areas may benefit from strictly regulated land-use intensity, this land-use planning policy has led to the segregation of lands for nature conservation and agricultural production. In other words, under the current land-use policy arrangement in China, only lands designated as Nature Reserves are recognized for sustaining biodiversity[8].

High biodiversity in China's farmlands

Agriculture takes the most fertile lands in China which also provide abundant resources for associated wild species (Fig.

1a). According to remote sensing data, cultivated landscapes covered 1.79 million km^2 in 2015[9], that is, almost twice as much as China's national nature reserves, stretching over 0.97 million km^2 (ref. [10]). Data to assess biodiversity distribution in China's farmlands are very limited overall. However, blooming citizen science approaches on bird species resulted in the most comprehensive nationwide avian database with fine resolution and up-to-date information on species occurrences collectively compiled by over 7,000 bird watchers[11]. Although abundance data remain insufficient in the citizen science database, regional study in Europe has reported congruent trends of avian richness and abundance influenced by different farmland management regimes[12]. Using these bird data as the best available biodiversity indicator, we simulated potential habitats of 1,111 avian species, including 167 national-protected species and 70 threatened species (see Supplementary Methods). Nearly 25% of the national-protected species and 20% of the threatened species use farmland as habitat (see Supplementary Methods and Supplementary Table 1). Looking at the top 17% (Aichi Target 11) and 50% (the 'Half-Earth' Advocacy[12]) simulated avian-species-rich pixels (1-km grain size), the ratio of cultivated landscapes or national nature reserves to the 17% and 50% pixel areas increases from 15.2% and 3.6% to 28.7% and 3.9%, respectively. The importance of the cultivated landscape is more pronounced for threatened birds, with the ratio reaching 37.6%/3.1% and 30.5%/3.6%, respectively. Among the 220 birds that use farmland for feeding or nesting, more than half have over 50% simulated potential habitats in cultivated landscapes (see Supplementary Methods and Supplementary Fig. 1). The potential habitats of the 220 species identify six avian-diverse farming regions of China: (1) northwest Xinjiang; (2) the Bohai Rim and parts of the North China Plain; (3) the Sichuan Basin; (4) the Poyang Lake plain and the plain of Hunan and Hubei; (5) the coastal areas and plains of the Yellow Sea; and (6) the West Guangdong and East Guangxi areas (Fig. 1b). Nevertheless, to date there has been a lack of both regulatory and institutional arrangements to support the enormous avian conservation value in these identified species-rich farmland regions.

CBD post-2020 framework as an opportunity for mainstreaming

China's obligation to conserve biodiversity is bound to its CBD ratification. However, among the eight megadiverse countries that have over 40% agricultural territory, China is the only nation that lacks explicit farmland biodiversity targets in its NBSAP[5]. The only other exception is the United States, which is not a CBD signatory. Heading towards the post-2020 biodiversity framework, a broad consensus has been reached for setting conservation targets high in order to reverse the steep species-decline trajectory[13,14]. The current global protected area system is unlikely to meet such a requirement[15]. In this context, the post-2020 framework may serve as an opportunity for China to review its biodiversity strategies on farmland. On the one hand, China inherits a myriad of sustainable agricultural systems that facilitate the coexistence of humans and nature[16]. The value of this long and rich bio-cultural heritage is a great asset for the future. On the other hand, during the same time period set for achieving the Aichi Targets, China has become the world's largest consumer of chemical fertilizer and pesticide[17]. The rapid agricultural intensification with heavy use of pesticides has profoundly undermined ecosystem services sustained by traditional farming[18], putting both biodiversity and food safety at risk. Establishing China's farmland biodiversity strategy requires the recognition of the environmental function of agricultural land at the decision-making level. Farmland has to be valued not only for agricultural production, but also as a shared space within which a great number of species complete their life cycles, especially in areas where farmlands are small and scattered. In this sense, farmland biodiversity is one form of public good produced by agriculture as an environmental externality, which should be integrated into China's ecological compensation schemes.

To ensure domestic food security, China has set up a redline of 1.2 million km^2 of arable land which cannot be transformed into other types of land use. Farmland to be spared for the conservation of birds and other wild fauna and flora is rather limited at present. Thus, new agricultural systems in China should be developed to integrate both traditional wisdom and scientific knowledge of sustainable intensification towards the conservation of focal species in high-priority areas. First, a national baseline of biodiversity distributions in farmlands should be established to set spatial conservation targets, such as within the six avian-diverse farming regions in China. Second, interdisciplinary research projects should be launched to investigate the integration of traditional agricultural knowledge and modern scientific knowledge to foster the successful coupling of sustainable farming with species protection. Third, policy and market incentives should be created to reward wildlife-friendly farming or compensate for farmers' losses in production (that is, a fund for farmland eco-compensation). Lastly, farmland biodiversity monitoring should be installed to facilitate both action- and performance-based payment. We propose that conserving farmland biodiversity should become part of the jurisdiction of state-level administrative responsibility, and research funds should be directed towards finding novel solutions for human–nature coexistence.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article. ❐

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Author contributions
Z.L., L.L., J.H. and M.B. conceptualized and framed the main perspective of the Comment. J.Z. organized nationwide birding records of China. R.H. conducted all species modelling and mapping and wrote the chapter of Supplementary Methods. Z.Z. reviewed the current agricultural policies of China. J.H. provided recommendations regarding agricultural policies. L.L. drafted the manuscript; M.B., Z.L. and J.H. revised the content and language of the manuscript.

Competing interests
The authors declare no competing interests.

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Study description	To assess avian diversity distributions in China's farmland, we used MaxEnt 3.4.1 to model range maps of birds in China based on citizen science data. 160,086 independent localities of 1,111 bird species were used for the modelling.
Research sample	For each species, the MaxEnd model was performed to derive their distribution range in farmland. Taking the most widespread hawk in China's farmland for example, we collected 479 independent localities of Accipiter nisus, the model results showed that the habitat in farmland contains 443,413 pixels. The test AUC is 0.832, and the training AUC 0.853.
Sampling strategy	Occurrence data of 1,111 birds were collected from the citizen science project, Bird Report (www.birdreport.cn). To ensure the accuracy of location and species identification, each submitted record was checked by an experienced reviewer to filter out questionable entries. Only birdwatchers who have submitted more than 300 bird species and 100 birding reports in China are eligible to become reviewers. Collecting 47 thousand birding reports (one report may contain 1-120 species records) from 1998 to 2017, we verified the accurate coordinates of each bird species record using Google Maps API.
Data collection	All birding data from 1998 to 2017 were collected from birdreport.cn by Ruocheng Hu. Bird Report is the only large-scale nationwide project for submitting birdwatching records in China, with records of more than 1,390 bird species from 1998 to 2017. To ensure the accuracy of location and species identification, each submitted record was checked by an experienced reviewer to filter out questionable entries.
Timing and spatial scale	Original birding data were collected for the time period 1998 to 2017 from all over China.
Data exclusions	We corrected statistical errors, including over-fitting and high-variability predictions: 1) Bird species with fewer than five independent localities were excluded; 2) when localities were clustered for a species (i.e., the distance between any two records was less than one arc-minute), we randomly remove the extra locality when conducting the habitat modeling. The exclusion criteria were pre-established and were applied consistently throughout the analysis.
Reproducibility	The MaxEnt model was set by 10 cross-validated replicates for each species. Consistent results can be derived for each habitat range model.
Randomization	We modelled distribution range for all species in the citizen science database of China. The randomization was not relevant to our study except that when localities were clustered for a species (i.e., the distance between any two records was less than one arc-minute), we randomly remove the extra locality when conducting the habitat modeling.
Blinding	In the MaxEnt modeling, we randomly set 80% data for training and 20% data for testing to produce the final distribution map.

Did the study involve field work? ☐ Yes ☒ No

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