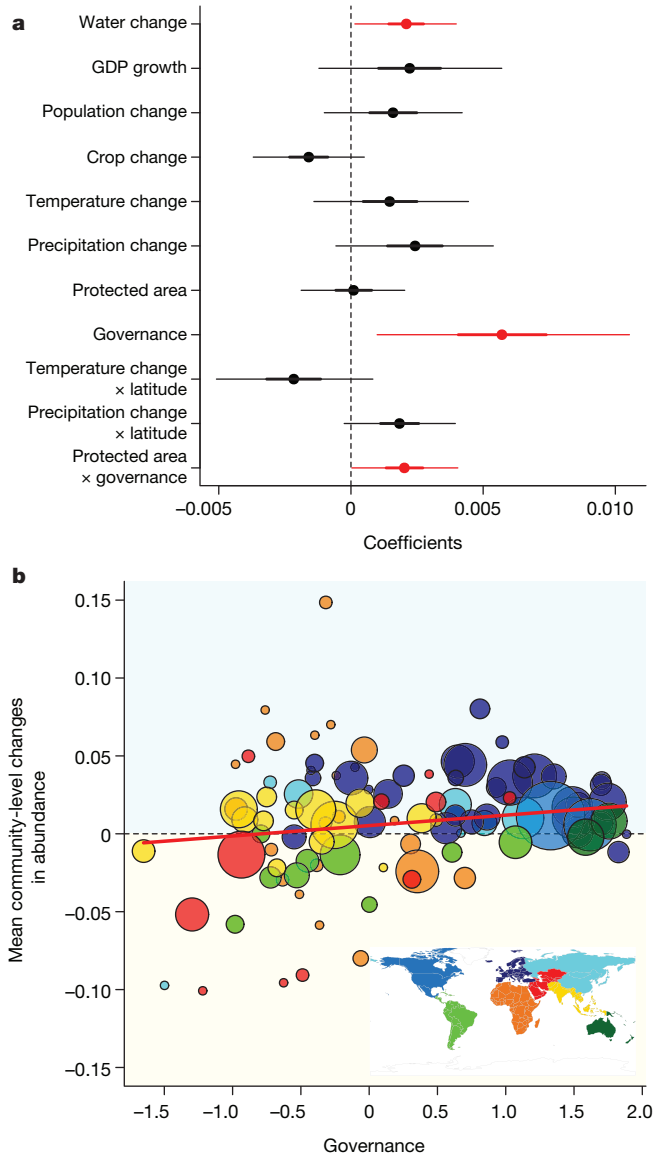

Figure 3 | Effects of predictors on community-level changes in waterbird abundance. a, Estimated coefficients in the multivariate analysis ($n = 2{,}079$). Posterior medians with 95% and 50% (thick lines) credible intervals are shown. Coefficients with 95% credible intervals that do not overlap with zero are shown in red. The coefficients represent the effect size of the standardized variables. **b**, Relationship between community-level changes and countries' governance. Each circle represents a country; circle size, the number of 1° × 1° grid cells with estimates; colour indicates the region shown in the inset map; regression line shown in red. Map produced from Natural Earth data v.1.4.0 (http://www.naturalearthdata.com/).

a higher rate of surface water loss (for example, western and central Asia[16], Extended Data Fig. 3b).

To explore the possible causes of community-level changes, we partitioned the effects of explanatory variables into species-level (explaining variations in species-level changes between species) and population-level effects (explaining variations in population-level changes within species) for 293 species with sufficient data. Species-level changes were explained by the interaction between governance and protected area coverage, by gross domestic product (GDP) growth rates and by body mass (Fig. 4a). Consistent with the community-level analysis, waterbird species with a higher coverage of protected areas increased more, but only in countries with more effective governance (Fig. 4c). Species in countries with rapidly growing economies, as well as small-bodied species, experienced greater declines (Fig. 4b, d). Governance was also the best predictor of population-level abundance changes, and most of the species that were significantly affected by governance showed larger population-level declines in areas with less effective governance (Extended Data Fig. 4 and Supplementary Discussion). These conclusions were robust even when considering the correlation between governance and GDP per capita, and were also robust to other sensitivity analyses (Extended Data Figs 5–7, Supplementary Discussion).

Although our data are not spatially complete (Extended Data Fig. 1 and Supplementary Discussion), by quantifying abundance changes within each species over large geographic areas we uncovered new hotspots of threats to bird species in wetland ecosystems. Previous studies (see Supplementary Discussion) did not identify biodiversity loss in, for example, western and central Asia, mainly because relevant data were unavailable. This spatial overlap between general data gaps and biodiversity loss could cause an underestimation of the ongoing biodiversity crisis, which highlights the need for global monitoring of species' abundances.

Our results emphasize the importance of governance—presumably the environmental aspects of governance (see Methods)—in explaining global patterns in waterbird abundance changes. Local and regional studies have increasingly highlighted the environmental consequences of ineffective governance, such as species population declines[17], deforestation[18] and agricultural expansion[19]. Ineffective governance is often associated with the absence of positive attitudes to environmental protection, weakly enforced environmental legislation and low levels of investment in conservation[20–22], leading to habitat loss and degradation. For example, unsustainable water management and dam construction in western and central Asia have caused drastic losses in permanent water over the past 30 years[16]. As a result, in Iran even some wetlands designated as protected areas have dried out[23]. In South America, wetlands in central Argentina lack legal protection or regulations on water use, and many have been lost[24]. Ineffective hunting regulations can also explain decreases in abundance under conditions of ineffective governance. Political instability can weaken the legal enforcement of hunting regulations and thereby promote unsustainable and often illegal killing, even in protected areas[25]; numerous waterbird species are under severe hunting pressure in Iran[23] and South America[26]. As wetland loss and hunting pressure are the main threats to most taxa, the hotspots of waterbird declines identified here merit urgent attention as areas of potential loss and degradation of wetland biodiversity, and its concomitant functions and services.

This study corroborates the observation that protected areas improve the conservation status of waterbird species, although the benefits of these protected areas are applicable only in countries with more effective governance. Our results provide strong support at the global scale for the argument that effective governance is critical for protected areas to achieve their goals[27]. Even in developing countries with less effective governance, protected area coverage can be high (Extended Data Fig. 8); however, these protected areas have been insufficient to maintain stable waterbird populations since 1990. By contrast, in wealthier regions with more effective governance, such as Western Europe, waterbirds have responded positively to the establishment of refuges and stronger legal protection under measures governed by the EU Birds Directive[28].

Although the global coverage of protected areas continues to increase, our findings indicate that ineffective governance could undermine the benefits of such conservation efforts that aim to improve the status of global biodiversity. Levels of governance should be considered in the processes of identifying and prioritising areas of conservation importance, and distributing future research and funding efforts. There is also an urgent need to measure, monitor, improve and raise awareness about environmental governance globally. Global conservation conventions and specific agreements and frameworks could mobilize international resources and expertise to strengthen effective