where population was over 500,000, from the World Bank's World Development Indicators (WDI)[6]. The WDI data set records data on Hong Kong and Macao separately from China, so Hong Kong and Macao are treated as separate nations in this analysis. I constructed generalized least-squares panel models with the Prais–Winsten correction for first-order autocorrelation, using the nation-year as the unit of analysis. I originally estimated the models by including dummy variables for each year to control for general period effects. Models with the period effects produce very similar coefficient estimates to the models without them, however, and the asymmetric effect is significant in both types of models, so I present the models here without the period effects for the sake of parsimony (for the models estimated with the period dummy variables, see Supplementary Table S3). All variables are in natural logarithmic form, making these elasticity models. The models analyse the first-differenced (that is, annual change) variables, thereby focusing the analysis on change over time, not initial differences across nations in the magnitude of the values of the variables. First-differencing is necessary for analysing asymmetry, as it indicates whether change is positive or negative, but it also has the important advantage of controlling for any potentially omitted factors that are temporally invariant. In Models 1 and 2, slope dummies are used for the GDP per capita terms, where a separate slope is estimated for positive values of change in GDP per capita and for negative values of change, with the *y* intercept constrained to be equal for positive and negative values (models allowing separate *y* intercepts produce nearly identical results). All reports of statistical significance or non-significance are based on an alpha-level of 0.05 with a two-tailed test. Note that in references to the number of nation-years in the models, a year is one unit of change, for example 1960–61, so that there is one additional year of observation of the variables per nation than there are nation-years as I use the term in text (for example, a nation with data from 1960 to 2008 has 49 original data points, but only 48 after first-differencing). ❐

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Additional Information

Supplementary information accompanies this paper on www.nature.com/nclimate

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CORRESPONDENCE:

Carbon mismanagement in Brazil

To the Editor — Knowing the gaps in CO_2 inventories is fundamental for climate change science, as well as for global politics. The uncertainty of the emissions estimates is a great challenge for global greenhouse-gas (GHG) mitigation, as are emissions management strategies. Brazil missed its opportunity to lead by example[1] in the matter of mitigation. In most countries, CO_2 emissions mainly come from industrial sources, whereas in Brazil the majority (~80%) originates from land use, land-use change and forestry. Brazil's national climate change policy defines a GHG emission reduction target of 36.1–38.9% by 2020, however, recently approved amendments to the Brazilian Forest Code (BFC) frustrate any attempts to protect and manage wetlands[2]. BFC is now allowing the shrimp farming industry to convert 10–35% of all salt flats into ponds, which could hugely increase CO_2 emissions.

Estimates indicate that Brazilian salt flats cover ~230,000 ha. Freshwater and brackish tidal wetlands occupy an additional ~5,000,000 ha. Like salt flats, brackish wetlands are under a tidal regime but differ in interstitial salinity variation. Although these wetlands are biogeochemically different, they could be wrongly identified as suitable areas for conversion to shrimp ponds. Fifty thousand hectares have already been occupied by shrimp production[3,4], mainly on salt flats[5], and the BFC is now allowing the occupancy of another 36,000 ha. Agribusiness stakeholders claimed before the Brazilian Parliament that shrimp farming had the potential to be expanded over ~1,000,000 ha (ref. 6). This occupancy is actually only possible if brackish wetlands (~550,000 ha) are converted for shrimp production.

Despite the magnitude and increasing growth rate of shrimp farming during the past decade (from 7,000 to 90,000 tonnes per year production), its CO_2 emissions — resulting from both land conversion and shrimp production — have not been included in Brazil's emission statistics[7], thereby underestimating the country's share in the responsibility of climate change mitigation. If we consider only shrimp farms that have already been installed, that land conversion led to the emission of 0.012 gigatonnes of CO_2 per year, given that one hectare of wetland soil stores about 1,298 tonnes of CO_2 and that 75% of this sink is released immediately after clear cutting[8]. These land conversions correspond to 1.5% of all Brazilian marine wetlands, or only 0.03% of the national territory; however, they alone account for 1% of the total Brazilian yearly CO_2 emissions[9]. BFC's related uncertainties regarding wetland types could make these estimates escalate by a factor of eleven. This is important not only for meeting mitigation targets, but also for conservation. ❐

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