We would like to thank the editor and reviewers very much for the valuable comments and suggestions that greatly helped us to improve the manuscript. Thank you very much for your time and efforts. In this revised version, we have addressed all reviewer comments in detail. Major revisions include: (1) refining the discussion on data uncertainty and variable importance, especially regarding vegetation features and anthropogenic drivers; (2) incorporating Partial Dependence Plot (PDP) analyses to improve the interpretability of the models; (3) clarifying the rationale behind the use of suitability masks and addressing concerns about land cover assumptions; (4) explaining the variation in prediction accuracy across species. We believe these revisions have substantially strengthened the scientific rigor, clarity, and transparency of the manuscript.

Reviewer #2:

Comment 1. *The methods section lacks clarity in certain areas, particularly regarding the stratified sampling approach. The manuscript does not clearly describe how stratified sampling was implemented (L140-L146). This information is critical, as it directly influences the composition of the training dataset and consequently affects the accuracy and reliability of the global predictions. I recommend that the authors provide a more detailed explanation of the sampling procedure, including the criteria for stratification and how the strata were defined and selected.*

Response: Thanks for the comment. We agree that the stratified sampling strategy plays a crucial role in ensuring representative training data and improving model accuracy. We have revised the manuscript to clarify the stratification criteria and sampling intervals. Specifically, the stratification was based on pixel-level livestock density values derived from the recalibrated city-level statistics. Given the wide variation in livestock abundance across different species, we adopted species-specific stratification intervals. For instance, for ducks, which have high population densities and wide spatial variability, we used a stratification interval of 500 heads per grid cell. In contrast, for horses, a smaller interval of 1 head was used. Within each stratum, samples were randomly selected to ensure sufficient representation across density gradients. We have included this information in the revised Methods section (Lines 147-151) accordingly:

"Given the differences in population size and distribution range among livestock species, we adopted species-specific stratification intervals. For example, for ducks, whose densities tend to be high and spatially heterogeneous, we used a stratification interval of 500 heads per hectare grid cell; for horses, a finer interval of 1 head was applied. Each stratum was randomly sampled, and approximately 20,000 training samples per year were selected for each livestock category."

Comment 2. *The causal relationships between the predictors and the response variable warrant further clarification. In this study, the authors used a range of environmental and anthropogenic factors to predict livestock density (Fig 1). For predictors with limited historical data, such as population, the authors applied year-2000 values to years before 2000 and found that population had little influence. This conclusion seems counterintuitive. Unlike wildlife, livestock is more likely to be influenced by human* *management. Therefore, one would expect population density to be an important predictor. However, in this study, soil and climate variables were found to be more influential (fig 7). This may reflect correlations rather than causal mechanisms. A comparison between the spatial patterns of cattle or sheep and population density (https://hub-worldpop.opendata.arcgis.com/content/WorldPop::global-1km-population-total-grid-2000-2020/about) suggests that a strong spatial association likely exists. I think that the lack of observed influence in the model may be due to two reasons: (1) errors or bias introduced during stratified sampling (as noted in comment 1); and (2) potential multicollinearity among predictors. If population is indeed an important factor, I think the authors to revisit its treatment carefully. In addition, I strongly recommend including partial dependence plots or similar visualizations to show how each predictor relates to the response variable.*

Response: We appreciate the reviewer's comment regarding the interpretation of predictor influence, particularly the role of population density in livestock distribution modeling. We acknowledge that livestock is highly influenced by human activities, including population distribution, market access, and infrastructure. However, due to the lack of globally available historical population data prior to 2000 at consistent resolution, we used the year-2000 WorldPop layer as a proxy for years before 2000. We agree that this temporal mismatch could introduce uncertainty, especially in regions where population patterns have changed significantly. We have revised the Discussion section to clarify this limitation (Lines 290-293):

"The relatively minor influence of anthropogenic and vegetation features may be attributed to spatial correlations between human activity indicators and the suitable mask (e.g., impervious surface layers), and the use of temporally static historical data before the years of 2000 and 1980."

The observed limited contribution of population in our feature importance ranking (Fig. 7) may be attributed to population being partly spatially correlated with our suitability masks (especially impervious surface). To better illustrate the marginal effects of individual predictors and improve interpretability, we have now included partial dependence plots (PDPs) for all mapping features and two representative livestock types (cattle and ducks), as the reviewer kindly suggested. These new plots are added as a supplementary figure (Fig. S1 and Fig. S2), and referenced in the Discussion section (Lines 294-305):

"To further investigate the role of different input features and their influence on mapping outcomes, we performed Partial Dependence Plot (PDP) analyses using two representative livestock species: cattle and ducks. These species were selected due to their differing habitat preferences and spatial distributions, providing complementary perspectives on feature importance. The PDP results (Figures S1 and S2) reveal several consistent patterns, suggesting common influential factors of livestock distribution. Notably, population density, precipitation, and soil moisture show positive associations with predicted livestock density for both cattle and ducks. This highlights the importance of human activity and water availability in shaping livestock distributions. For instance, cattle and ducks both exhibit higher predicted densities in regions with greater population, suggesting the influence of demand-side factors such as local consumption and infrastructure accessibility. Additionally, elevation and wind speed at 10 m consistently show negative contributions across both PDPs, indicating a general preference for lower-elevation and less windy environments, which are typically more suitable for animal husbandry. Vegetation features (e.g. total number of valid vegetation cycles with peak) also display positive relationships with livestock density (Parente et al., 2025). These PDP results reinforce the rationale for selecting a comprehensive set of input features wherever data availability permits.”

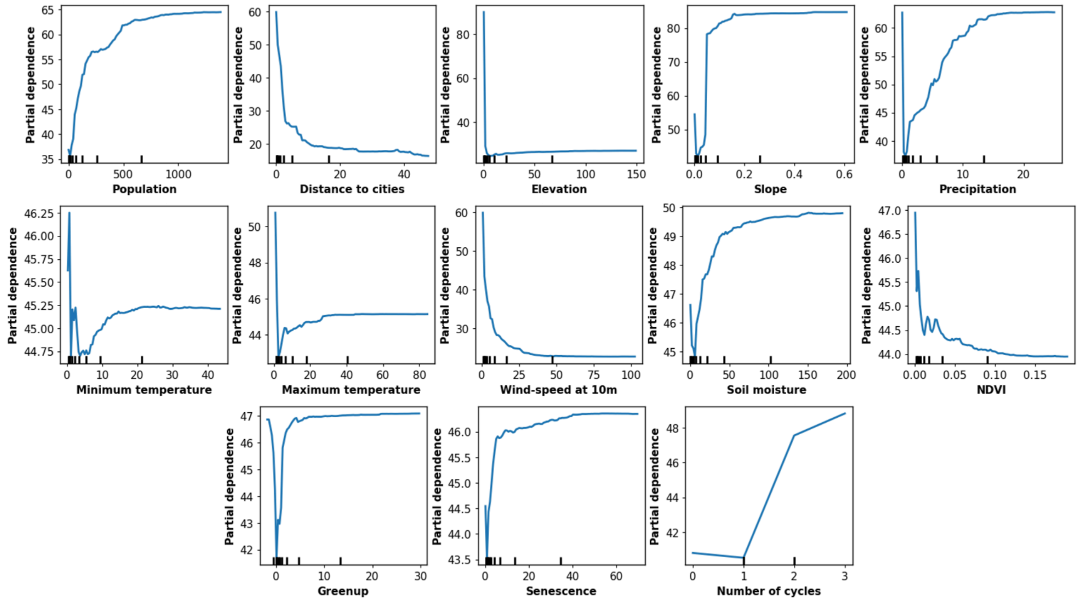

Figure S1. Partial dependence plots (PDPs) for cattle mapping in 2015. Features include anthropogenic (e.g., population, distance to cities), topographic (elevation, slope), climatic (precipitation, temperature, wind), soil (soil moisture), and vegetation variables (NDVI, green up, senescence, number of cycles).

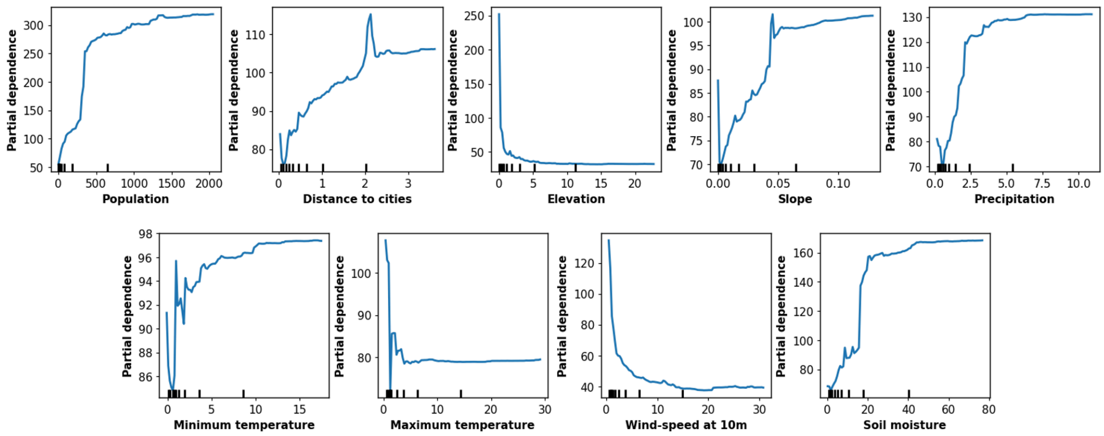

Figure S2. Partial dependence plots (PDPs) ducks mapping in 2015. Features include anthropogenic (e.g., population, distance to cities), topographic (elevation, slope), climatic (precipitation, temperature, wind), and soil (soil moisture).

Comment 3. *The meaning of the dots in some figures (e.g., figs 4-7) should be clarified in the figure captions.*

Response: We have revised the figure captions for Figures 4–7 to explicitly clarify the meaning of the dots. Specifically, in Figures 4 and 7, the dots represent correlation coefficients (r). In Figure 5, the dots indicate the number of livestock. In Figure 6, the dots indicate the pixel-level livestock density. These clarifications are now included in the updated figure captions.