

Farm distribution models developed along a gradient of intensification

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Intensification of livestock production foster the ease and speed at which diseases can emerge and spread [1]. To adequately plan measures limiting epidemic spread, epidemiological models requires farm locations and sizes (in terms of number of animals) [2]–[5]. However, such data are rarely available. In high-income countries where registries are maintained, these are not always accessible for privacy and confidentiality reasons [2]. In middle- and low-income countries (LMIC), when agricultural censuses are conducted, these vary in resolution from one country to another [6]. We aimed at developing farm distribution models (FDM), which would predict both location and number of animals per farm. Furthermore, intensification process which is operating in most LMICs, has been shown to come together with a spatial clustering of farms [4], [7]. As mathematical models are sensitive to this spatial clustering of farms [8], [9], we selected a method which could take it into account to predict farm locations. We selected four countries along a gradient of intensification: Nigeria, Thailand, Argentina and Belgium. These countries are presumably spread along a gradient as the proportion of animals raised in intensive systems increase in line with the per capita Gross Domestic Product (GDP) [10]. First, we explored how the distribution of chicken farms evolved along the spectrum of intensification showed by the four countries. Second, we built FDM based on censuses of commercial farms, recording population and location of chicken farms in each country. The FDM included two successive steps: (i) farm locations were predicted with the Log-Gaussian Cox Processes (LGCP) model from the point pattern analysis field (following a methodology, we already developed [4]) and (ii) population on farms was predicted using a Random Forest model. Finally, we tested our modelling procedure to predict farms locations and sizes in Bangladesh, and compared the predictions with the real data available. The number of chickens per farmer showed distributions which increased from Nigeria, through Thailand and Argentina to Belgium, in line with the GDP per capita gradient. Surprisingly, we did not find such a gradient of farm clustering. Farms in Argentina were the most clustered, followed by Nigeria and Thailand. Belgian farms were more homogeneously distributed, while still being better explained by the cluster model (LGCP model). Our modelling procedure could reproduce the observed datasets with reasonable accuracy in terms of locations and sizes in each of the four country. The LGCP with covariates was shown to produce better results in terms of clustering and cluster locations than random models. The Random Forest model explained 64% of the variance of the training data. The FDM approach could produce a distribution of farms in Bangladesh which was more realistic than a random distribution, however, the intensity of points was underestimated. As expected, the covariates selected in the Random Forest could explain partly the farm size, but could still reproduce a histogram of the distribution of chicken per farms similar to the observed one in Bangladesh. Further improvements of the methodology should explore covariates which would better explain the intensity of farms and farm sizes. However, this methodology could already be helpful to predict the distribution and population of farms in countries where data are scarce.

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