







Spatial analysis of wild bird trafficking in the state of Pernambuco, Brazil

Análise espacial do tráfico de aves silvestres no estado de Pernambuco, Brasil

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ABSTRACT

Wild animal trafficking is a growing practice worldwide and a complex problem that brings a lot of profit, moving billions of dollars. This illegal trade has Brazil as route due to its rich biodiversity. It is widespread throughout the state of Pernambuco, having constant growth because the state is in a geographical position that favors this type of illegal practice and has a great diversity of species. Thus, the objective of the study was to perform a spatial analysis of wild bird trafficking in the municipalities of the state of Pernambuco in the period from 2016 to 2021, through an exploratory data analysis with seven variables that could explain its occurrence. It was used as methodology the global and local Moran's indexes, all implemented in the Geographic Information System software. The findings revealed that the municipalities that showed high average rates of wild bird trafficking in the investigated period, in general, are geographically close to those that also showed high rates of seizure of birds, Intentional Lethal Violent Crime, Violent Crime against Property, and unemployment. In general, the results allowed us to conclude that the methods of spatial cluster analysis proved satisfactory for the analysis in question. Moreover, it is important to note that the precarious enforcement favors the continuity of this practice, and there is an urgent need for environmental policies to restrain it effectively.

Keywords: spatial autocorrelation; geographic information system; illegal trade; wild animals; global Moran's index.

RESUMO

O tráfico de animais silvestres é uma prática crescente em todo o mundo e um problema de difícil solução que traz bastante lucro, movimentando bilhões de dólares. Esse mercado tem o Brasil como rota por possuir rica biodiversidade. O comércio ilegal é amplo em todo o estado de Pernambuco, tendo crescimento constante por estar o estado em posição geográfica que favorece esse tipo de prática ilegal e possuir grande diversidade de espécies. Dessa forma, o objetivo do estudo foi realizar uma análise espacial do tráfico de aves silvestres nos municípios do estado de Pernambuco no período de 2016 a 2021, por meio de uma análise exploratória de dados com sete variáveis que pudessem explicar sua ocorrência. Foram utilizados como metodologia os índices de Moran global e local, todos implementados no *software* de Sistema de Informação Geográfica. Os resultados revelaram que os municípios que apresentaram altas taxas médias de tráfico de aves silvestres no período investigado, de maneira geral, encontram-se geograficamente próximos daqueles que também demonstraram elevadas taxas de apreensão de aves, taxas de crime violento letal intencional, taxas de crime violento contra o patrimônio e taxa de desemprego. De maneira geral, os resultados permitiram concluir que os métodos de análise espacial de agrupamentos se mostraram satisfatórios para a análise em questão. Além disso, é importante salientar que a fiscalização precária favorece a continuidade dessa prática, havendo necessidade de políticas ambientais com o objetivo de coibir tal prática de forma efetiva.

Palavras-chave: autocorrelação espacial; sistema de informação geográfica; comércio ilegal; animais silvestres; índice de Moran global.

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Introduction

Wild animal trafficking is a complex and difficult-to-trace phenomenon, and it is nowadays a legal problem as well, since it is internationally defined as an environmental crime (Gaynor et al., 2018; Klee and Zambiasi, 2018). Therefore, it is a problem of delicate solution worldwide, for being quite a lucrative business, with birds being one of the most seized groups of animals (Pontes Filho et al., 2021; Sales et al., 2022), which contributes to the reduction of faunal biodiversity and causes unbalance in the ecosystem (David and Rodríguez, 2021; Saldanha and Peixoto, 2021).

It is estimated that wild animal trafficking moves between 10 billion and 213 billion dollars worldwide, considered the third most illicit activity in the world (Mendes, 2020). In this list of trafficked animals are birds, which have a high number of captures. In view of this, Reis et al. (2017) claim that Brazil has become one of the main routes of wild bird traffickers since the Brazilian avifauna is highly coveted due to its exuberance and the great variety of existing species. This, according to Velden (2018), generates, annually, a financial flow on the order of 2,500 million reais, and 12 million animals extracted from their natural habitats.

The illegal trade of wild animals has caused a major negative impact on the planet, compromising the ecological processes since it interrupts the normal cycle of species (Karunatilaka, 2021), as well as impairing the dynamics and stability of the ecosystem, causing extinction and threatening the biodiversity (Martínez et al., 2017). In addition, it can also contribute to a proliferation of zoonoses in humans, as occurred in China, in which growing evidence points to SARS-CoV-2 as being of zoonotic origin transmitted by bats (Halabowski and Rzymyski, 2021).

In Brazil, the Biodiversity Convention was instituted through Decree No. 4,339 of 08/22/2002, with principles and guidelines for biodiversity conservation, strengthening the importance of preservation. In 2018, 65 countries joined the London Conference on the Illegal Wildlife Trade in an attempt to tackle animal trafficking by preventing illegal poaching; the approach is to verify local livelihoods, creating jobs and sustainable alternatives to generate income (Araujo, 2021). North, Northeast, and Midwest regions are predominant areas for captures, while South and Southeast concentrate the consumers and promoters of the national and international trafficking (Santos et al., 2022).

According to Cavalcanti and Nunes (2019), the Northeast Region of Brazil is appointed as the main illegal exporter of birds to other Brazilian regions and to other countries. In addition, the authors also stated that in the Northeast Region, birds are the main targets of traffickers, and among the most trafficked ones are papa-capim, parrot, red-cockaded rooster, and patativa. The transport of these birds is done with extreme cruelty in small, stuffy, and cramped compartments, such as tubes, suitcases, or small cages, in which they are often sedated, have their bones broken and their

eyes pierced in an attempt to silence them. Most of the birds that reach the buyers are raised as if they were domestic animals and many breeders are unaware of the harm they cause to nature (Saldanha and Peixoto, 2021).

In this sense, it is important to understand the extent of the trafficking of these animals by collecting accurate data so that combating measures can be implemented to curb this illegal business, and environmental awareness campaigns and more severe punitive laws can be developed (Pyke and Szabo, 2018). Several research studies have been conducted on wild bird trafficking, such as the ones carried out by Hidasi et al. (2013), Menes and Simonian (2016), Reis et al. (2017), Restrepo-Rodas and Pulgarín-Restrepo (2017), Cavalcanti and Nunes (2019), Ferreira and Barros (2020), Pontes Filho et al. (2021), Sales et al. (2022), and Santos et al. (2022). All these studies have shown that bird trafficking is growing all over the world, especially in countries with great biodiversity such as Brazil, and that it is difficult to eradicate since the traffickers are increasingly equipped, use routes, and lure uneducated people lacking environmental education, who live in poverty and need to survive, and thus are attracted by the low values offered.

Spatial analysis has been a recurrent technique in crime studies in general in the last two decades (Silva et al., 2020). Its use in crime studies contributes in the sense of having a better understanding of the phenomenon and for the development of action plans for the prevention of any type of crime (Silva et al., 2020). Studying the spatial patterns of crime incidence can provide information about the processes that determine areas where management actions are most needed (Reisen, 2010). Understanding how different aspects of crime events are distributed is important to understand each crime, as the ability to implement more specific responses means that more crimes can be intercepted or prevented.

In light of the above, the general goal of this research was to conduct a spatial analysis of wild bird trafficking in the municipalities of the state of Pernambuco in the period from 2016 to 2021. It is notorious that wild bird trafficking is a crime that generates consequences for the environment and is the focus of great concern for the government and civil society. Therefore, a study that aims to collect data from birds confiscated by law enforcement and environmental agencies to perform a spatial analysis is essential.

Methodology

Study area

According to the Brazilian Institute of Geography and Statistics (IBGE, 2020), the population of the state of Pernambuco is estimated at 9,674,793 inhabitants. Located in the Northeast Region of Brazil, Pernambuco (Figure 1) has a territorial extension of 98,067.877 km² and has 185 municipalities, being considered the seventh most populous state based on the 2010 census, representing 4.7% of the country's population.

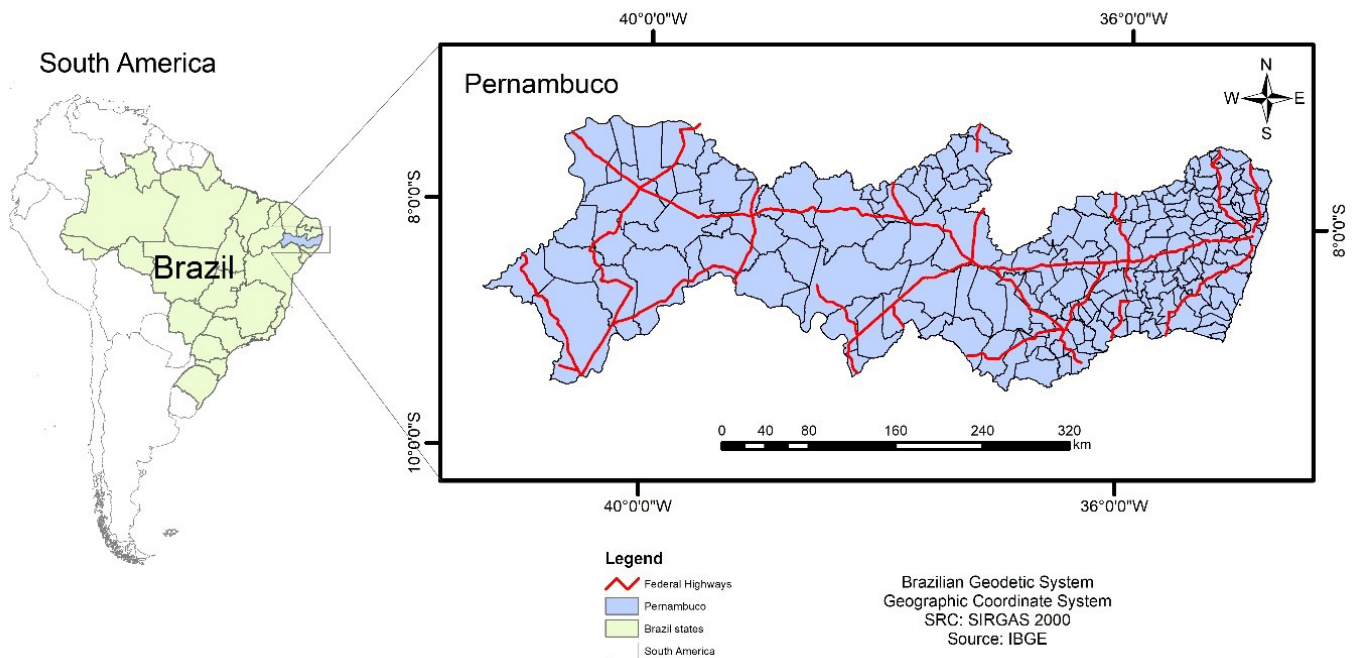


Figure 1 – Location of the state of Pernambuco, Brazil.
Source: IBGE (2020).

Additionally, the state is divided into five mesoregions: Metropolitan Region of Recife, *Mata Pernambucana*, *Agreste Pernambucano*, *Sertão Pernambucano*, and *São Francisco Pernambucano* (IBGE, 2010).

In 2017, the Human Development Index (HDI) of Pernambuco was 0.673, according to the continuous National Household Sample Survey (PNAD), which is below the general index of Brazil (IBGE, 2017).

In terms of Intentional Lethal Violent Crimes (ILVCs), according to the Management of Criminal Analysis and Statistics (GACE) of the Secretary of Social Defense (SDS) in Pernambuco (PE), from January to August 2022, the capital city Recife had a total of 369 cases of deaths, the metropolitan region, 654, and the interior of the state, 1,294, totaling 2,317 victims. Compared to the statistics of 2021, when 3,368 cases were registered in these regions, there was a decrease in the number of ILVCs (SDS-PE, 2022). As for Violent Crimes Against Property (VCAP), a total of 34,685 cases of such crimes were registered in the period from January to August 2022. Recife itself registered 12,836 cases, the metropolitan region had 10,386 occurrences, and the interior of the state, 11,463. Comparing with 2021, the state registered 51,738 cases from January to December, it can be acknowledged that there was a reasonable drop in the number of registrations (SDS-PE, 2022).

In 2020, according to the PNAD-Continuous data (IBGE), Pernambuco had an average unemployment rate of 17.2%. In the first quarter of that year, 14.3% of people were unoccupied in the capital,

Recife. In 2021, this percentage rose to 19.9%, one of the highest rates ever recorded in Brazil (Benedicto, 2012; IBGE, 2020).

Data source

The spatial analysis applied in this study was carried out firstly by data collection. Initially, the analysis was applied through the amount of wild bird trafficking crimes, seizures from environmental enforcement, at open fairs, and originating from complaints, for 184 municipalities (except Fernando de Noronha) of Pernambuco in the period from 2016 to 2021, making a total of 6 years. Data regarding bird trafficking crimes were obtained from the 1st Independent Company of Environmental Policing (CIPOMA, 2022).

Population data for each municipality were obtained from the IBGE from 2016 to 2021. The socioeconomic, demographic, and crime data (Table 1) were based on the last demographic census (IBGE, 2010), SDS of Pernambuco (2022), and CIPOMA (2022). For the socioeconomic variables: unemployment rate (%), HDI (%), and Gini index (%) were considered; for the demographic variable: degree of urbanization (%); and for the crime variables: ILVC Rate (%), VCAP Rate (%), and Seizure of Wild Birds Rate (%).

The city boundaries were also acquired from the IBGE in shapefile form. In addition, the open-source softwares Quantum Geographic Information System (QGIS) and Geographic Data Analysis (Geoda) were used.

Table 1 – Socioeconomic, demographic and crime variables.

| Variable | Description | Source |
|---------------------------------------|---|--------------|
| Wild animal trafficking rate | Rate of wildlife trafficking by municipality. | CIPOMA, 2022 |
| Unemployment Rate | Percentage of people in the workforce that are unemployed. | PNAD, 2010 |
| Human Development Index | Statistical index composed of life expectancy, education, and per capita income indicators. | IBGE, 2010 |
| Gini Index | Degree of concentration of income in a given group. | IBGE, 2010 |
| Intentional Lethal Violent Crime Rate | Percentage of intentional homicide, robbery, and personal injury resulting in death per municipality. | SDS-PE, 2022 |
| Violent Crime against Property Rate | Rate of crimes classified as robbery, except robbery followed by death (larceny). | SDS-PE, 2022 |
| Seizure of Wild Birds Rate | Rate of wild bird seizures by municipality. | CIPOMA, 2022 |

Source: IBGE and Secretaria de Defesa Social de Pernambuco (2022).

Method

The study investigates the variables capable of spatially explaining the distribution of the wild bird's trafficking rate occurrence in the municipalities of Pernambuco. Based on this, two statistical approaches were used, the global and local bivariate Moran's index.

The identification of clusters can therefore be indicated from the local or global perspective, which is complementary statistics. The global Moran's index estimates the magnitude of spatial autocorrelation between areas, the significant values are considered above 95% ($p < 0.05$). With this index, it is possible to evaluate whether the value of a variable studied, in a given area, has a relationship with the values of the neighboring areas. That is, the generated value I index, is the result of a comparison between two variables (bivariate), in this case, the socioeconomic indicators and the average rate of wild bird trafficking. The p -value (p) refers to the empirical pseudo-significance test based on 9,999 random permutations. The Z -value is a statistical test that measures the difference between an observed statistic and its population parameter in standard error units. The indicator was constructed based on the queen contiguity matrix. The global Moran's index was obtained using Equation 1:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n w_{ij} (y_i - \bar{y})(y_j - \bar{y})}{(\sum_{i=1}^n (y_i - \bar{y})^2) \sum_{i \neq j} w_{ij}} \quad (1)$$

Where:

n = the number of areas;

y_i = the value of the considered attribute in area i ;

\bar{y} = the average value of the attribute in the study region;

w_{ij} = the elements of the normalized spatial proximity matrix;

ij = the value of the first-order neighbors variable.

From the global perspective, the spatial autocorrelation occurs throughout the analyzed area, while the local Moran's statistics indicate in which part of the analyzed area this phenomenon occurs (Silva et al., 2020). Thus, the local Moran's index was expressed by Equation 2:

$$I_i = z_i \sum w_{ij} z_j \quad (2)$$

Where:

w_{ij} = the value in the neighborhood matrix for region i with region j .

z_i and z_j = deviations from the mean.

It is worth mentioning that, from the local Moran's index, it is possible to know the exact contribution that each area represents in the value of the global Moran's index (Serrano and Valcarce, 2000).

The classification of the clusters in the local perspective occurs in a High-High (HH) way, which forms a set of municipalities with high rates that are surrounded by others with high average rates of wild bird trafficking. Low-Low (LL) clusters form a set of municipalities with low rates surrounded by municipalities with low wild bird trafficking rates. Finally, all global and local spatial autocorrelation coefficients are considered significant when $p < 0.05$.

Results and Discussion

The results of the bivariate global Moran's statistics were presented in Table 2. The bivariate global Moran's I statistics was presented for each socioeconomic indicator correlated with the average rate of wild bird trafficking applied to the municipalities of Pernambuco in the time span from 2016 to 2021, and have as coefficient I , the autocorrelation values of the variables.

The results regarding the Moran's index values ranged from 0.189 to 0.268 and confirm a positive spatial autocorrelation for four socioeconomic variables (seizure of wild birds' rate, ILVCs rate, VCAPs rate, and unemployment rate). With a significance level of 1% for all variables, and rejecting the hypothesis of spatial randomness throughout the analyzed period, the results indicated that there is evidence of positive spatial dependence in these variables. This means that the municipalities that presented high average rates of wild bird trafficking in the period investigated, in general, are geographically close to those that also showed high rates of wild bird seizures, ILVCs, VCAPs, and unemployment. On the other hand, the municipalities that displayed low rates of wild bird trafficking are generally around municipalities that also show low values of socioeconomic indicators.

Table 2 – Global bivariate Moran’s I coefficient of wild bird trafficking rates and the other variables, for the State of Pernambuco.

| Variable | I | p-value | z-value |
|---------------------------------------|-------|---------|---------|
| Seizure of Wild Birds Rate | 0.189 | 0.001 | 12.160 |
| Intentional Lethal Violent Crime Rate | 0.210 | 0.001 | 8.785 |
| Violent Crime against Property Rate | 0.200 | 0.001 | 10.033 |
| Unemployment Rate | 0.268 | 0.001 | -9.890 |

Regarding the results from LISAMap, it was possible to identify the areas that relate wild bird trafficking rates with the socioeconomic variables. Figure 2 displays the cluster formation in the state of Pernambuco in the form of maps that inform the records of the local patterns of spatial autocorrelation. The four variables were submitted to the significance test of the Moran’s index; when significance was not found, the clusters were presented in gray.

Regarding the variable seizure rate of wild birds (Figure 2A), we can infer the existence of 4 high-high clusters with a total of 12 municipalities, that is, where there is a high average rate of trafficking crimes there is also a high rate of seizure of wild birds. In the case of the low-low clusters, it was possible to observe the presence of 6 clusters with a total of 21 municipalities, all of which are present in the *sertão* and *agreste* of Pernambuco. That is, where there is a low rate of wild bird trafficking crimes, there is a low rate of seizure of wild birds.

The results found corroborate those reported by Alves (2014) which revealed that in areas where high unemployment rates prevail, activities related to wild animal trafficking can be very profitable, causing the rate of these crimes to increase. In another perspective, the economic development index of a region does not influence the decrease in animal trafficking, as happens in several Brazilian states, due to a tradition and popular culture of capturing wild animals to keep them as pets (Santos et al., 2018; Chaves and Devezas, 2019; Oliveira, 2019; Mendes, 2020; Almeida and Calandrini, 2021; Araujo, 2021; Wyatt et al., 2022), to use them for medicinal purposes, in religious rituals, as well as hunting as a sport or for food, and also trade to supplement income (Reis, 2014; Santos et al., 2018; Silva, 2018; Cavalcanti and Nunes, 2019; Oliveira, 2019).

In relation to the variable ILVCs (Figure 2B), it was possible to observe the presence of 6 high-high clusters with a total of 24 municipalities. In this case, it is possible to infer that where there is a high rate of wild bird trafficking crimes, there is also a high rate of ILVCs. As for the results for the low-low clusters, it was possible to observe the presence of 3 clusters in a total of 27 municipalities. Thus, it can be inferred that where there is a low rate of wild bird trafficking crimes, there is a low rate of ILVCs.

The results on the variable ILVCs rate are in line with those found by Wyatt (2013) and Gaynor et al. (2016), which present that when wildlife trafficking occurs in a given area, communities are often exposed to violence, corruption, homicides, co-optation of institutions, and additional forms of criminality. Furthermore, the wildlife trafficking crime can increase not only the violent crime rate but also the VCAP.

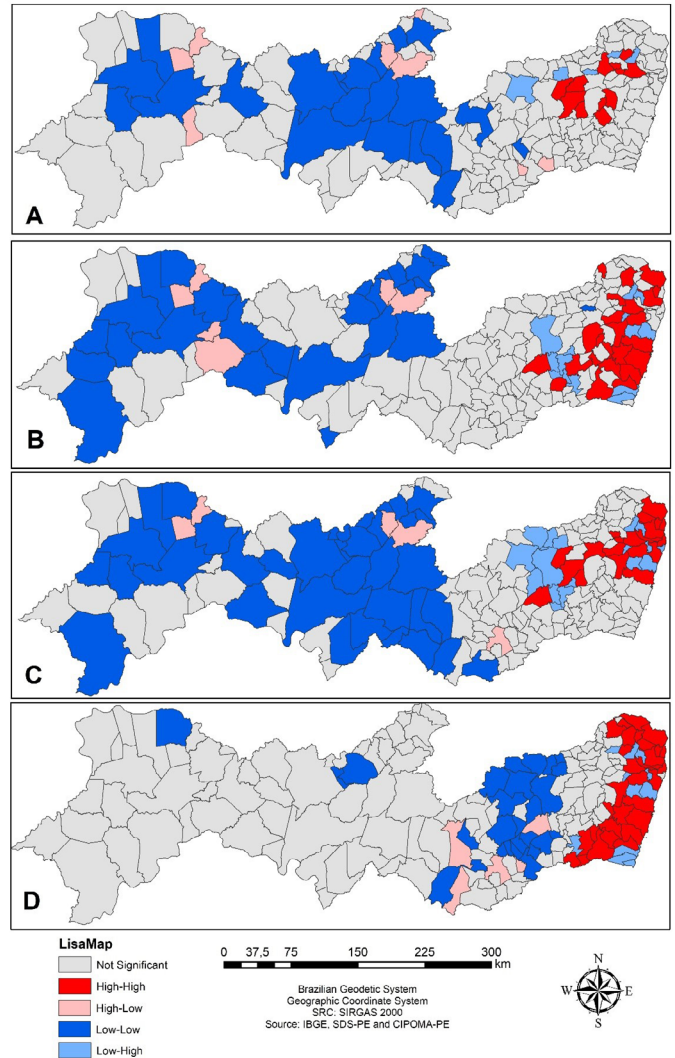


Figure 2 – Bivariate LisaMap between wild bird trafficking rates and other explanatory variables: (A) Seizure of Wild Birds Rate; (B) Intentional Lethal Violent Crime Rate; (C): Violent Crime against Property Rate; (D) Unemployment Rate.

For the variable rate of VCAP (Figure 2C), it was possible to observe that there are 2 high-high clusters with 20 municipalities, which indicates that where there is a high rate of wild bird trafficking, there is a low rate of VCAP. In relation to the low-low clusters it was possible to observe the presence of 3 clusters with a total of 36 municipalities, that is, where there is a low rate of wild bird trafficking crimes, there is also a low rate of VCAP.

As is well known, this type of trafficking uses technical devices which facilitate the exchange of information over the routes, animals with the highest prices on the black market, among other knowledge. It is noticeable that criminal networks are very flexible and change eas-

ily, resembling other types of illegal activities such as drug trafficking and property crimes that move millions until today.

Lastly, regarding the unemployment rate variable (Figure 2D), it was possible to observe the presence of only 1 cluster, with a total of 30 municipalities, that is, where there is a high rate of wild bird trafficking crime, there is a high unemployment rate. As for the low-low clusters, it was possible to observe the presence of 6 clusters with a total of 27 municipalities. In this case, it was possible to infer that where there is a low rate of wild bird trafficking crime, there is a low unemployment rate.

The high unemployment rate strengthens bird trafficking, that is, the illegal trade in these animals is related to the unemployment factor. Such a statement was corroborated by Mendes (2020), who asserted that bird trafficking, in places with an unsatisfactory economic index, is very pronounced once it is a region with a great variety of birds that attract buyers, which makes it a busy route for traffickers, and keeps this practice constant (Menes and Simonian, 2016; Sales et al., 2022).

As observed, the unemployment rate contributes to the increase in these animals trafficking. Sales et al. (2022) stated that every year the amount of seized wild animals increases and, in 2018 alone, 13 thousand wild animals were seized, the vast majority were birds, which were taken in by the Wild Animal Sorting and Rehabilitation Center (CETRAS), data contained in the Management Report of the State Environmental Agency of Pernambuco (CPRH). The CETRAS are units legally constituted to receive, analyze, identify, recover, rehabilitate, and dispose of the seized animals in their custody (Freitas et al., 2015; Santos et al., 2018).

According to Saldanha and Peixoto (2021), it is very common to see the trade of wild birds in open fairs (Cavalcanti and Nunes, 2019), as well as on the margins of rivers and roads, in pet shops, and through the internet. The emergence of new technologies has been assisting in locating the routes used that facilitate transactions between suppliers and sellers. It is notorious that the internet has been a great facilitator for the sale of wild animals, as it provides a sense of security in negotiations and facilitates the sale of small animals such as birds; besides, it makes the network more diluted and complex for the performance of inspection agencies (Hernandez and Carvalho, 2006; Chaves and Devezas, 2019; Wyatt et al., 2022).

Reaffirming what was exposed before, Braga Junior and Lima (2021) pointed out that about 3.5 million messages have circulated in the computer network in more than 250 Whatsapp groups; the trade of animals in this means of communication has grown due to the advantage of the traffickers to remain anonymous, animals to be easily disclosed, and the way in which the ads circulate and may reach a high number of buyers.

Containing this illegal trade requires implementing strategies as well as more effective laws, which are already done by many nations, creating procedures, standards, and guidelines aimed at the preservation of species and ecosystem conservation (Campello, 2019). An example of this was the conception of conventions such as the

Convention on Biological Diversity (CBD) created in 1992, in which 160 countries participated, besides Brazil, being one of the most important international instruments dealing with the environment. This CBD is based on three guiding principles: sustainable use of biodiversity, conservation of biological diversity, and fair and equitable sharing of the benefits arising from the use of genetic resources. The convention, directly and indirectly, incorporates everything that concerns biodiversity, operating as a kind of legal and political outline for the other more peculiar environmental conventions and agreements (Reis, 2014; Souza, 2017; Trajano and Carneiro, 2019; Araujo, 2021). As for the legislation, in Brazil, there is the Environmental Crimes Law nº 9.605/98 and the National Environmental Policy nº 6.938/81 (Cunha et al., 2014; Reis, 2014; Souza, 2017; Cavalcanti and Nunes, 2019; Chaves and Devezas, 2019; Silva, 2018; Vaz, 2018; Trajano and Carneiro, 2019; Araujo, 2021; Braga Junior and Lima, 2021; Silva, 2021; Menezes and Fontgalland, 2022; Sales et al., 2022), which addresses fauna as an environmental resource.

The spatial analysis results on the distribution of illegal seizures of wild birds in the municipalities of Pernambuco suggested that these crimes are spatially concentrated in those municipalities closer to major state and federal highways. In addition, these crimes are concentrated in places that have open fairs and which commercialize these animals illegally. Thus, given the severely limited nature of enforcement, the results of the spatial analyses have contributed with the necessary evidence to better allocate the resources of environmental inspectors and law enforcement officers, and perhaps facilitate some sort of educational training to employees of the environmental agencies in the state of Pernambuco that works in these specific locations close to these highways.

Some observations from this study should be considered in light of its limitations, such as more up-to-date information regarding the demographic census. This data should already be available; however, the government suspended the census in 2020 due to the lack of resources for the IBGE. In the year 2021, the suspension was due to the COVID-19 pandemic. Therefore, the absence of updated data impacts several of the country's socioeconomic issues analyses.

Conclusions and Recommendations

In conclusion, spatial analysis of wild bird trafficking is a valuable tool for understanding the dynamics of this illegal trade and for identifying areas of risk for wildlife conservation. By the means of geoprocessing technologies and data analysis, it is possible to map trafficking routes, identify the main points of origin and destination of birds, and to assess the impact of illegal trade on biodiversity. This approach can help the prevention, repression and implementation of measures against bird trafficking, as well as promoting actions for conservation and sustainable management of threatened species. It is essential that spatial analysis is combined with other strategies, such as environmental education, strengthening of public policies, and involvement of lo-

cal communities, to achieve effective results in the fight against wild bird trafficking.

In general, the results revealed that the municipalities that presented high average rates of wild bird trafficking in the investigated period are geographically close to those that also showed high rates of bird seizures, ILVCs, VCAPs, and unemployment. On the other hand, municipalities that presented low wild bird trafficking rates, generally, are around municipalities that also presented low values of socioeconomic indicators. Thus, the study can corroborate the literature in understanding the factors associated with such a practice.

In summary, the findings indicated that public policies to prevent wild bird trafficking should be focused on raising the HDI of the municipalities of Pernambuco, that is, increasing investments in education, income, longevity, and public safety.

For future studies, it is recommended that spatial analyses are performed with updated socioeconomic variables, which are gathered through the demographic census, currently being conducted by the IBGE, in order to shed light on the determinants that influence the increase in the trafficking not only of birds but of any wild animal, and not just in Pernambuco but throughout Brazil and the world.

Contribution of authors:

ALBUQUERQUE, C. L. G. C.: Conceptualization; Data curation; Formal Analysis; Funding acquisition; Investigation; Resources; Validation; Visualization; Writing — Original Draft; Writing — Review & Editing. BARRETO, E. P.: Conceptualization; Project Administration; Resources; Supervision; Visualization; Writing — Original Draft; Writing — Review & Editing. SILVA, C. F. A.: Conceptualization; Investigation; Methodology; Project Administration; Resources; Software; Supervision; Validation; Visualization; Writing — Original Draft; Writing — Review & Editing. SILVA, M. C.: Visualization; Writing — Original Draft; Writing — Review & Editing. SOBRAL, A. C. S.: Visualization; Writing — Original Draft; Writing — Review & Editing. MELO, D. C. P.: Visualization; Writing — Original Draft.

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