

SPATIAL ANALYSIS OF THE ECOLOGICAL ICMS TRANSFERRED TO PARANÁ MUNICIPALITIES IN 2000 AND 2017

Dr. Luciana Virginia Mario Bernardo

Unioeste

lucianamario@yahoo.com.br

Me. Maycon Jorge Ulisses Saraiva Farinha

UFGD

maycondes@hotmail.com

Professor Dr. Lucir Alves

Unioeste

lucir_a@hotmail.com

Professor Dr. Adelson Soares Filho

UFGD

adelsonfilho@ufgd.edu.br

Professor Dr. Clandio Favarini Ruviano

UFGD

clandioruviano@ufgd.edu.br

Me. Vanderson Aparecido de Souza

UFGD

Vanderson_aparecido@hotmail.com

Abstract

The replacement of natural vegetation was the way by which certain food crops could be produced in different regions of Brazil. The state of Paraná has undergone such process of replacing its natural vegetation, but the state is considered a pioneer in the adoption of a measure entitled Ecological ICMS for biodiversity. The aim is to promote the conservation of natural vegetation by creating conservation units and preserving water sources that supply the population living in the municipality and in other locations. The objective of this study is to perform a spatial analysis of the transferring of Ecological ICMS resources per municipality of the state of Paraná in 2000 and 2017. These years comprise the period with availability of information. Spatial data analysis was used as methodology. Data refer to the amounts of Ecological ICMS transferred to the municipalities during the years of analysis, the origin of the resources, and their share in the total revenue of these municipalities. The results indicate that the number of municipalities that received Ecological ICMS increased between the first and the last year of analysis. The main source of collection is the creation of conservation units. In addition, the eastern macroregion of the state of Paraná concentrates the municipalities with the highest share of income provided by this tax.

Keywords: environmental conservation; ecological tax transfers; spatial data analysis.

1. Introduction

Brazil has a great biodiversity and different biomes. In the course of its history, food production and consumption have shown different behaviors, with periods of import and periods of export of food surpluses (BACHA, 2004; FARINHA et al., 2018). Food surpluses reflect the expansion of the agricultural frontier in Brazil combined with the use of technologies for a productive management (VIEIRA FILHO, 2018). By expanding the agricultural frontier, there is a change in land use so that agricultural crops replace native vegetation. Such replacement results in a gradual loss of ecosystem products and services (FARINHA et al., 2019). In a global context, the importance of decisions on land use has been strongly recognized. The impacts on economic, environmental,

social, and cultural issues related to such land use surpass the limits of rural properties (GOLDSTEIN et al., 2012).

Regardless of the scale (local or global) of environmental issues, government actions should encourage behaviors towards caring for the environment (RING, 2008). In Brazil, the state of Paraná is a pioneer in the adoption of a measure called Ecological ICMS for biodiversity, an action implemented by the Complementary Law no. 59 of 1991. This action is a public policy that promotes the transfer of financial resources to municipalities with conservation units (or protected areas) and water sources in their territory and that supply neighboring municipalities (IAP - Environmental Institute of Paraná, 2018). The resources of the Ecological ICMS result from the collection of the Tax on the Circulation of Goods and Services (ICMS), where 5% of the total state revenue is destined to municipalities that comply with the requirements of the Ecological ICMS (PARANÁ, 1991; IAP, 2018). From these 5%, 50% are destined to municipalities with water springs that supply sediment water for other populations outside their territory. The other half of the resources are for municipalities with conservation units and indigenous lands inside their territory (PARANÁ, 1991; IAP, 2018).

The Ecological ICMS, besides contributing to the conservation of biodiversity and maintenance of water sources that supply populations outside the limits of the municipality, helps to increase municipal revenues. The municipal revenue is responsible for the provision of services to the local population. When properly applied, it provides quality of life to local residents. In recent years, in Brazil, even though there is an expressive tax collection, states and municipalities have gone through a fiscal crisis that hinders even the payment of public servants. The collection capacity, or the revenue, of the Brazilian municipalities, as identified by the Firjan Fiscal Management Index in 2016, showed that 86% of Brazilian municipalities are in a difficult or a critical fiscal situation. In addition, 82% of municipalities generate less than 20% of their revenues. Thus, they depend on intergovernmental revenue transfers for the development of their activities (FIRJAN, 2017).

The objective of this study is to perform a spatial analysis of the distribution of Ecological ICMS resources per municipality in the state of Paraná in 2000 and 2017.

This period was defined based on the availability of information from the Instituto Paranaense de Desenvolvimento Econômico e Social - IPARDES (2018).

2. CIRCUMSTANCED REPORT

2.1 Characterization of the study area

The state of Paraná is the ninth largest Brazilian state in area, with a population estimated at ten million people in 2010 (IPEADATA, 2018). It has 399 municipalities. In this study, each municipality received an identification number (listed in Annex 1). The information in the annex should be used to read the results. Parana is located in the Southern region of Brazil. The Atlantic Forest biome comprises 98% of its territory, and the Cerrado Biome comprises 2% the territory (IBGE, 2004). Both biomes are considered a hotspot vegetation, that is, areas of biodiversity reserves that may be threatened with destruction and therefore should be conserved as a priority (MYERS et al., 2000; RYLANDS; BRANDON, 2005).

2.2 Data collection, representation of the spatial distribution of the Ecological ICMS, and share in municipal revenues

Data collection was performed on the IPARDES website. Table 1 shows which variables were collected and how they were used in this research.

Table 1: Source and treatment of Ecological ICMS information

Source	Variable	Information treatment	Period
IPARDES	Total Ecological ICMS Value	Multiscale geo-cartographic analysis of information.	2000 and 2017.
	Total revenue of the municipalities of Paraná	% of share of Ecological ICMS in the total revenue of the municipalities - represented when greater than or equal to 5%	

The years chosen for the analysis have information available, in this case, 2000 and 2017. Finally, an Exploratory Spatial Data Analysis (ESDA) on the total Ecological ICMS was conducted to identify the existence of clusters.

2.2.1 Matrix of Space Weights

The initial procedure of the ESDA is the creation of a spatial weighting matrix (W_{ij}). This matrix should be a square matrix of order n by n . Its elements indicate the degree of spatial connection (in this case, among municipalities analyzed) based on a criterion of proximity. This criterion is related to contiguity (usually queen and tower - both first-order contiguities, in which the difference is that the queen considers the vertices as a region of tangency). It is assumed that contiguous regions have a greater spatial interaction than not contiguous regions. For the formation of the matrix, the value 1 is assumed if two municipalities are contiguous and 0 otherwise (ALMEIDA, 2012; RAIHER et al., 2017).

Global spatial autocorrelation tests were performed. The purpose was to identify whether there was a spatial distribution of Ecological ICMS in the municipalities of the state of Paraná. By rejecting the hypothesis of randomness, it is understood that the distribution of the Ecological ICMS of a municipality affects the municipalities close to it. To calculate the global spatial autocorrelation, we used the Moran I statistic (MORAN, 1948) (1):

$$I = \frac{n}{S_0} \frac{z'Wz}{z'z} \quad (1)$$

Where, n is the number of municipalities, z is the Ecological ICMS of the municipality, Wz is the mean value of the standardized Ecological ICMS in the neighbors defined according to the spatial weighting matrix (W), and S_0 is the sum of all elements of the spatial weighting matrix (W) (RAIHER et al., 2016).

The null hypothesis to be tested is that the distribution of Ecological ICMS in the municipalities of Paraná occurs randomly; for this case, the expected value of the test is $-\{1/(n-1)\}$. If the Moran I statistic is equal to the expected value, according to the level of significance adopted, it will indicate that there is randomness in the spatial

distribution; otherwise, it rejects the null hypothesis. A higher than expected Moran I value indicates the existence of a positive spatial autocorrelation, and a Moran I value below expected indicates a negative spatial autocorrelation. To complement the analysis, a pseudo-significance test was performed.

Then, the local spatial autocorrelation - I of Local Moran was verified. The purpose was to qualify the degree of spatial association referring to each location that is part of the sample set. For this, a pre-established neighborhood model is used, known as Local Indicators of Spatial Association (LISA). The LISA indicates significant clusters in which the values are similar for the localities (ANSELIN, 1995). The Local Moran I is obtained by the equation (2):

$$I_i = z_i \sum_{j=1}^j w_{ij} Z_j \quad (2)$$

Where Z_i refers to the value of the standardized Ecological ICMS received by the municipality i , w_{ij} is the element of the spatial weighting matrix (W), and Z_j is the standardized Ecological ICMS value of the municipality j . The normality condition is the expected value of the statistic I_i : $E[I_i] = -w_i/(n-1)$. To represent the results, we used the LISA cluster map, which shows the municipalities as significant Moran I_i (ALMEIDA, 2012).

2.3 Results and Discussion

The Ecological ICMS is transferred to the municipalities in two situations. The first situation is water supply to the population of other municipalities because of the existence of available water sources. The second situation is because the municipality contains areas considered as conservation units. Table 2 lists the municipalities with the highest income from tax transfers and the respective values.

Table 2: Municipalities and amounts received - 2000

Municipality	Amount received (R\$) and source
Matelândia	1,056,352.14 - conservation units
Guaraqueçaba	1,082,694.20 - conservation units
Castro	1,151,328.68 - both sources
Serranópolis do Iguaçu	1,184,425.14 - conservation units
Cambé	1,247,979.61 – both sources
São Jorge do Patrocínio	1,260,611.68 - both sources
Campo Magro	1,365,906.94 – water spring
Céu Azul	1,430,010.14 - conservation units
Piraquara	3,931,775.63 - both sources
São José dos Pinhais	9,664,022.63 - both sources

In 2017, the number of municipalities that received the Ecological ICMS increased by approximately 15%. These municipalities were in the group of municipalities that receive up to R\$ 65,317.00. A greater number of municipalities received this resource. These municipalities are grouped in the transfer range between R\$ 671,750.00 and R\$ 23,607,285.00. Among them, the municipalities with the highest amounts received are listed in Table 3.

Table 3: Municipalities and amounts received - 2017

Municipality	Amount received (R\$) and source
Antonina	4,936,405.99- conservation units
Campo Largo	5,361,407.79 - both sources
Quatro Barras	5,445,514.34 - both sources
Carambeí	6,137,192.81- both sources
Castro	6,859,298.69 – both sources
Cambé	7,315,502.71 - both sources
São Jorge do Patrocínio	8,216,316.06 - conservation units
São José dos Pinhais	9,160,783.00 – both sources
Campo Magro	10,766,454.76 – water springs
Piraquara	23,607,257.81- both sources

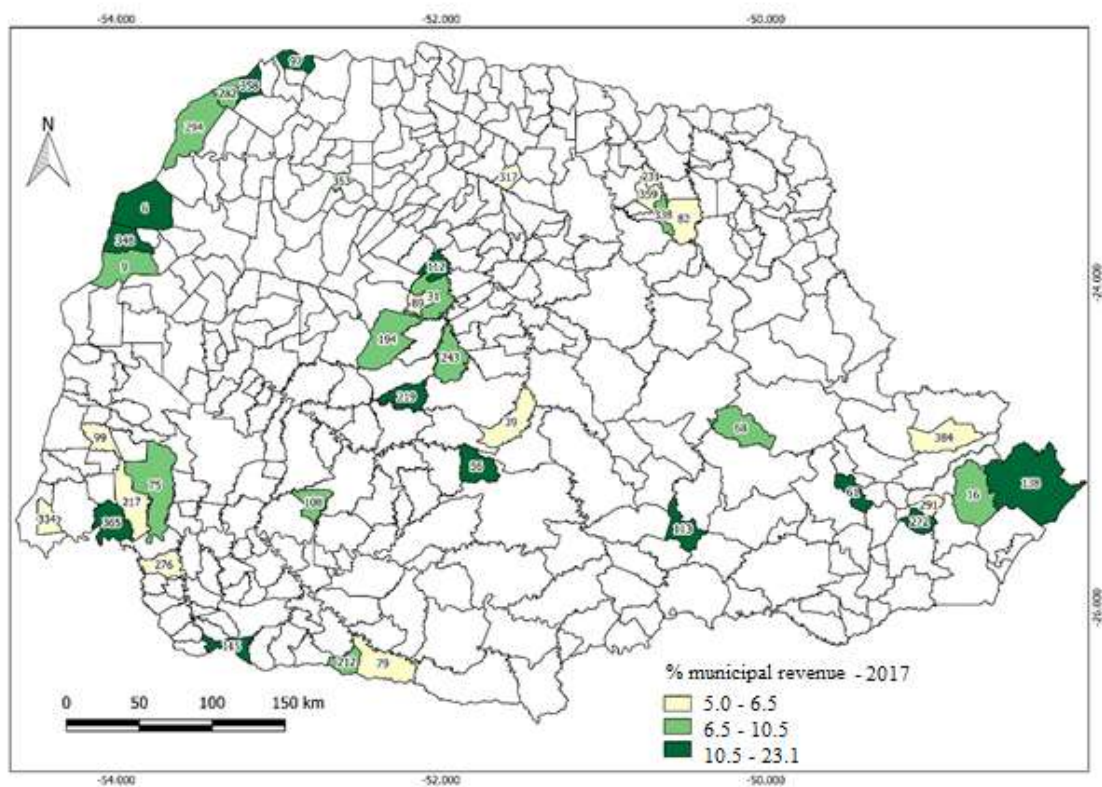
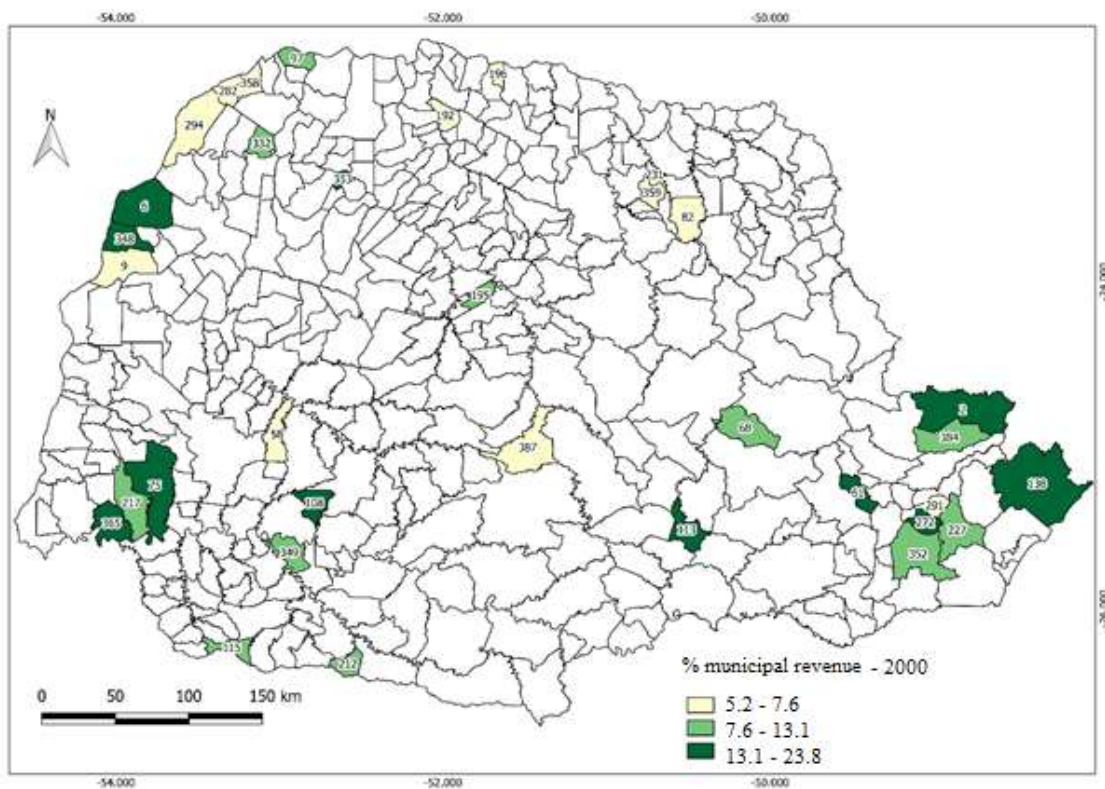
It was observed that, in 2000, of the 214 municipalities that received this resource, approximately 47% were classified into the highest transfer class of this research. The total amounts transferred from Ecological ICMS to the municipalities of the state of Paraná totaled R\$ 54,439,882.57 in 2010 and R\$ 289,650,678.78 in 2017 (IPARDES, 2018). If these values were equally distributed to all municipalities, the amount transferred to each one would be R\$ 136,440.81 in 2010 and of R\$ 725,941.55 in 2017. There are repeated municipalities in the years analyzed, such as those that

received the highest values of Ecological ICMS. As the legislation regarding this type of ICMS does not define how these resources can be used, websites of municipalities were consulted to investigate if there is any legislation or specificity in relation to the use of such resources, mainly for the purpose of environmental demands. The websites of the prefectures of Castro, Cambé, São Jorge do Patrocínio, São José dos Pinhais, Campo Magro, and Piraquara were consulted.

Of these municipalities, news items have been identified highlighting the importance of the Ecological ICMS, which helps to pay general expenses. Only the municipality of São José dos Pinhais had 50% of its resource directed for exclusive use by the rural area of the municipality in 2001 (SÃO JOSÉ DOS PINHAIS, 2001) as the criterion for using the Ecological ICMS. The need for organization of municipalities regarding the use of resources from the Ecological ICMS is evident, so that part of it be destined for environmental conservation.

Berke et al. (2013) considered that conservation specialists have stated the need for spatial planning among municipalities collectively, so that conservation units can cross borders and improve ecosystem services. The second factor regarding the transfer of resources of the Ecological ICMS refers to the share of these resources in the revenue of municipalities. Municipalities in which Ecological ICMS resources represent at least 5% of the total revenue were selected (Figure 1).

Figure 1: Participation of the Ecological ICMS in Municipal Revenue - 2000 and 2017



Source: Prepared from IPARDES (2019).

The Ecological ICMS is the economic result of the care that public and private agents of a given municipality have with the environment through the preservation of springs or the creation of conservation units. In terms of the importance of preserving water supply, there are indications that the global demand for water is expected to grow by 55% by 2050, with 2.3 billion people living in areas with severe water stress (OECD, 2012). In addition, the combination of a fast urbanization and an unplanned land use has resulted in the degradation of water bodies, especially in developing countries (EDUFUL; SHIVELY, 2015).

In addition, the creation of protected areas as conservation units is an initial strategy for the protection of flora and fauna (CHAPE et al., 2005). It is worth noting that conservation can be rewarded by two main measures: (i) payment for environmental services, and (ii) ecological tax transfers (RING; SCHRÖTER-SCHLAACK, 2011). The Ecological ICMS, in force in the state of Paraná since 1991, is classified as an ecological tax transfer. Transfers can be understood as a redistribution of public revenues (RING et al., 2011), in this case, between the state government and municipalities.

In relation to the spatial distribution of Ecological ICMS transfers to the municipalities, the Moran I statistic (Table 3) identified a spatial association pattern independent of the weighting matrix used, in this case, queen and tower. In addition, there is a positive spatial autocorrelation. Thus, municipalities that receive Ecological ICMS values above the average are surrounded by municipalities that receive transfers above the average; municipalities that receive Ecological ICMS values below the average are surrounded by municipalities that receive transfers below the average. Thus, there are features of Tobler's Law in this context, that is, closer things are more related than things that are more distant. It should be noted, however, that local factors could make an area significantly different from the others (Sui, 2004). It is also noted, by the result of the Moran I in the analyzed years, that there was little change in spatial association. In 2000 and 2017, there is practically the same spatial concentration of resources transferred as Ecological ICMS.

Table 3: Global Moran I and Pseudo value - p

Year	Global Moran I - Queen	Pseudo value-p	Global Moran I - Tower	Pseudo value-p
2000	0.216112	0.002	0.216159	0.002
2017	0.289411	0.002	0.288948	0.002

Note: Empirical pseudo-significance is based on 999 random permutations.

Figure 2 shows the LISA for 2000 and 2017. In each year, there was a classification of information regarding the transfer of Ecological ICMS based on four categories of spatial association (i - high-high, ii - low-low, iii - low-high, and iv - high-low). The category i, represented in red, are agglomerations formed by municipalities that receive the highest transfers of Ecological ICMS. The category ii, represented in dark blue, are spatial associations of municipalities that receive the lowest transfers of Ecological ICMS. Light blue (iii) and light red (iv) denote atypical spatial associations. It can be seen that these categories group municipalities identified as statistically significant. There is an increase in the number of municipalities between 2000 and 2017.

In addition, in relation to the clusters, there are agglomerations in 2000 in the low-low classification through the concentration of municipalities of Alto Piquiri, Assis Chateaubriand, Cafezal do Sul, Perobal, and Toledo. In the high-high classification, in the same year, the agglomeration of municipalities was formed by Almirante Tamandaré, Antonina, Campo Magro, Curitiba, Guaratuba, Morretes, Pinhais, Piraquara, and São José dos Pinhais. In 2017, these agglomerates increased due to the incorporation of other municipalities. In the low-low classification, to which they appear as neighbors, municipalities such as Alto Piquiri, Anahy, Assis Chateaubriand, Corbélia, Iguatu, Nova Aurora, Toledo, Tupãssi, and Ubiratã can be identified. In the high-high classification, Campo Largo, Campo Magro, Almirante Tamandaré, Colombo, Quatro Barras, Curitiba, Pinhais, Piraquara, São José dos Pinhais, Tijuca do Sul, Guaratuba, Campina Grande do Sul, and Guaraqueçaba can be identified.

Figure 2: LISA Cluster Map, Ecological ICMS Transfers, 2000 and 2017

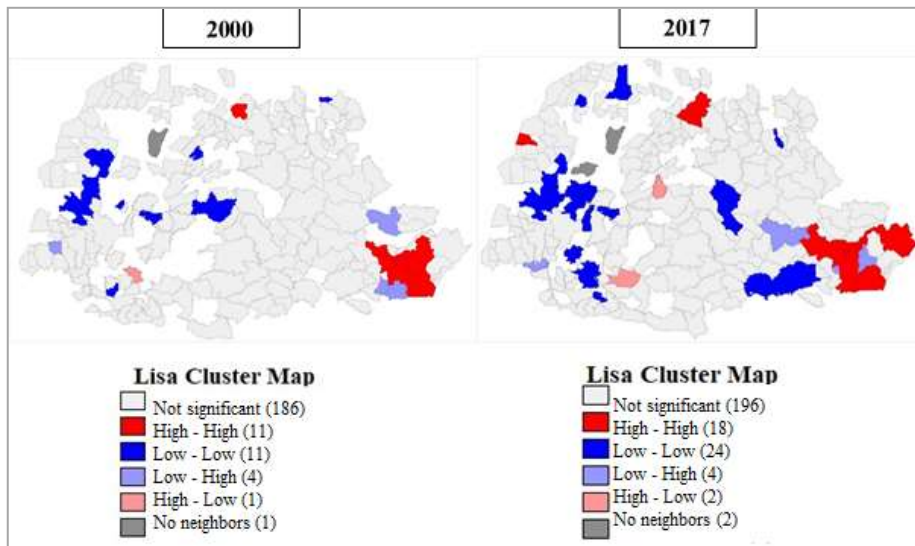


Figure 2 shows that the easternmost region of the state of Paraná has a concentration of municipalities classified as receiving the highest amount of Ecological ICMS transfers in both years. In the most western region of the state, part of the municipalities received the lowest or medium amount of transfers. Figure 2 shows these agglomerations by identifying municipalities classified as high-high and low-low, respectively.

4. Conclusion

The results of this study indicate that there was an increase in the number of municipalities in the state of Paraná that received Ecological ICMS transfers in 2017 compared to 2000. The main source for this resource is conservation units. There is concentration in the state's Eastern macroregion, with municipalities classified within the range of highest tax transfers; in the other macroregions, tax transfers are diversified. Another issue refers to the contribution that the Ecological ICMS values received by the municipalities represent, in percentage, in the share of income. The increase observed in the number of municipalities classified among the highest percentages indicates that the municipalities had a greater economic dependence on the transfers by the state of Paraná of ecological tax transfers in 2017 than in 2000.

Ecological tax transfers such as the Ecological ICMS are important measures to encourage the preservation of water resources, such as the water sources used as common resources, which supply populations outside their location area. The creation of conservation units that allow the maintenance of ecosystem services in conserved areas and provide well-being to individuals through the externalization of environmental benefits are also important measures. The state of Paraná is a pioneer in the use of this measure in Brazil. However, discussions within the state can be expanded so that part of these resources made available to municipalities can be used for improvements in the maintenance of these areas. The creation of protected areas alone is not enough to guarantee the maintenance of the areas. There is therefore a need for a qualitative management of spaces. This implies costs so that the areas become environmentally effective. In the case of the state of Paraná, May et al. (2002) observed that the creation of the Ecological ICMS allowed an increase by 165% in protected areas between the 1990s and the 2000s. However, the environmental effectiveness of this creation was not accounted.

In addition, the measure becomes restrictive to the municipal government since the economic resources are transferred to municipalities. Thus, the incentive for conservation is directed to the public sphere. However, Brazil, through its conservation legislation, allows it to be a practice carried out by individuals who have the desire to conserve part or all of their area. The importance of private protected areas complements the protection of biodiversity as carried out by public agencies (RODRIGUES et al., 2014), considering that many endangered species are located only in private lands (KRUG, 2001; FIGGIS; HUMANN; LOOKER, 2005, FISHER; DILLS, 2012). Thus, there is a need to pay for ecosystem services in conservation areas in Paraná to complement public conservation policies. As a result, there would be incentives to the private sector in conserving the environment in the state.

5. References

ALMEIDA, E. **Econometria espacial aplicada**. Campinas: Alinea, 1-498. 2012.

- ANSELIN, L. Local Indicators of Spatial Association - LISA, **Geographical Analysis**, 27(2), 93–115, 1995.
- BACHA, C.J.C. **Economia e política agrícola no Brasil**. Atlas: São Paulo. 2004.
- BERKE, P.; SPURLOCK, D.; HESS, G.; BAND, L. Local comprehensive plan quality and regional ecosystem protection: The case of the Jordan Lake watershed, North Carolina, U.S.A. **Land Use Policy**, 31, 450-459, 2013.
- BRASIL. **Lei nº 9.985**. Dispõem sobre o Sistema Nacional de Unidades de Conservação – SNUC. 2000.
- CDB. **COP 10 – Decision Strategic Plan for Biodiversity 2011–2020**. 2017. Disponível em: <<https://www.cbd.int/decision/cop/?id=12268>>. Acesso em: nov. 2018.
- CHAPE, S.; HARRISON, J.; SPALDING, M.; LYSENKO, I. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. **Phil. Trans. R. Soc. B Biol. Sci.**, 360 (1454), 443-455, 2005.
- DAILY, G.C.; DASGUPTA, S. Ecosystem services, concept of. **Encyclopedia of Biodiversity**, 2, 353-362, 2001.
- EDUFUL, M.; SHIVELY, D. Perceptions of urban land use and degradation of water bodies in Kumasi, Ghana. **Habitat International**, 50, 206-213, 2015.
- FARINHA, M.J.U.S.; BERNARDO, L.V.M.B.; SOUZA, V.A.; FERREIRA DA SILVA, L. Characterization of conservation units of the Central-West region of Brazil. **Multitemas**, 25(54), 205-224, 2018.
- FARINHA, M.J.U.S.; BERNARDO, L.V.M.B.; SOAREA FILHO, A.; BEREZUK, A.G.; FERREIRA DA SILVA, L.; RUVIARO, C.F. Opportunity cost of a private reserve of natural heritage, Cerrado biome – Brazil. **Land Use Policy**, 81, 49-57, 2019.
- FERNANDES, G.W. **Ecology and Conservation of Mountaintop Grasslands in Brazil**, Springer International Publishing, 1-567, 2016.

FIGGIS, P.; HUMANN, D.; LOOKER, M. Conservation on private land in Australia. **Parks**, 15(2), 19-29, 2005.

FIRJAN. **Índice FIRJAN de Gestão Fiscal**: recorte municipal abrangência nacional. Rio de Janeiro. 1-34, 2017.

FISHER, J.R.B.; DILLS, B. Do private conservation activities match science-based conservation priorities? **PLoS ONE**, 7(9), 2012.

GOLDSTEIN, J.H.; CALDARONE, G.; DUARTE, T.K.; ENNAANAY, D.; HANNAHS, N.; MENDOZA, G.; POLASKY, S.; WOLBY, S.; DAILY, G.C. Integrating ecosystem-service tradeoffs into land-use decisions. **Proceedings of the National Academy of Science of the United States of America - PNAS**, 109, 7565-7570, 2012.

IAP – Instituto Ambiental do Paraná. **ICMS Ecológico por Biodiversidade**. 2018. Disponível em: < <http://www.iap.pr.gov.br/pagina-418.html>>. Acesso em: nov. 2018.

IBGE – Instituto Brasileiro de Geografia e Estatística. **Brasil em síntese**: território. 2004. Disponível em: < <https://brasilemsintese.ibge.gov.br/territorio.html>>. Acesso em: nov. 2018.

IPARDES – Instituto Paranaense de Desenvolvimento Econômico do Paraná. **Base de dados do Estado – BDEWeb**. 2019. Disponível em: <<http://www.ipardes.pr.gov.br/imp/index.php>>. Acesso em: nov. 2019.

IPEADATA. **Dados**. 2018. Disponível em: < <http://www.ipeadata.gov.br/Default.aspx>>. Acesso em: nov. 2018.

KRUG, W. **Private supply of protected land in southern Africa: a review of markets, approaches, barriers and issues**. World Bank/OECD International Workshop on Market Creation for Biodiversity Products and Services. Paris, France: World Bank. 1-42, 2001.

MORAN, P.A.P. The interpretation of statistical maps. **Journal of Royal Statistical Society**, 10(2), 243-251, 1948.

MYERS, N.; MITTERMEIER, R.A.; MITTERMEIER, C.G.; FONSECA, G.A.B.; KENT, J. Biodiversity hotspots for conservation priorities. **Nature**, 403, 853-858, 2000.

OECD. **Environmental Outlook to 2050**. Publishing, OECD, 2012.

OVERBECK, G.E.; VÉLEZ-MARTIN, E.; SCARANO, F.R.; LEWINSOHN, T.M.; FONSECA, C. R.; MEYER, S.T. Conservation in Brazil needs to include non-forest ecosystems. **Diversity and Distributions**, 21, 1455-1460, 2015.

PARANÁ. **Lei Complementar nº 91**. Dispõe sobre a repartição do ICMS, a que alude o art. 2º da Lei nº 9.491, de 21 de dezembro de 1990, aos municípios com mananciais de abastecimento e unidades de conservação ambiental. 1990. Disponível em: <<https://www.legislacao.pr.gov.br/legislacao/listarAtosAno.do?action=exibir&codAto=8383&indice=1&totalRegistros=9&anoSpan=1995&anoSelecionado=1991&mesSelecionado=0&isPaginado=true>>. Acesso em: nov. 2018.

RAIHER, A.P.; FERREIRA DE LIMA, J.; OSTAPECHEN, L.A.P. Crescimento Econômico Regional no Sul do Brasil. **Revista de Economia e Agronegócio**, 15(2), 224-249, 2017.

RAIHER, A.P.; OLIVEIRA, R.A.; CARMO, A.S.S.; STEGE, A.L. Convergência da Produtividade Agropecuária do Sul do Brasil: uma análise espacial. **RESR**, 54(3), 517-536, 2016.

RING, I. Integrating local ecological services into intergovernmental fiscal transfers: The case of the ecological ICMS in Brazil. **Land Use Policy**, 25, 485-497, 2008.

RING, I.; SCHRÖTER-SCHLAACK, C. Justifying and Assessing Policy Mixes for Biodiversity and Ecosystem Governance. In: **Instrument mixes for biodiversity policies**. Policymix: Alemanha. 1-212, 2011.

RODRIGUES, A. S. L.; ANDELMAN, S. J.; BAKARR, M. I.; BOITANI L.; BROOKS, T. M. et al. Effectiveness of the global protected area network in representing species diversity. **Nature**, 428, 640-643, 2004.

RYLANDS, A.B.; BRANDON, K. Brazilian protected areas. **Conservation Biology**, 19, 612-618, 2005.

SÃO JOSÉ DOS PINHAIS. **Lei nº 257/2001**. Destina 50% de cada parcela do ICMS Ecológico, para exclusivo atendimento à Zona Rural. 2001. Disponível em: <http://externo.sjp.pr.gov.br:65368/atoteca/upload/12526/12526_95473165087_F_D_200112311312.pdf>. Acesso em: nov. 2018.

SUI, D. Z. **Tobler's First Law of Geography**: A Big Idea for a Small World?. *Annals of the Association of American Geographers*: Washington, 94, 269 – 277, 2004.

VIEIRA FILHO, J.E.R. **Efeito poupa-terra e ganhos de produção no setor agropecuário brasileiro**. IPEA, 7-41, 2018.

Annex 1 - Identification number of the municipalities of Paraná

Municipalities of Parana and ID Number

Abatiá – 1; Adrianópolis – 2; Agudos do Sul – 3; Almirante Tamandaré – 4; Altamira do Paraná – 5; Alto Paraíso – 6; Alto Paraná – 7; Alto Piquiri – 8; Altônia – 9; Alvorada do Sul – 10; Amaporã – 11; Ampére – 12; Anahy – 13; Andirá – 14; Ângulo – 15; Antonina – 16; Antônio Olinto – 17; Apucarana – 18; Arapongas – 19; Arapoti – 20; Arapuã – 21; Araruna – 22; Araucária – 23; Ariranha do Ivaí – 24; Assaí – 25; Assis Chateaubriand – 26; Astorga – 27; Atalaia – 28; Balsa Nova – 29; Bandeirantes – 30; Barbosa Ferraz – 31; Barra do Jacaré – 32; Barracão – 33; Bela Vista da Caroba – 34; Bela Vista do Paraíso – 35; Bituruna – 36; Boa Esperança – 37; Boa Esperança do Iguaçu – 38; Boa Ventura de São Roque – 39; Boa Vista da Aparecida – 40; Bocaiúva do Sul – 41; Bom Jesus do Sul – 42; Bom Sucesso – 43; Bom Sucesso do Sul – 44; Borrazópolis – 45; Braganey – 46; Brasilândia do Sul – 47; Cafeara – 48; Cafelândia – 49; Cafezal do Sul – 50; Califórnia – 51; Cambará – 52; Cambé – 53; Cambira – 54; Campina da Lagoa –

55; Campina do Simão – 56; Campina Grande do Sul – 57; Campo Bonito – 58; Campo do Tenente – 59; Campo Largo – 60; Campo Magro – 61; Campo Mourão – 62; Cândido de Abreu – 63; Candói – 64; Cantagalo – 65; Capanema – 66; Capitão Leônidas Marques – 67; Carambeí – 68; Carlópolis – 69; Cascavel – 70; Castro – 71; Catanduvas – 72; Centenário do Sul – 73; Cerro Azul – 74; Céu Azul – 75; Chopinzinho – 76; Cianorte – 77; Cidade Gaúcha – 78; Clevelândia – 79; Colombo – 80; Colorado – 81; Congonhinhas – 82; Conselheiro Mairinck – 83; Contenda – 84; Corbélia – 85; Cornélio Procópio – 86; Coronel Domingos Soares – 87; Coronel Vivida – 88; Corumbataí do Sul – 89; Cruz Machado – 90; Cruzeiro do Iguaçu – 91; Cruzeiro do Oeste – 92; Cruzeiro do Sul – 93; Cruzmaltina – 94; Curitiba – 95; Curiúva – 96; Diamante do Norte – 97; Diamante do Sul – 98; Diamante D'Oeste – 99; Dois Vizinhos – 100; Douradina – 101; Doutor Camargo – 102; Doutor Ulysses – 103; Enéas Marques – 104; Engenheiro Beltrão – 105; Entre Rios do Oeste – 106; Esperança Nova – 107; Espigão Alto do Iguaçu – 108; Farol – 109; Faxinal – 110; Fazenda Rio Grande – 111; Fênix – 112; Fernandes Pinheiro – 113; Figueira – 114; Flor da Serra do Sul – 115; Floráí – 116; Floresta – 117; Florestópolis – 118; Flórida – 119; Formosa do Oeste – 120; Foz do Iguaçu – 121; Foz do Jordão – 122; Francisco Alves – 123; Francisco Beltrão – 124; General Carneiro – 125; Godoy Moreira – 126; Goioerê – 127; Goioxim – 128; Grandes Rios – 129; Guaíra – 130; Guairaçá – 131; Guamiranga – 132; Guapirama – 133; Guaporema – 134; Guaraci – 135; Guaraniaçu – 136; Guarapuava – 137; Guaraqueçaba – 138; Guaratuba – 139; Honório Serpa – 140; Ibaiti – 141; Ibema – 142; Iporã – 143; Icaraíma – 144; Iguaçu – 145; Iguatu – 146; Imbaú – 147; Imbituva – 148; Inácio Martins – 149; Inajá – 150; Indianópolis – 151; Ipiranga – 152; Iporã – 153; Iracema do Oeste – 154; Irati – 155; Iretama – 156; Itaguajé – 157; Itaipulândia – 158; Itambaracá – 159; Itambé – 160; Itapejara d'Oeste – 161; Itaperuçu – 162; Itaúna do Sul – 163; Ivaí – 164; Ivaiporã – 165; Ivaté – 166; Ivatuba – 167; Jaboti – 168; Jacarezinho – 169; Jaguapitã – 170; Jaguariaíva – 171; Jandaia do Sul – 172; Janiópolis – 173; Japira – 174; Japurá – 175; Jardim Alegre – 176; Jardim Olinda – 177; Jataizinho – 178; Jesuítas – 179; Joaquim Távora – 180; Jundiaí do Sul – 181; Juranda – 182; Jussara – 183; Kaloré – 184; Lapa – 185; Laranjal – 186; Laranjeiras do Sul – 187; Leópolis –

188; Lidianópolis – 189; Lindoeste – 190; Loanda – 191; Lobato – 192; Londrina – 193; Luiziana – 194; Lunardelli – 195; Lupionópolis – 196; Mallet – 197; Mamborê – 198; Mandaguaçu – 199; Mandaguari – 200; Mandirituba – 201; Manfrinópolis – 202; Mangueirinha – 203; Manoel Ribas – 204; Marechal Cândido Rondon – 205; Maria Helena – 206; Marialva – 207; Marilândia do Sul – 208; Marilena – 209; Mariluz – 210; Maringá – 211; Mariópolis – 212; Maripá – 213; Marmeleiro – 214; Marquinho – 215; Marumbi – 216; Matelândia – 217; Matinhos – 218; Mato Rico – 219; Mauá da Serra – 220; Medianeira – 221; Mercedes – 222; Mirador – 223; Miraselva – 224; Missal – 225; Moreira Sales – 226; Morretes – 227; Munhoz de Melo – 228; Nossa Senhora das Graças – 229; Nova Aliança do Ivaí – 230; Nova América da Colina – 231; Nova Aurora – 232; Nova Cantu – 233; Nova Esperança – 234; Nova Esperança do Sudoeste – 235; Nova Fátima – 236; Nova Laranjeiras – 237; Nova Londrina – 238; Nova Olímpia – 239; Nova Prata do Iguaçu – 240; Nova Santa Bárbara – 241; Nova Santa Rosa – 242; Nova Tebas – 243; Novo Itacolomi – 244; Ortigueira – 245; Ourizona – 246; Ouro Verde do Oeste – 247; Paiçandu – 248; Palmas – 249; Palmeira – 250; Palmital – 251; Palotina – 252; Paraíso do Norte – 253; Paranacity – 254; Paranaguá – 255; Paranapoema – 256; Paranaíba – 257; Pato Bragado – 258; Pato Branco – 259; Paula Freitas – 260; Paulo Frontin – 261; Peabiru – 262; Perobal – 263; Pérola – 264; Pérola d'Oeste – 265; Piên – 266; Pinhais – 267 - Pinhal de São Bento – 268; Pinhalão – 269; Pinhão – 270; Piraí do Sul – 271; Piraquara – 272; Pitanga – 273; Pitangueiras – 274; Planaltina do Paraná – 275; Planalto – 276; Ponta Grossa – 277; Pontal do Paraná – 278; Porecatu – 279; Porto Amazonas – 280; Porto Barreiro – 281; Porto Rico – 282; Porto Vitória – 283; Prado Ferreira – 284; Pranchita – 285; Presidente Castelo Branco – 286; Primeiro de Maio – 287; Prudentópolis – 288; Quarto Centenário – 289; Quatiguá – 290; Quatro Barras – 291; Quatro Pontes – 292; Quedas do Iguaçu – 293; Querência do Norte – 294; Quinta do Sol – 295; Quitandinha – 296; Ramilândia – 297; Rancho Alegre – 298; Rancho Alegre D'Oeste – 299; Realeza – 300; Rebouças – 301; Renascença – 302; Reserva – 303; Reserva do Iguaçu – 304; Ribeirão Claro – 305; Ribeirão do Pinhal – 306; Rio Azul – 307; Rio Bom – 308; Rio Bonito do Iguaçu – 309; Rio Branco do Ivaí – 310; Rio Branco do Sul – 311; Rio Negro – 312; Rolândia – 313; Roncador – 314;

Rondon – 315; Rosário do Ivaí – 316; Sabáudia – 317; Salgado Filho – 318; Salto do Itararé – 319; Salto do Lontra – 320; Santa Amélia – 321; Santa Cecília do Pavão – 322; Santa Cruz de Monte Castelo – 323; Santa Fé – 324; Santa Helena – 325; Santa Inês – 326; Santa Isabel do Ivaí – 327; Santa Izabel do Oeste – 328; Santa Lúcia – 329; Santa Maria do Oeste – 330; Santa Mariana – 331; Santa Mônica – 332; Santa Tereza do Oeste – 333; Santa Terezinha de Itaipu – 334; Santana do Itararé – 335; Santo Antônio da Platina – 336; Santo Antônio do Caiuá – 337; Santo Antônio do Paraíso – 338; Santo Antônio do Sudoeste – 339; Santo Inácio – 340; São Carlos do Ivaí – 341; São Jerônimo da Serra – 342; São João – 343; São João do Caiuá – 344; São João do Ivaí – 345; São João do Triunfo – 346; São Jorge do Ivaí – 347; São Jorge do Patrocínio – 348; São Jorge d'Oeste – 349; São José da Boa Vista – 350; São José das Palmeiras – 351; São José dos Pinhais – 352; São Manoel do Paraná – 353; São Mateus do Sul – 354; São Miguel do Iguaçu – 355; São Pedro do Iguaçu – 356; São Pedro do Ivaí – 357; São Pedro do Paraná – 358; São Sebastião da Amoreira – 359; São Tomé – 360; Sapopema – 361; Sarandi – 362; Saudade do Iguaçu – 363; Sengés – 364; Serranópolis do Iguaçu – 365; Sertaneja – 366; Sertanópolis – 367; Siqueira Campos – 368; Sulina – 369; Tamarana – 370; Tamboara – 371; Tapejara – 372; Tapira – 373; Teixeira Soares – 374; Telêmaco Borba – 375; Terra Boa – 376; Terra Rica – 377; Terra Roxa – 378; Tibagi – 379; Tijucas do Sul – 380; Toledo – 381; Tomazina – 382; Três Barras do Paraná – 383; Tunas do Paraná – 384; Tuneiras do Oeste – 385; Tupãssi – 386; Turvo – 387; Ubiratã – 388; Umuarama – 389; União da Vitória – 390; Uniflor – 391; Uraí – 392; Ventania – 393; Vera Cruz do Oeste – 394; Verê – 395; Virmond – 396; Vitorino – 397; Wenceslau Braz – 398; Xambrê – 399.