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Geocollaboration in environmental inspection activities in the Environmental Military Police of Rio de Janeiro State – Brazil

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The cost of geotechnologies are becoming more accessible. The capacity to generate real-time maps with ubiquitous access and applications based on geocollaborative platforms developed for the most diverse purposes have been multiplying, allowing users to generate, share, and collect information about geographical spaces. Even so, the geotechnologies employing geographic information system (GIS) are still limited among the Brazilian environmental military police. This lack of geotechnologWies diffusion occurs due to the absence of specific training, requiring a constant update from these professionals. The current stage of evolution on geotechnology through cloud computing, user-centered design, and geocollaboration demands the police command-and-control structures to rethink their strategies. Several platforms are available and open for developers to create applications under this technology. This article analyzes the potential applicability of geocollaboration in environmental inspection activities, through a case study in the CPAm/PMERJ.

Keywords: Collaborative Mapping. Crowdsourcing. Environmental Patrolling. Command and Control. Law Enforcement.

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Geocolaboração na fiscalização ambiental: estudo de caso na Polícia Militar Ambiental do Estado do Rio de Janeiro – Brasil

O custo das geotecnologias estão se tornando mais acessível. A capacidade de gerar mapas em tempo real, com acesso ubíquo e aplicativos baseados em plataformas geocolaborativas desenvolvidas para os mais diferentes propósitos estão se multiplicando, permitindo aos usuários gerar, compartilhar, e coletar informações sobre o espaço geográfico. Mesmo assim, as geotecnologias empregando o Sistema de Informações Geográficas (SIG) ainda são limitadas entre as polícias militares ambientais brasileiras. Essa falta de difusão das geotecnologias ocorre devido a ausência de treinamento específico, requerendo um constante aperfeiçoamento desses profissionais. O estágio atual da evolução da geotecnologia por meio da computação em nuvem, design centrado no usuário, e geocolaboração exigem que estruturas de comando e controle repensem suas estratégias. Várias plataformas estão disponíveis e abertas para desenvolvedores criarem aplicativos com essa tecnologia. Este artigo analisa a potencial aplicabilidade da geocolaboração nas atividades de fiscalização ambiental, por meio de um estudo de caso no CPAm/PMERJ.

Palavras-chave: Mapeamento colaborativo. Crowdsourcing. Policiamento ambiental. Comando e controle. Aplicação da lei.

Geocolaboración en supervisión ambiental: estudio de caso en la Policía Militar Ambiental de Estado de Río de Janeiro – Brasil

El costo de la geotecnología es cada vez más accesible. La capacidad de generar mapas en tiempo real con acceso ubicuo y aplicaciones basadas en plataformas geo-colaborativas desarrolladas para una variedad de propósitos se está multiplicando, permitiendo a los usuarios generar, compartir y recopilar información sobre el espacio geográfico. Aun así, las geotecnologías que emplean el Sistema de Información Geográfica (SIG) siguen siendo limitadas entre las policías ambientales militares brasileñas. Esta falta de difusión de geotecnología se produce debido a la ausencia de formación específica, lo que requiere una mejora constante de estos profesionales. La etapa actual de la evolución de la geotecnología a través de la computación en la nube, el diseño centrado en el usuario y la geo-colaboración requiere estructuras de comando y control para repensar sus estrategias. Hay varias plataformas disponibles y abiertas para que los desarrolladores creen aplicaciones con esta tecnología. Este documento analiza la aplicabilidad potencial de la geo-colaboración en actividades de vigilancia ambiental a través de un estudio de caso en CPAm/PMERJ.

Palabras clave: Mapeo colaborativo. Crowdsourcing. Vigilancia ambiental. Comando y control. Cumplimiento de la ley.

Geocollaboration in environmental inspection activities in the Environmental Military Police of Rio de Janeiro State – Brazil

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1 Introduction

The World Commission on Environment and Development Report (1991) entitled "Our Common Future," already warned about need to protect the environment and the parsimonious use of its natural resources at the risk of compromising its sustainability, which would compromise its availability for future generations.

In Brazil, daily aggressions are witnessed to the environment in many different forms. The authorities, in turn, are charged by the society for a response that does not always occur in time to prevent or enforce the law over those responsible for environmental damage. The society expects that the state command-and-control mechanisms will be increasingly effective.

Nevertheless, without technology and social participation, this long-awaited effectiveness cannot be achieved. One of the most significant institutions responsible for environmental command-and-control in Brazil and one of the least known is the Environmental Military Police Unit, whose first entity appeared in São Paulo State in 1949.

Currently, all federal states have at least one unit specialized in environmental policing, with more than 7,000 officers dedicated to protecting the environment. In Rio de Janeiro, environmental policing is carried out by the Environmental Police Command (CPAm for its acronym in Portuguese) of the Military Police of Rio de Janeiro State (PMERJ for its acronym in Portuguese), through its subordinate Environmental Policing Units (UPAm for its acronym in Portuguese).

Social participation is an essential component for the improvement of quality over the environmental inspections by the CPAm. One of the tools that could optimize and stimulate social participation in environmental protection would be the use of geotechnologies, in particular, geocollaboration. The use of geocollaboration in environmental protection is still recent and has little literature in the academic world. The study aims to evaluate how social participation occurs in environmental issues and whether tools based on geocollaboration have the potential to improve the performance of the environmental police.

The research was based on an epistemological review over the environmental inspections of the CPAm, and the analysis of environmental crimes in the Rio de Janeiro State from 2014 to 2016, and over the available strategies, and platforms for the use of geocollaboration in environmental policing by the CPAm.

2 The PMERJ Environmental Surveillance

2.1 The modernization of policing

In 2000, the Rio de Janeiro State updated its Public Plan for Security, Justice and Citizenship. In this plan, the state government already recognized that it was not possible to enforce the law over the increasing levels of criminality by just using the resources in place. It was also necessary to invest in science and technology. Among the several projects that were in the planning stage was the tracking of vehicles using GPS (Global Position System). The use of GPS became a landmark in the use of geotechnology at PMERJ (RIO DE JANEIRO, 2000). The plan was also addressed to the modernization of the administrative and organizational areas. It aimed to rationalize and better use the human and material resources of the police and promote their regional integration. With this in mind, the projects of the Integrated Areas of Public Security[1] (AISP for its acronym in Portuguese), the Legal Police Program[2] , and the Institute of Public Security (ISP for its acronym in Portuguese) were developed.

The modernization proposed and developed from 2000 onwards established the bases for implementing a set of Goals for the Strategic Indicators of Crime in Rio de Janeiro State in 2009. With a historical series of crimes compiled by the ISP[3], strategic crime indicators have been established and analyzed phenomenologically[4] through thematic maps. This work was done by the civil and military police in a search for integrated solutions through the adoption of "joint, adequate, and intelligent" strategies and tactics (RIO DE JANEIRO, 2009, p.7).

If the analysis and treatment of common criminal phenomena underwent a paradigm shift since the year 2000, the same can't be said about environmental crimes. Although the PMERJ had an organizational unit specialized in environmental policing since 1986, the phenomenological analysis of environmental crimes did not exist until 2013, when the exact location of the occurrences became georeferenced by the Environmental Police Command.

2.2 Environmental policing at PMERJ

Environmental policing at PMERJ arrived late. Despite the federal legislation, since 1970, addressing the responsibility for executing forest and water policing to the military police (BRASIL, 1970), and the Military Police of São Paulo State having a unit specializing in this type of policing since 1949 (ARAGÃO, 2009), The first PMERJ unit with the mission to protect forests emerged only in 1986.

In 1986, the 23rd Military Police Battalion (BPM for its acronym in Portuguese) was created with a specific mission of executing forest policing, according to the country's legislation (RIO DE JANEIRO, 1986). The next year, the unit was changed to the Forest Police and Environment Battalion (BPFMA for its acronym in Portuguese), expanding its activities to protect other natural resources and preservation of the environment throughout the state (RIO DE JANEIRO, 1987). In 2012, BPFMA was transformed into an Environmental Police Command (CPAm), and the environmental police units (UPAm) were created (RIO DE JANEIRO, 2012).

Nevertheless, despite the advanced administrative steps, operational practices remained archaic. Still, in 2012, when the entire PMERJ sought to develop professional police practices, guiding patrolling for criminal patches, there was no record in the CPAm of the historical series of environmental crimes served, nor an analysis of the environmental criminal phenomenon.

The professional police practices were only adopted by January 2013, when all occurrences were georeferenced by GPS navigators. Simultaneously with the geo-referencing of the occurrences, information received through various channels of information (e-mail, telephone, Dial-Denunciation, etc.) is now handled by the Internal Affairs Division (DAI for its acronym in Portuguese), which is the intelligence sector of the CPAm. The BatchGeo free platform was used to

[1] AISP - this refers to the geographical correspondence between the area of a PMERJ battalion and one or more circumscriptions of Civil Police stations.

[2] The Legal Delegation Program consists of a radical transformation of building designs, making them comfortable and functional places equipped with state-of-the-art technological equipment and systems for employment in Intelligence and technology areas ighting crime, aiming to rescue the investigative function of the Civil Police.

[3] ISP - An authority directly linked to the State Secretary of Public Security, created with the main function of promoting, in practice, the unification of the Civil and Military Police. He is currently responsible for compiling all the common criminal statistics of Rio de Janeiro State.

[4] Phenomenological research is a form of empirical social research in which researchers are involved in a cooperative or representative manner. In this particular case, the police propose to analyze the main characteristics of the crimes, as well as places and times of greater incidence, comparing them with other periods and other factors that contribute to their incidence.

establish the environmental crime spot.

The paradigmatic shift in the operational planning of the CPAm allowed an increase in the effectiveness of its actions, reflected in the increase in the number of environmental criminal records every year without a significant increase in its staff.

2.3 The Environmental Police Unit

The UPAm are small police units with a workforce of around 30 men, with a light administrative structure, generally composed of two men and one commander, and located in a full protection unit (UC for its acronym in Portuguese) or its buffer zone (RIO DE JANEIRO, 2012). They are currently numbered seven, ordinally named according to the order of their creation and additionally receive the name of the UC where they are inserted or the specific mission that they execute. The 1st, 3rd, 5th, and 6th UPAm are installed in the State Parks of Pedra Branca, Desengano, Três Picos and Serra da Tiririca.

The 4th UPAm is located in the Juatinga State Ecological Reserve. The 2nd and 7th UPAm are units to support the others. The 2nd UPAm is located in the headquarters of the CPAm and is called Mobile, as it would reinforce the other units when their operational capacity fell short of the mission to be performed. Despite its operational support to the others and its area of operation encompassing the entire Rio de Janeiro State, it received a specific area of action in the absence of a closer unit to carry out policing in municipalities in the Médio Paraíba. The 7th UPAm is called Maritime-Fluvial, being responsible for carrying out operations or supporting the other units in operations in marine or fluvial environments and has the entire State as its area of action.

The geographical area of action for UPAm units took into account geopolitical, environmental, and traffic factors, to facilitate the development of the mission. As a result, each municipality was assigned a municipal unit of full state protection so that all 92 municipalities in the state could be policed; according to Chart 1.

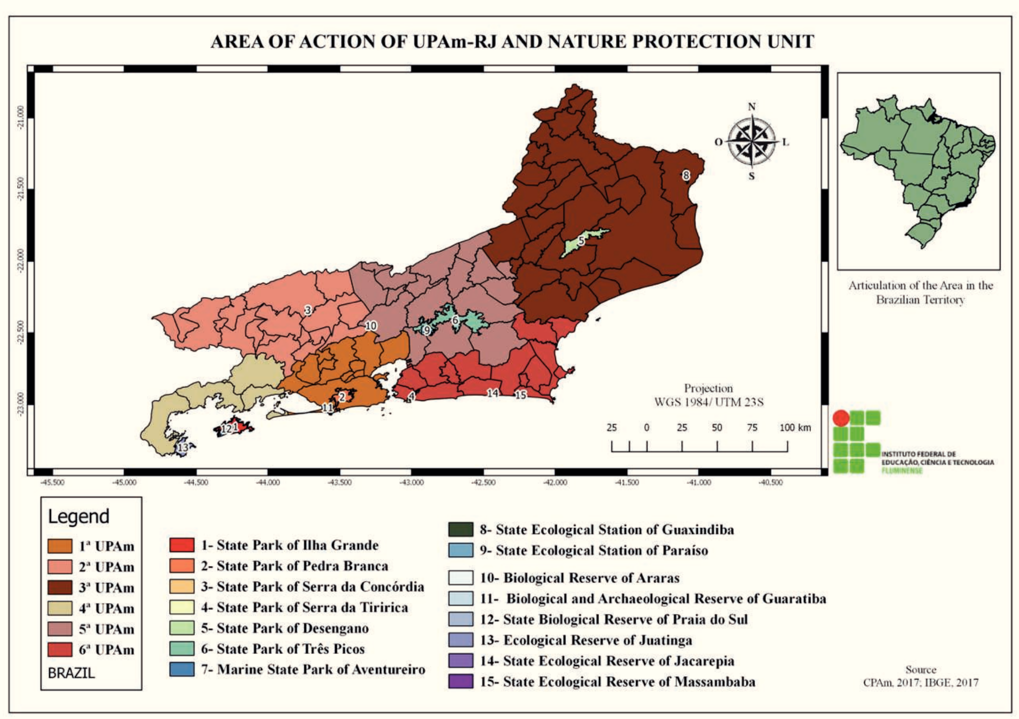
Chart 1. UPAm Units Geographical Area of action

1ª UPAm - Pedra Branca	2ª UPAm - Mobile	3ª UPAm - Desengano
Belford Roxo, Duque de Caxias, Itaguaí, Japeri, Magé, Nilópolis, Nova Iguaçu, Queimados, Rio de Janeiro, São João de Meriti, Seropédica e Mesquita (12)	Barra do Piraí, Barra Mansa, Engenheiro Paulo de Frontin, Itatiaia, Mendes, Miguel Pereira, Paracambi, Paty do Alferes, Pinheiral, Piraí, Porto Real, Quatis, Resende, Rio das Flores, Valença, Vassouras, Volta Redonda (17)	Aperibé, Bom Jesus do Itabapoana, Cambuci, Carapebus, Campos dos Goytacazes, Cantagalo, Cardoso Moreira, Conceição de Macabu, Italva, Itaocara, Itaperuna, Laje do Muriaé, Macaé, Macuco, Miracema, Natividade, Porciúncula, Quissamã, Santa Maria Madalena, Santo Antônio de Pádua, São Fidélis, São Francisco do Itabapoana, São João da Barra, São José de Ubá, São Sebastião do Alto, Trajano de Moraes e Varre-Sai (27)
4ª UPAm - Juatinga	**5ª UPAm - Três Picos**	**6ª UPAm - Serra da Tiririca**
Angra dos Reis, Paraty, Mangaratiba e Rio Claro (4)	Areal, Bom Jardim, Cachoeiras de Macacu, Carmo, Comendador Levy Gasparian, Cordeiro, Duas Barras, Guapimirim, Nova Friburgo, Paraíba do Sul, Petrópolis, São José do Vale do Rio Preto, Sapucaia, Silva Jardim, Sumidouro, Teresópolis e Três Rios (17)	Araruama, Armação dos Búzios, Arraial do Cabo, Cabo Frio, Casimiro de Abreu, Iguaba Grande, Itaboraí, Maricá, Niterói, Rio Bonito, Rio das Ostras, São Gonçalo, São Pedro da Aldeia, Saquarema e Tanguá (15)

Source: CPAm/PMERJ, 2014.

Figure 1 shows the geographical distribution of the UPAm area of action, as well as State protected areas.

Figure 1. Geographical distribution of UPAm area of action and State protected areas



Source: Authors (2017)

From the record of the occurrence of each UPAm, we can investigate the geographical distribution of different forms of environmental crimes occurred in the Rio de Janeiro State.

3 The geography of environmental crimes in Rio de Janeiro State

3.1 The recording of occurrences

The record of police occurrences in the PMERJ follows the rules established in the Vade Mecum of military police occurrences (RIO DE JANEIRO, 2013). This document was organized methodologically so that each legislation item received a specific treatment and codification. The occurrence coding is composed of five digits. The first two are followed by a dot and indicate some code, specific legislation, or even groups or categories of crimes. The last three numbers indicate a classification pertained to law.

Environmental incidents are codified based on Law 9605/98, which deals with criminal and administrative sanctions derived from actions and activities that harm the environment (BRAZIL, 1998), and are classified into six groups according to the nature of the crime:

a) 27.XXX – crimes and environmental infractions related to activities potentially polluting and/or degrading the environment;

b) 28.XXX – environmental infringements relating to water resources;

c) 29.XXX – infractions against urban planning, cultural heritage, and environmental management;

d) 30.XXX – environmental crimes and infractions related to fishery and fauna;

e) 31.XXX – environmental infringements relating to fauna;

f) 32.XXX – crimes and environmental infractions related to flora.

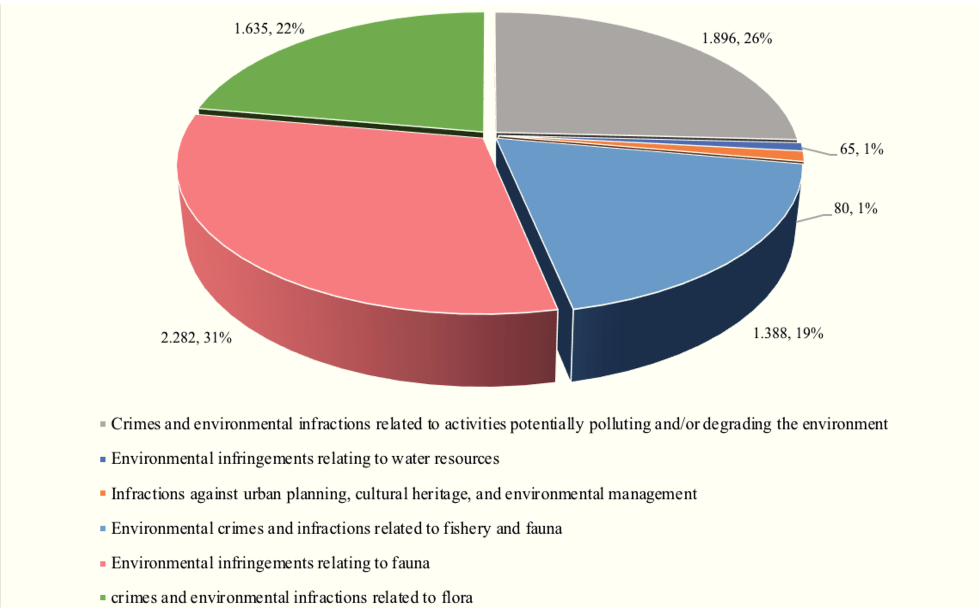
By analyzing the records of occurrences related to the codes and subcodes of groups 27, 28, 29, 30, 31 and 32, the geography of environmental crimes occurred in Rio de Janeiro State could be established. The specification of all codes relating to environmental crimes is described in Annex A.

3.2 State environmental crimes

Throughout the years 2014 to 2016, Rio de Janeiro State has been showing an increase of records for environmental crimes. The frequencies of those years were 1,747, 2,597, and 3,002 occurrences, respectively in a total of 7,346 occurrences over three years.

The dominant occurrences were those related to crimes against fauna, with 31% of cases; crimes related to potentially polluting activities, accounting for 26%; crimes related to flora, stamped 22% of events; and fisheries crimes accounted for 18% of the total. Graph 1 shows the description of the absolute and relative frequencies of environmental occurrences of the triennium 2014 – 2016.

Graph 1. Frequency of environmental crimes (2014 a 2016)



Source: CPAm/PMERJ (2017)

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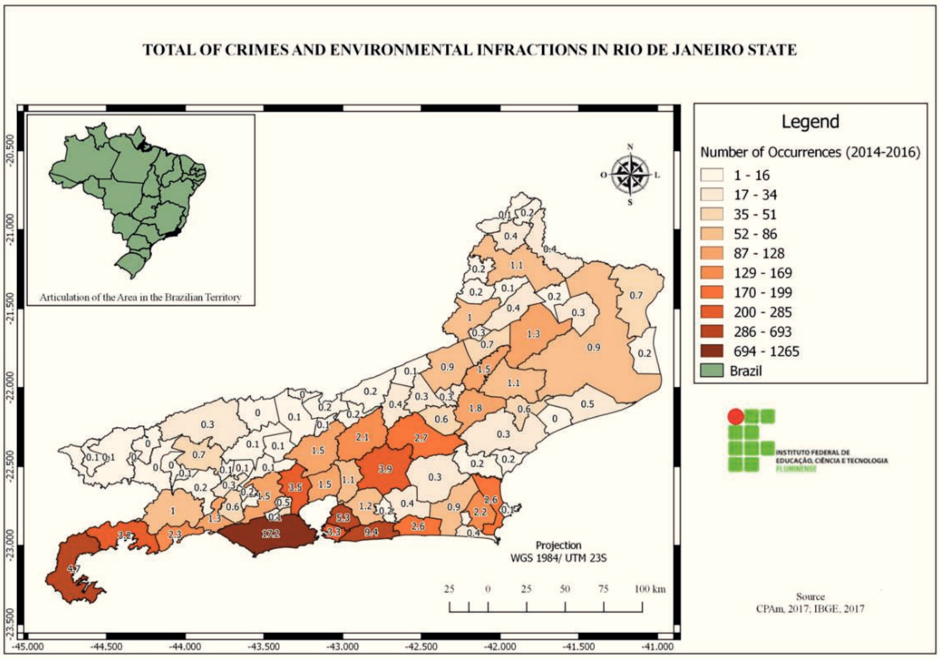
Crimes related to water resources and urban planning were not representative when analyzed quantitatively in absolute and relative terms, representing 1% of cases each.

The ten municipalities with the highest number of occurrences of environmental crimes, corresponding to 55.8% of the total, were: Rio de Janeiro (17.2%), Maricá (9.4%), São Gonçalo (5.3%), Rio de Janeiro (17.2%), Paraty (4.7%), Cachoeiras de Macacu (3.9%), Duque de Caxias (3.5%), Niterói (3.3%), Angra dos Reis (3.2%), Nova Friburgo (2.7%), Cabo Frio and Saquarema (2.6%). Figure 2 shows the geographical distribution of environmental crimes as a whole in the State.

Figure 2. Geographical distribution of environmental crimes – Rio de Janeiro (2014 a 2016)



Source: Authors (2017)

After a general notion of environmental crimes groups predominant in Rio de Janeiro State, each group will be analyzed geographically, identifying the municipalities in which each one prevails, as well as the predominant subgroup of occurrence. Thus, an overview of environmental crimes will be achieved.

3.3 The geography of crimes related to potentially polluting activities

The occurrences of environmental crimes and infractions related to potentially polluting and /or degrading environmental activities rank second among those that most affect the CPAm statistics. They corresponded to 1,896 records or 26% of all environmental crimes suppressed between 2014 and 2016 throughout the state.

The highest frequencies of environmental crimes were found in the municipalities described in Table 1 and correspond to more than half of all crimes committed and related to potentially polluting and/or environmental degradation activities.

Table 1. Municipalities with highest records of crimes related to potentially polluting activities

MUNICIPALITY	2014	2015	2016	TOTAL	%
Rio de Janeiro	67	127	150	344	18,1%
Paraty	42	41	62	145	7,6%
Cachoeiras de Macacu	34	39	54	127	6,7%
Angra dos Reis	10	28	42	80	4,2%
Nova Friburgo	15	32	32	79	4,2%
São Gonçalo	28	29	20	77	4,1%
Maricá	12	32	29	73	3,9%
Mangaratiba	8	21	36	65	3,4%
Teresópolis	10	25	25	60	3,2%
Petrópolis	5	29	19	53	2,8%
TOTAL	231	403	469	1.103	58,2%

Source: CPAm (2017)

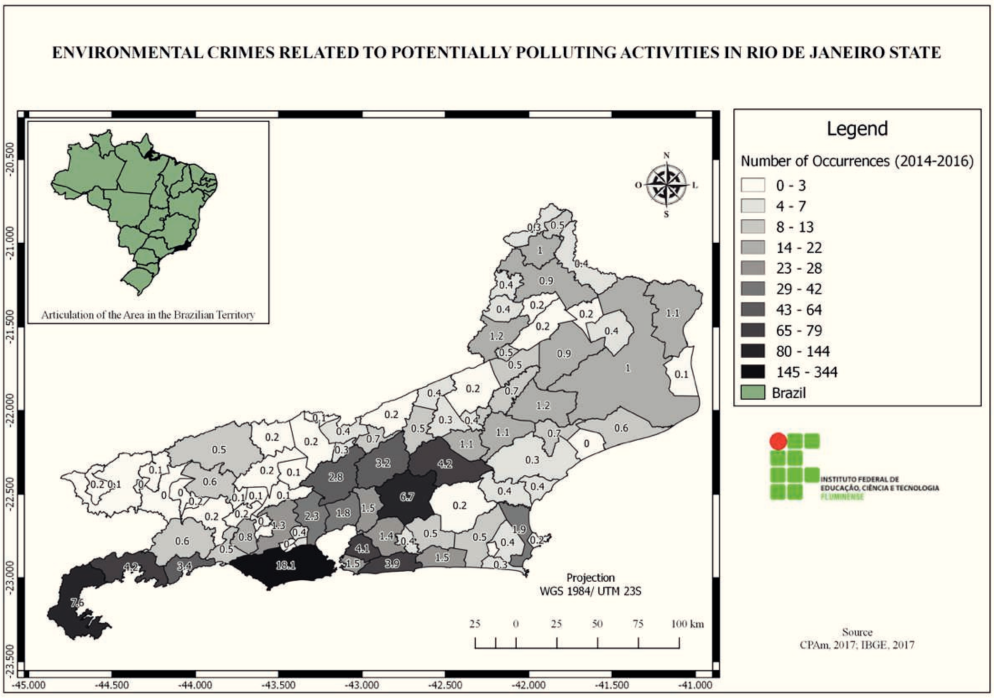
Among the most representative crimes of this group, 27,112 (19.8%), 27,113 (35.2%), and 27,134 (27.8%) are the most common crimes and together account for 82.8% of all crimes of this category. These codes refer to the following criminal codes (RIO DE JANEIRO, 2013):

> 27.112 - install, construct, test, operate or expand an activity that is effective or potentially polluting or degrading the environment without the installation or operating licenses, provided it is not protected by a behaviour adjustment agreement with the

competent environmental agency or entity, if not the existence of environmental pollution or degradation;
27.113 - to install, construct, test, operate or expand an activity that is effective or potentially polluting or degrading the environment without installation or operating licenses if pollution or environmental degradation is found;
27.134 - perform research, mining or extraction of mineral resources without the competent authorization, permission, concession or license, or in disagreement with that obtained.

Figure 3 describes the distribution of environmental crimes and infractions related to activities potentially polluting and/or degrading the environment.

Figure 3. Environmental crimes related to potentially polluting activities (2014 to 2016)



Source: Authors (2017)

3.4 The geography of environmental infringements related to water resources

Environmental infractions related to water resources represent only 1% of all environmental crimes in the State. Table 2 shows the municipalities where this category was most recorded, with the predominant being the code "28.204 - extracting groundwater, capturing or deriving surface water for human consumption purposes, without the respective license" (RIO DE JANEIRO, 2013) with 90% relative frequency.

Table 2. Municipalities with more records of environmental infractions related to water resources

MUNICIPALITY	2014	2015	2016	TOTAL	%
Rio de Janeiro	2	11	3	16	24,6%
Cachoeiras de Macacu	2	3	1	6	9,2%
Nova Friburgo	1	1	4	6	9,2%
São Gonçalo	0	6	0	6	9,2%
Maricá	0	2	3	5	7,7%
Saquarema	1	2	2	5	7,7%
Magé	0	4	0	4	6,2%
São João de Meriti	1	3	0	4	6,2%
Duque de Caxias	0	1	1	2	3,1%
Laje do Muriaé	2	0	0	2	3,1%
TOTAL	9	33	14	56	86,2%

Source: CPAm (2017)

Figure 4 shows the map with the geographical distribution of environmental infractions related to water resources throughout Rio de Janeiro State.

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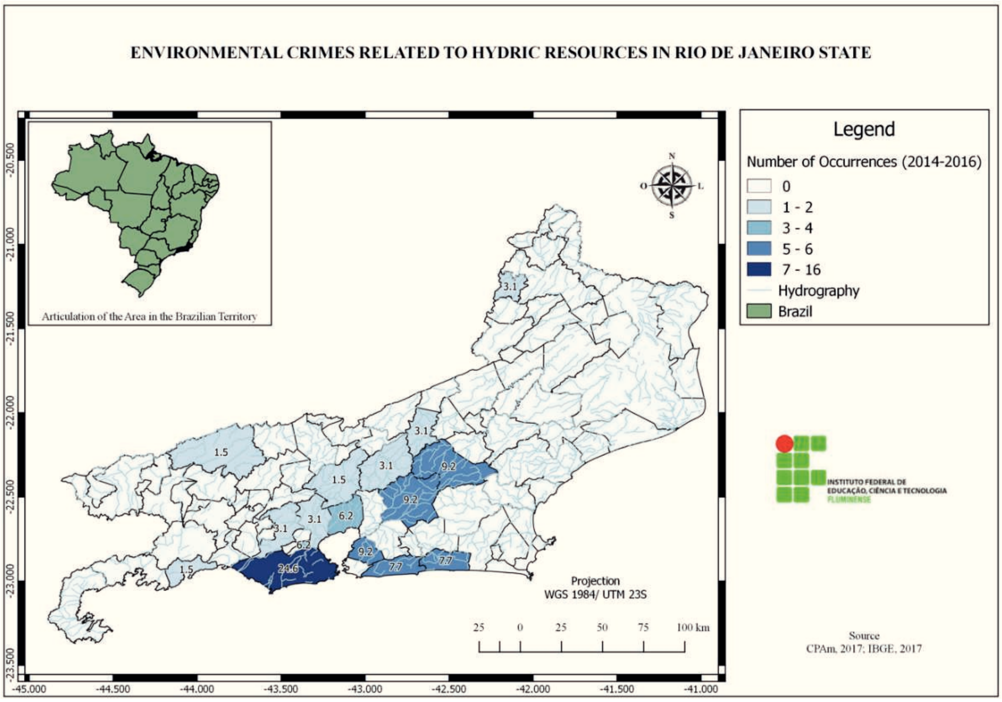
Figure 4. Geographical distribution of environmental infractions related to water resources (2014 to 2016)



Source: Authors (2017)

3.5 The geography of environmental infractions against urban planning

Another category of unrepresentative infraction in the universe of crimes registered by the CPAm are those against urban planning, cultural heritage, and against the environmental administration, with only 1% of relative frequency in all cases. The municipalities with the highest incidence of this group are listed in Table 3. The dominant code in this group was the no. 29.003 – "To promote construction on non-buildable land or its surroundings" (RIO DE JANEIRO, 2013), with a relative frequency of 91.3% of the records for this group.

Table 3. Municipalities with records of environmental infractions over urban planning, cultural heritage, and environmental management

MUNICIPALITY	2014	2015	2016	TOTAL	%
Rio de Janeiro	2	8	5	15	18,8%
Cabo Frio	1	4	6	11	13,8%
Niterói	3	4	4	11	13,8%
Angra dos Reis	1	5	1	7	8,8%
Cachoeiras de Macacu	3	1	1	5	6,3%
Maricá	0	2	2	4	5,0%
Duque de Caxias	0	3	0	3	3,8%
Mangaratiba	1	0	2	3	3,8%
Teresópolis	0	2	1	3	3,8%
Arraial do Cabo	0	0	2	2	2,5%
TOTAL	11	29	24	64	80,0%

Source: CPAm (2017)

Figure 5 illustrates the environmental infractions against urban planning, cultural heritage and environmental management.

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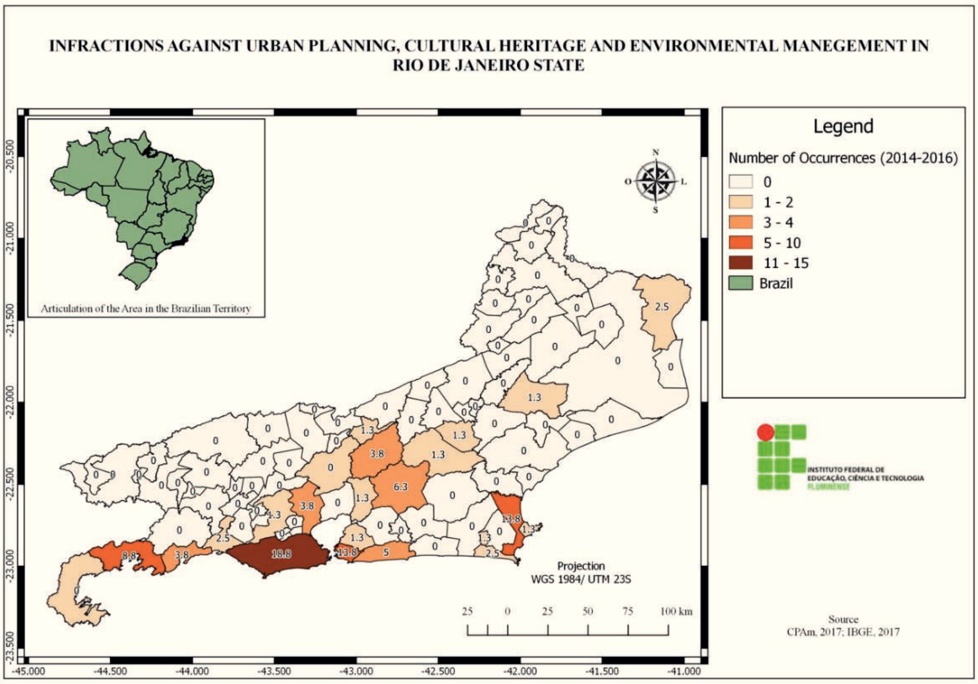
Figure 5. Environmental infractions against urban planning, cultural heritage and environmental management (2014 to 2016)



Source: Authors (2017)

3.6 The geography of fishery crimes

Crimes related to fishery accounted for 19% of cases (1,388 records). The highlights are the municipalities of Maricá, São Pedro da Aldeia and Saquarema, located in the Region of the Baixadas Litorâneas, which together represent more than half of all records of crimes against fishery. Table 4 describes the municipalities with the highest frequency of these crimes.

Table 4. Municipalities with highest records of crimes and environmental infractions related to fishery and fauna ***(continues)***

MUNICIPALITY	2014	2015	2016	TOTAL	%
Maricá	34	176	240	450	32,4%
São Pedro da Aldeia	94	52	8	154	11,1%
Saquarema	20	56	34	110	7,9%
Niterói	11	39	48	98	7,1%
Cabo Frio	9	58	26	93	6,7%

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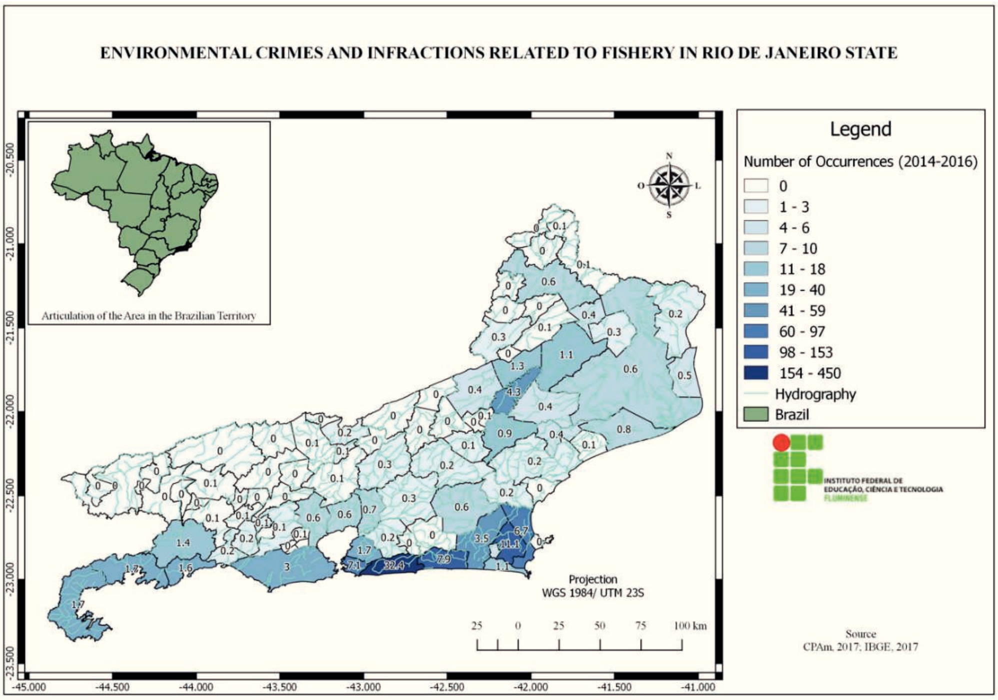
Table 4. Municipalities with highest records of crimes and environmental infractions related to fishery and fauna (conclusion)

MUNICIPALITY	2014	2015	2016	TOTAL	%
São Sebastião do Alto	27	18	15	60	4,3%
Araruama	6	26	17	49	3,5%
Rio de Janeiro	7	16	18	41	3,0%
Angra dos Reis	4	7	13	24	1,7%
São Gonçalo	8	6	10	24	1,7%
TOTAL	220	454	429	1.103	79,5%

Source: CPAm (2017)

The geographical distribution of environmental crimes and infractions related to fishery can be visualized in Figure 6.

Figure 6. Environmental crimes and infractions related to the fishery (2014 to 2016)



Source: Authors (2017)

The top crimes were 30.435 (10.2%), 30.438 (25.4%), and 30.443 (56.7%), which together represent 92.4% of all infractions against fisheries occurred in the State. These infractions correspond to the following delinquent behavior: "30.435 – The use prohibited fishing gear for all categories of fishery; 30.438 – To carry out fishery acts in prohibited or prohibited places, by the environmental agency; 30.443 - To carry out fishery activities with prohibited techniques or methods" (RIO DE JANEIRO, 2013).

3.7 The geography of environmental infringements related to wildlife

The group of environmental infractions related to fauna was the one with the highest incidence among all environmental crimes registered by the CPAm. They accounted for 31% of all records in the state, equivalent to 2,282 occurrences. Rio de Janeiro, São Gonçalo and Duque de Caxias were the municipalities with the highest number of cases, is related to more than 40% of all records produced. Table 5 shows the municipalities with the highest frequency of crimes against wildlife.

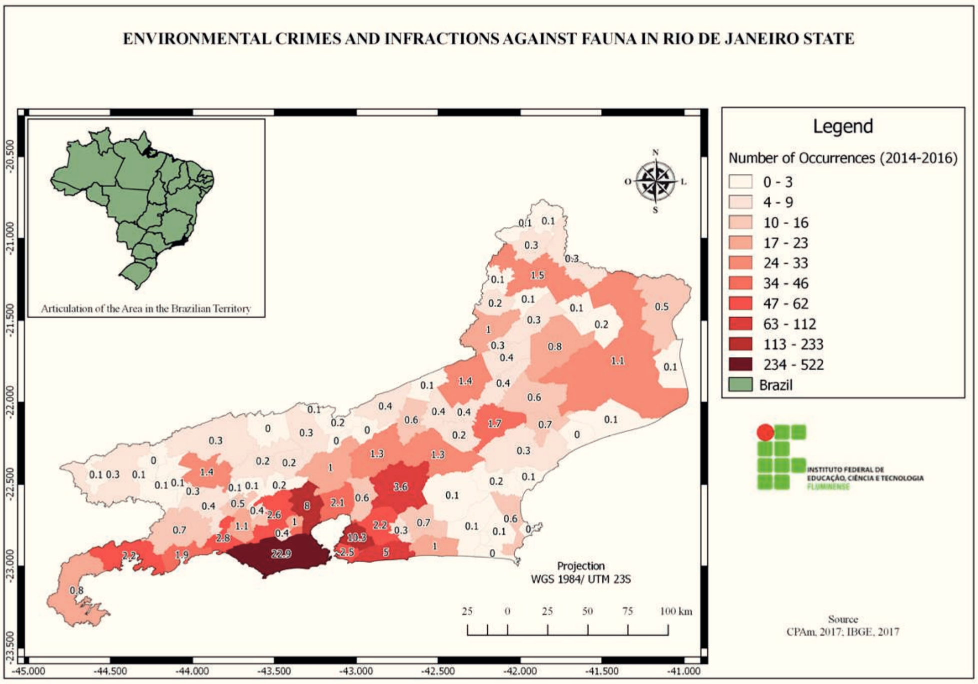
Table 5. Municipalities with more records of environmental infractions related to fauna

MUNICIPALITY	2014	2015	2016	TOTAL	%
Rio de Janeiro	157	131	234	522	22,9%
São Gonçalo	73	53	108	234	10,3%
Duque de Caxias	56	67	59	182	8,0%
Maricá	28	25	60	113	5,0%
Cachoeiras de Macacu	9	10	64	83	3,6%
Itaguaí	5	16	42	63	2,8%
Nova Iguaçu	16	13	30	59	2,6%
Niterói	14	12	32	58	2,5%
Angra dos Reis	20	17	14	51	2,2%
Itaboraí	9	13	28	50	2,2%
TOTAL	387	357	671	1.415	62,0%

Source: CPAm (2017)

Crimes against fauna have their geographical distribution shown in Figure 7.

Figure 7. Environmental Crimes and Infractions against fauna (2014 a 2016)



Source: Authors (2017)

The crimes under code 31.008 predominated over all others. The conduct of "acquiring, stocking, confining or storing specimens of native wildlife as well as products and objects from it, without a license" (RIO DE JANEIRO, 2013) accounted for 86.6% of all occurrence records between 2014 and 2016, with 1,976 bulletins written.

3.8 Geography of environmental crimes related to flora

The damages caused to the flora were responsible for 1,635 records of occurrences by the CPAm and represented 22% of all frequency of cases throughout the State. Table 6 shows the sites with the highest incidence of this category of environmental crime.

Table 6. Municipalities with more records of environmental crimes related to flora

MUNICIPALITY	2014	2015	2016	TOTAL	%
Rio de Janeiro	86	113	128	327	20,0%
Paraty	55	57	48	160	9,8%
Nova Friburgo	11	50	21	82	5,0%
Angra dos Reis	11	31	31	73	4,5%
Cachoeiras de Macacu	16	30	15	61	3,7%
Trajano de Moraes	24	18	14	56	3,4%
Teresópolis	7	23	25	55	3,4%
Maricá	17	15	17	49	3,0%
Niterói	6	19	20	45	2,8%
São Gonçalo	20	18	6	44	2,7%
TOTAL	253	374	325	952	58,2%

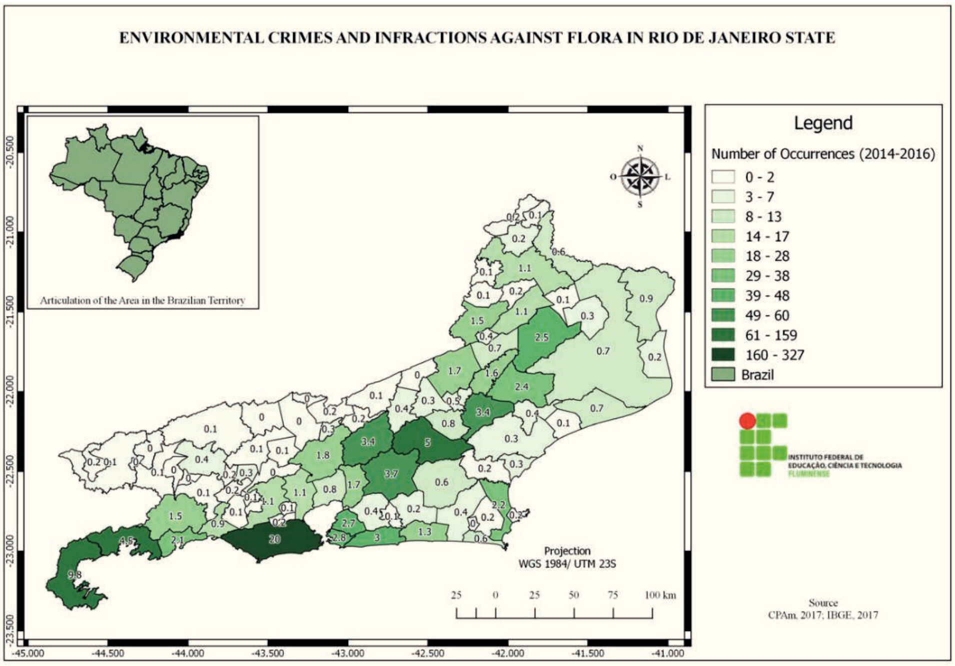
Source: CPAm (2017)

The group of environmental crimes against flora was, among the other groups of environmental crimes, the one which presented a greater distribution among the dominant occurrence codes. The codes 32.304 (8.2%), 32.305 (33.6%), 32.308 (10%), 32,316 (12.5%), 32,326 (8.5%) and 32,327 (10.8%) represented 83,6% of all crimes against flora practiced in any state territorial extension. These codes are thus described (RIO DE JANEIRO, 2013):

> 32.304 - to exploit, deforest, remove, extract, damage or cause the death of forests and other forms of vegetation in protected areas without prior authorization of the competent body and/or without respecting the norms of sustainable exploitation;
> 32.305 - to explore, deforest, extract, suppress, cut, damage or cause the death of forests and other forms of vegetation in a permanent preservation area, without special authorization or intervene in a permanent preservation area, even if it is discovered of vegetation;
> 32.308 - cutting or suppression of isolated trees in permanent preservation areas, legal reserve or integral protection conservation units;
> 32.316 - to develop activities that hinder or impede the natural regeneration of forests and other forms of vegetation;
> 32.326 - manufacture, sell, transport, take possession or release balloons that may cause forest fires and other forms of vegetation;
> 32.327 - cause fire in forests, woods or any other form of vegetation.

Figure 8 shows the geographical distribution of environmental crimes and infractions against the flora.

Figure 8. Environmental crimes and infractions related to flora (2014 to 2016)



Source: Authors (2017)

This set of organized information, used in a structured system could help the process, by producing information and analysis that would contribute to the planning of the environmental policing developed by the CPAm, avoiding wasted time and waste of human and material resources.

These systems have been available on the market for a long time and are increasingly accessible from a financial point of view, and broadly accepted by users, given the various Web platforms from which they can be accessed. They are the Geographic Information Systems (GIS), which will be discussed in the next section.

4 Geocollaboration based on web platforms

The technological and computational developments allowed Geography and Cartography to develop new perspectives of analysis. The development of Spatial Engineering with the construction of artificial satellites and the Internet has allowed the advance of geotechnologies and the democratization of access to maps. Geotechnology allowed to collect, process, analyze, and make available data with geographic references, offering robust support for decision making (FITZ, 2008; ROSA, 2011).

Geoprocessing is a more generic term and covers several geotechnologies such as remote sensing, GIS, digital cartography, GPS and georeferenced topography. The popularization of geotechnologies is due to the evolution and accessibility, both from the user and the financial one, of the computers (hardware) and the specific programs (software), (FITZ, 2008; ROSA, 2011).

The 21st century brought significant advances in the popularization of Cartography. Since 2005 when computer giant Google has launched two popular mapping services programs, Google Maps and Google Earth, GIS has undergone a real revolution, which has given rise to new Web mapping technologies, including geocollaboration or crowdsourcing, which will be better discussed in the next part of the research (TSOU, 2011, MENEGUETTE, 2012).

Tsou (2011) argues that in 2005 few cartographers were engaged in Web mapping research or material related to this topic and that this would be because they understood that Web mapping was more of a technical solution than a subject of academic research.

Cartographic surveys on the Web present two critical categories. The first one is the use of maps on the Internet, such as map type, multiple users, and the number of maps created. The second one is the construction of maps on the Internet, including the graphic design of maps, file formats, printing, map scale and customized maps on demand (TSOU, 2011; MENEGUETTE, 2012).

Tsou (2011) emphasizes the role of new map users in Web Mapping, which are very different from traditional map users, as well as the characteristics of these new Web map users and the increased importance of user-centered design (UCD), and control over Web-mapping for ubiquitous access[5].

Tsou (2011) identifies five generations in the evolution of Web mapping technologies: the first generation was based on HyperText Markup Language (HTML) and Common Gateway Interfaces (CGI). The second generation was developed based on applets and component-oriented Web tools. The third generation included mashups, asynchronous JavaScript and XML (AJAX) and the provision of mapping applications by the Application Programming Interface (API). The fourth generation came with the creation of Google Earth and other digital globes such as NASA World Wind and Microsoft Virtual Earth, providing an immersive mapping environment for users. The fifth generation created three technological keys to the next generation of Web maps, namely cloud computing support, rich internet applications (RIA), and crowdsourcing (TSOU, 2011; MENEGUETTE, 2012).

The maps on the Web have changed the context of cartographic representation in our society. From traditional paper themed maps or desktop computers we turn to various applications aimed at users of mobile devices, virtual globes and Web browsers.

The Cartography on the Web at the beginning of its development and as a consequence of this new design, made the researchers come up with several neologisms such as 'online mapping, Internet mapping, CyberCartography or Cybernetic Mapping, Web Mapping, Maps 2.0, GIS / 2, geospatial Web or geoweb, neogeography, neo-cartographers, locative media, DigiPlace and spatial crowdsourcing, or geocollaboration.' The need for new Web map designers to deal with these dynamic changes was also emphasized (CRAMPTON, 2009; TSOU, 2011; MENEGUETTE, 2012).

The development of map design over Web occurred in two revolutionary waves. The first was in 2005 when Google launched its mapping applications, Google Maps and Google Earth, which some researchers called a new form of GIS, called GIS/2. According to Crampton (2009), only Google Earth has been downloaded more than 250 million times. It is also responsible for coining the term Maps 2.0 to designate the explosion of these new space media on the Web, indicating that knowledge production is in the hands of public, and no longer in accredited and trained professionals (TSOU, 2011).

However, the critical factor for Web design revolution was the improvement in mapping performance with the use of tile-based mapping engines and the AJAX technology, which provided

[5] Ubiquitous mapping is a term coined by Ota in 2004 to designate a person's access to any map, anywhere at any time through an information network, that is, ubiquitous computing access (GARTNER; BENNETT; MORITA, 2007).

a significant improvement in client-server response and the generation of multiscale cartographic representations. Grid-based mapping machines also allowed the storage of a set of overlapping layers of images at different scales on map servers over the Web. Google Maps and Maps.search.ch are examples of the combined use of these technologies.

The second wave of map design over the Web revolution has recently come about with the development of mobile mapping on smartphones, tablet PCs, and GPS navigators. Hundreds of Web mapping applications have already been developed for smartphones and tablets, such as Urbanspoon, GPS HD by Motion X, UpNext 3D Cities, ESRI ArcGIS for iPad, Zilliow.com, etc. This was only possible thanks to the portable hardware design and the rapid distribution structure of software. These service stores (Apple Store and Android's Market Place) offered the majority of mobile software development suites in open and free codes for program developers to download for free. Another facility was to allow users to download and install programs directly from their mobile devices without worrying about complicated software licenses and setup or installation procedures. The free software development environment and online application stores have created an excellent opportunity for small GIS companies and individuals in the development and sharing of Web mapping services (TSOU, 2011; MENEGUETTE, 2012).

Unlike the traditional users of GIS-based projects that are mostly decision makers, and familiar with the system and Cartography, the users of the Web mapping services are diverse, and, in no small extent, with no cartographic knowledge or experience in SIG (TSOU, 2011; MENEGUETTE, 2012). (make sure the commas are in the correct place, I'm having trouble determining it).

Web mapping tools were responsible for significantly reducing costs in map production. They have provided professional and amateur cartographers with the use or free combination of online mapping services and high-quality online mapping (road maps, aerial images or topographic maps), (TSOU, 2011; MENEGUETTE, 2012).

Another contributing factor for Web mapping was the development of free and open source software (FOSS) and free mapping APIs, making FOSS Mapping and essential mashup maps components of Cartography on the Web. In this way, amateur cartographers were able to produce freely and efficiently distribute their maps. They have adopted these Web mapping tools and the free mapping APIs to publish and share their maps with the world. These devices provide flexibility and portability in the display and map output formats options for Web mapping services (TSOU, 2011; MENEGUETTE, 2012).

Finally, Tsou (2011) states that the ultimate goal of the innovative development of Web mapping software and research is to improve the human well-being, mediate conflicts, and facilitate the sustainable development of society. He cites the ideal partnership in projects would be between cartographers, computer scientists, sociologists, activists, psychologists and information technology (IT) engineers who would become "spatial information designers" or "geospatial information architects" to create innovative Web mapping. These cartographic innovations would help to make society more collaborative, humane, and sustainable.

An innovative example is the ArcGIS mapping and analysis platform, developed by the company Earth Sciences Research Institute (ESRI).

The ArcGIS is equipped with tools that allow mapping and rationale over events, allowing users to visualize the interconnection between various events, as well as share the results through other applications with other people. Its functionalities include the ability to perform spatial analyzes, mappings, and visualizations, 3D modelling and visualization, real-time data updating, remote sensing, imaging, and data management (through access and storage of individual data, database, geodatabase, or virtual-cloud database). This set of features allows users to map the various events, understand how they relate, what they mean, and thus decide on the best decision to take ("Transform corporate GIS", [n.d.]). Its online version, called ArcGIS Online, is based on cloud computing using a Rich Internet Application (RIA) -based programming method. RIA promotes user-friendly, high-performance, responsive Web applications with compelling user interface tools and appliances (TSOU, 2011).

ArcGIS Online has some tools and applications, extending from those who enable mapping and information sharing through mobile devices (tablets and smartphones) to those who allow developers to build their applications based on that platform. Another advantage is that it integrates with ArcGIS Desktop, which is a set of GIS applications developed by ESRI for desktop computers ("Transform Corporate GIS", [n.d.]).

In January 2016, ESRI made a new product available to users, which is integrated with the ArcGIS platform: ArcGIS Earth. It is a platform for visualizing geospatial data in 2D and 3D format, which supports KML files, shapefiles or Web archives ("ArcGIS Earth launched, download it for free!", [n.d.], "ArcGIS Earth", [n.d.]).

IT giant, Google Incorporation, launched in 2005 the application that has become one of the most popular tools for viewing and sharing environmental data: Google Earth. This technology allowed visualization and continuous exploration of 2D and 3D spatial data through high and medium resolution images from anywhere in the world, creating an opportunity for access to images, involvement, and collaborative use of spatial information never seen before (SHEPPARD; CIZEK, 2009).

According to Chowdhry (2015), in October 2011 Google Earth Desktop hit the mark of one billion downloads. In January 2015 Google announced that the full paid version ($ 399 per year), Google Earth Pro, was available for free download by regular and corporate users. For the Google Earth Pro Product Manager, Stafford Marquardt, this software had been used for more than ten years by entrepreneurs, scientists and hobbyists to observe Earth and space for a wide range of purposes, from planning to the study for the placement of photovoltaic panels on the roofs. With Google Earth Pro all users will be able to use the same images of the free and open source version, along with advanced tools that will help the user to measure 3D buildings, print and record videos in high resolution. Another feature of the Pro version is support for a variety of file formats, including those with layered images with raster and dot matrix ("Google Earth Pro is now free", 2015).

Ziolkowska and Reyes (2016) attribute that the success of multidimensional visualization applications is due to:

a) provide an interactive visualization platform that allows users to adjust their input parameters and specify the research needs more precisely;

b) offer a multidimensional perspective on a simple KLM structure

c) allow a temporal space analysis covering the geographical location and the variable time without animation;

d) freedom of access by the end user (open access models) and do not require sophisticated software installation processes or license application requirements;

e) the possibility of use in various operating systems of computers (Windows, Mac, Linux, etc.) and mobile devices (Android, iOS, Windows Phone, etc.);

f) ease of transfer and compatibility with other platforms.

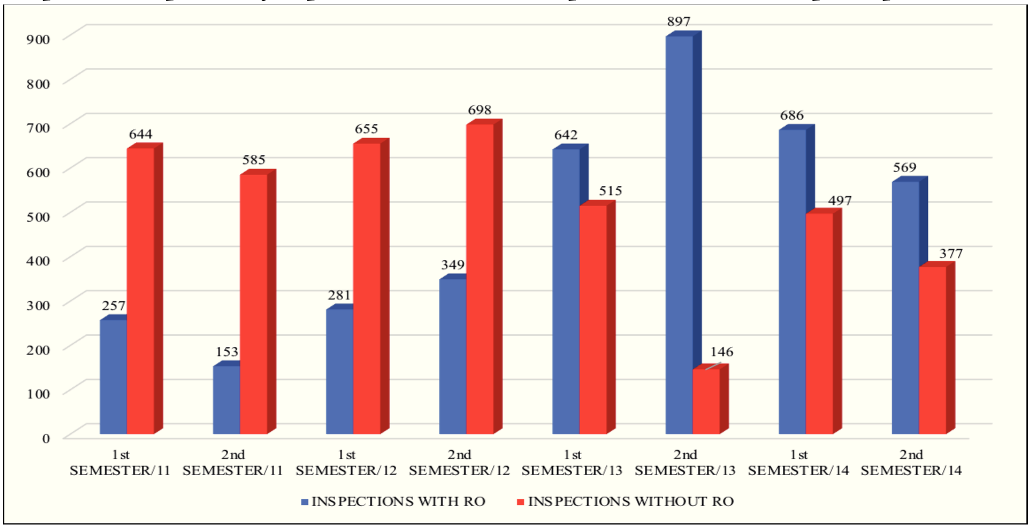
5 *Geocollaboration in the environmental surveillance by CPAm/PMERJ*

The use of geotechnologies by the CPAm began timidly in 2013 when the place of the occurrences under its jurisdiction was georeferenced by GPS devices. A second moment arose when these occurrences were arranged on a map through a FOSS application called BatchGeo.

This software allows the generation of maps with ease from the insertion of data, such as postal code (postal code), address, city, intersections, and state, which are arranged in a spreadsheet table or program. This allowed the elaboration of maps where it was possible to visualize the environmental crime spot in the State of Rio de Janeiro ("About our mapping characteristics and use cases | BatchGeo", [n.d.]).

Another change that shifted the operational paradigm of the CPAm was to support its actions on information received from various sources and ways, which after being addressed by DAI were sent to the CPAm. From that moment on they had a specific place to inspect and were no longer employed in patrolling without any information. The result was an increase in the efficiency of the units, validated by the number of Occurrence Records (RO for its acronym in Portuguese) in the circumscription stations, as shown in Graph 2.

Graph 2 – Comparison of inspections with RO and inspections without RO (up to Sept 2014)



Source: CPAm/PMERJ (2016)

The DAI also began to verify how anonymous complaints could be confirmed, noting that in the year 2013 the confirmation rate was approximately 50%, and in the first half of 2014 was 46%. Considering the excellent index of confirmation of the accusations, the APC invested in publicity campaigns with the purpose of publicizing its work and means of contact, to stimulate the communication of crimes by the population. During the first half of 2014, 861 complaints were received and, in the same period of 2017, 2,245, without verification of its confirmation index (RIO DE JANEIRO, 2014a; RIO DE JANEIRO, 2014b).

In 2013, the CPAm promoted recruitment in the corporation of professionals with higher education in several areas of knowledge so that they could add knowledge needed to improve the delivery of their service. Thus, while in January 2013, the unit had 8 officers with a college degree; in December that number was 21, as shown in Table 7.

Table 7. Professionals with Post Graduation – 2013

GRADUATION DEGREE- 2013	JAN	DEZ
Master	1	2
Associate	5	17
Bachelor	2	2
TOTAL	**8**	**21**

Source: CPAm/PMERJ (2013)

In his research, Júnior (2015, p. 60) had already addressed the lack of specialized personnel as an obstacle to the implementation of geotechnology applications. He also stated the importance of the use of SIG, mainly in the "implementation of collaborative mapping methodology by the population, and exchange of information between the organs of environmental protection and public safety". Thus, it is demonstrated that the CPAm does not use the geocollaboration methodology for the development of its environmental inspection activities.

After reviewing the literature, this research will continue to describe the material and method employed, the results and discussion, and finally the conclusions.

6 Materials and method

The research was based on the empirical-phenomenological methods of exploratory-descriptive characteristics. Thus, the study begins with exploratory research to acquire a greater familiarity with the activities of environmental policing and geocollaboration, covering the necessary bibliographical survey regarding the objects of study.

Descriptive research was then carried out using a case study procedure from the CPAm, using the documentary analysis of the data of occurrence bulletins in Rio de Janeiro State, from 2014 to 2016. The research also presents a phenomenological character, considering the participatory involvement of authors in the activities of environmental policing in the years of 2006, 2013, and 2014.

All data from occurrence reports were analyzed, tabulated, and described according to statistical principles, presenting their absolute and relative frequencies using graphs, tables, and thematic maps.

For the mapping and spatialization of environmental crimes, the QGIS, ArcGIS and Google Earth Pro applications were used.

7 Results

This article indicated that the environmental crimes occurred in the State of Rio de Janeiro during the years 2014 to 2016 had an increasing range, going from 1,747 to 3,002 records respectively. This increase in registration numbers was due to a change in their operational practices, and adopted professional police practices, such as the establishment of criminal patches, georeferencing of occurrences by GPS navigators, treatment of data received through community collaborations; anonymous or not.

The methodology of the registries obeyed to an internal normalization of the PMERJ and allowed them to be classified into groups. From the groups, it was possible to analyze the occurrences of predominant environmental crimes, as well as to identify that among the 92 municipalities of the state, ten municipalities are responsible for only 55.8% of all registries.

The thematic analysis of the occurrence groups also made it possible to visualize the municipalities in which the crimes and infractions related to the potentially polluting and/or degrading activities of the environment, water resources, against urban planning, cultural heritage and environmental management, fishery, fauna, and flora.

This thematic register of occurrences is of particular importance because it has the potential to produce a criminal environmental inventory of Rio de Janeiro State. Such inventory could be used by managers at all three levels of government to establish public policies relating to the public environmental decision-makers, so they can decide on the best decision to adopt. It would also guide the CPAm and UPAm commanders about the characteristics of the crimes in their areas of action, allowing direct instructions, and repressive and preventive actions such as environmental education.

Another beneficiary of this inventory would be the society and its various leaders, allowing them to know the reality of the environmental crimes that occur in their geographic region. Thus, they would be able to put pressure on the public organs responsible for environmental protection and conservation, and ultimately provide a better service in order to mitigate the damage caused, as well as to oversee the accountability of degrades. However, such data would not be available in real time.

Leading developers of Web mapping software allow experts to build applications based on their platforms. These could generate real-time data, information, and report analysis, allowing decision-makers to assess the immediate action needed for each specific case.

However, research has shown that while there are already affordable technologies and free tools that allow the generation of maps on the Web, in platforms such as ArcGIS Online, ArcGIS Earth, and Google Earth Pro with the help of society, the geocollaboration has not yet been used by CPAm. However, it has a culture of social collaboration, with a reasonable rate of confirmation of denouncements (between 46 and 50%).

8 Final considerations

The fifth generation of Web mapping technologies built on cloud computing support, RIA, and collaborative mapping or geocollaboration has opened a new dimension in how citizens can handle geographic space. Responsive applications enable ubiquitous access to a wide range of data through desktops and mobile devices from different operating systems. The citizen today has the world in his hands.

The CPAm has the culture of social collaboration, with a good rate for denouncements confirmation, but not for geocollaboration. The low technical qualification of its staff and the lack of adequate resources are obstacles to the adoption of geocollaboration. Nevertheless, there is a potential to develop it due to the process of hiring professionals from several areas within the corporation, including those of the natural sciences. The system also uses the available robust event log data, allowing several fields of analysis.

One of these fields of analysis is related to the fact that more than half of the recorded environmental crime reports focus only on ten, instead of 92 state municipalities, distributed in the Metropolitan, Serrana, Costa Verde and Coastal Basins. Another important matter is the fact that more than 80% of the records of crimes related to potentially polluting activities can be grouped into two types of criminal conduct: irregular mineral extraction and the development of potentially polluting activities without a license.

Regarding the records of crimes related to water resources and urban planning, which represent 1% each of all the bulletins generated, the standard violations that predominated with more than 90% of the cases were: the use of water resources for human consumption without a license, and construction on the non-buildable ground, respectively.

Regarding the records of crimes and infractions related to the fishery, it is important to point out that more than half of all case reports were carried out in three of the 92 municipalities in the state: Maricá, São Pedro da Aldeia and Saquarema. The typical predominant behaviours, with more than 90% of cases, are those related to the practice of fishery with prohibited devices or techniques and to fish in prohibited or restricted places. This research did not have the scope to make a temporal analysis of the records, but their concentration in those municipalities may indicate that this fact may be related to the Araruama lagoon closure, which occurs annually between August and October.

In crimes related to fauna, the predominant delinquent behaviour, with almost 90% of the records, refers to the acquisition, stocking or captivity of wild animals without a license, and more than 40% of these records occurred in the municipalities of Rio de Janeiro, São Gonçalo, and Duque de Caxias. It is not by chance that in these three municipalities run the most famous fairs of illegal trade of wild animals, revealing the culture of the fowler that still seems to persist in our society in the 21st century. Regarding crimes against flora, more than 80% of the bulletins are related to the crimes of deforestation, the release of balloons with fire, and arson; the latter two are closely related.

This article addresses a new subject in a multidisciplinary field and opens the possibility for future research. Detailed studies of the thematic cut-offs of environmental crime, mapping of criminal occurrences; the analysis of criminal occurrences related to types of crimes with geographic and geomorphological information; examining the interrelationship between the frequency of the environmental violations and the social and populational data (employment, average income, educational attained, etc.), and the UPAm staff, are examples of several topics that can be explored for future works.

It's wishful thinking that the development of a specific geocollaborative application for environmental policing activities would enhance the activities developed by the Brazilian military environmental police.

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