UNIVERSITY OF BRASÍLIA

CENTER FOR SUSTAINABLE DEVELOPMENT

Associations of weather variables, violent crimes and urbanism in Brasília, Distrito Federal.

Abner Luis Calixter

Advisor: Prof. Carlos José Sousa Passos

Co-Advisor: Prof. Marta Adriana Bustos Romero

Doctoral Dissertation

Brasília – Distrito Federal
August 2020, Brazil

CALIXTER, Abner L.
Associations of weather variables, violent crimes and urbanism in Brasília, Distrito Federal.
Abner Luis Calixter.
Brasília, 2020.
215 pages p.: il.

Ph.D. Dissertation. Center for Sustainable Development. University of Brasília, Brasília, Brazil.

1. Urban resilience. 2. Sustainable cities. 3. urban violence. 4. urban climate. 5. Heat resilience. 6. Heat stress. 7. Sustainable urbanism.
8. Urban planning. I. University of Brasília. CDS.
II. Title

`

Abner Luis Calixter

UNIVERSITY OF BRASÍLIA (UnB)

CENTER FOR SUSTAINABLE DEVELOPMENT (CDS)

Associations of weather variables, violent crimes and urbanism in Brasília, Distrito Federal.

Abner Luis Calixter

Doctoral dissertation submitted to the University of Brasília's Center for Sustainable Development, as a partial requirement for obtaining the Doctoral Degree in Sustainable Development, with a major in Sustainability Policy and Management.

Approved in defense by:

Carlos José Sousa Passos, Ph.D. (Center for Sustainable Development - UnB)
(Advisor)

Marta Adriana Bustos Romero, Ph.D. (Faculty of Architecture and Urbanism, FAU – University of Brasília)
(Co-advisor)

Maria Silvia Rossi Ph.D. – External Examiner (Government of Distrito Federal – GDF)

Cristiane Gomes Barreto, Ph.D. (CDS - UnB)
(Internal Examiner)

Gustavo Macedo de Melo Baptista, Ph.D. (Geosciences Institute – UnB, External Examiner)

Stephanie Caroline Nasuti Ph.D. (CDS - UnB) (Substitute examiner)

Brasília-DF
August 2020

This thesis embeds my original work facilitated by the Center for Sustainable Development and the Faculty of Architecture and Urbanism (LaSUS - Laboratory for Urban Sustainability and Architecture) at the University of Brasília having no content previously published nor submitted for obtaining any other degree or diploma in any other university or institute. It is important to highlight that although this interdisciplinary research has had somehow support from many contributors, I am the principal investigator of all components presented in this thesis.

This study was financed in part (doctoral scholarship) by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* – Brazil (CAPES) – Finance Code 001.

To all development practitioners,
urban planners and human lovers,
who indefatigably struggle with the utopia
of an inclusive,
and sustainable life.

TABLE OF CONTENTS

LIST OF MAPS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Weather – Daily conditions of the atmosphere (such as cloudy, sunny, warm)[1]

Climate – the weather features of a place averaged for a longer period of time[2]

New fashion – refers to a new tendency

Violent crimes – "behaviors by individuals that intentionally threaten, attempt, or inflict physical harm on others"[3]

Abrupt warming – changing temperatures from a space to another (such as feeling the cool when passing near by a park)

Hotspots – a place of significant activity or danger.

Raster – "matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature".[4]

Land Surface Temperature (LST) – The Land Surface Temperature (LST) is the radiative skin temperature of the land surface, as measured in the direction of the remote sensor.[5]

Routine Activity Theory – weather favoring outdoors encounters, more alcohol intake and others potential factors for influencing violent crimes. Theory by Cohen & Felson (1979)

Temperature Aggression Model – Theory by Anderson & Anderson (1984) that predicts increasing violence accordingly to higher temperatures.

Brasília – Plano Piloto – RA 1 (Administrative Region 1)

Distrito Federal – the whole territory including the 30 administrative regions and the *Plano Piloto.*

UnB – University of Brasília

---

[1] NSIDC – National Snow and Ice Data Center

[2] NSIDC https://nsidc.org/cryosphere/arctic-meteorology/climate_vs_weather.html#:~:text=Weather%20is%20the%20day%2Dto,cloudiness%2C%20visibility%2C%20and%20wind.&text=Climate%20is%20the%20weather%20of,of%20time%2C%20often%2030%20years. Accessed Aug 13th 2020

[3] Oxford bibliographies - https://www.oxfordbibliographies.com/view/document/obo-9780195396607/obo-9780195396607-0001.xml Accessed Aug 13th 2020

[4] https://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/what-is-raster-data.htm#:~:text=In%20its%20simplest%20form%2C%20a,pictures%2C%20or%20even%20scanned%20maps. Accessed Aug 13th 2020

[5] https://land.copernicus.eu/global/products/lst#:~:text=The%20Land%20Surface%20Temperature%20(LST,direction%20of%20the%20remote%20sensor.&text=In%20turn%2C%20the%20LST%20influences,determines%20the%20surface%20air%20temperature. Accessed Aug 13th 2020

ABSTRACT

It has been long assumed that weather plays a role in violent behavior. Nevertheless, empirically demonstrating this association is a complex task to overcome. Thus, we adopted innovative approaches such as processing big data in-cloud combined with temporal and spatial analyses revealed that warmth beyond average temperature accounted for a variation of 9% of homicides monthly in Brasília (2009 - 2017). Also, mapped hotspots of violent crimes and high land surface temperatures revealed similarities between criminogenic cityscapes such as extremely dense urban tissues and green spaces that are not so green from the perspective of sustainable urbanism. Temperatures are insightful indicators of spatial vulnerability to violence as demonstrated in this study. Besides finding seasonal patterns for violent crime occurrence, this thesis correlated a time-series of air temperature and land surface temperature (LST) to geocodes of crime. Results mapped similar urban morphologies prone to heat and crime. Advancing with the 11th Sustainable Development Goal which foresees more inclusive, safer, just and sustainable cities means tackling abrupt microclimate changes due not only to thermal comfort and aesthetics but also for enhancing public security.

RESUMO

Há muito se supõe que o clima desempenha um papel importante no comportamento violento. No entanto, demonstrar empiricamente essa associação é uma tarefa complexa de superar. Assim, adotamos abordagens inovadoras como o processamento de big data em nuvem combinado com análises temporais e espaciais revelando que o calor acima da temperatura média foi responsável por uma variação de 9% dos homicídios mensais em Brasília de 2009 a 2017. Além disso, pontos críticos mapeados de crimes violentos e altas temperaturas da superfície da terra revelaram semelhanças entre paisagens urbanas criminogênicas, sendo estes identificados como tecidos urbanos extremamente densos e espaços verdes que não são necessariamente tão verdes do ponto de vista do urbanismo sustentável. As temperaturas se mostraram como sendo indicadores de vulnerabilidade espacial à violência, conforme demonstrado neste estudo. Além de encontrar padrões sazonais para a ocorrência de crimes violentos, esta tese correlacionou séries temporais de temperatura do ar, temperatura da superfície da terra (LST) e pontos geocodificados de crime. Os resultados mapearam morfologias urbanas criminogênicas semelhantes como vazios urbanos abandonados, por exemplo. Avançar com a 11ª Meta de Desenvolvimento Sustentável, que prevê cidades mais inclusivas, seguras, justas e sustentáveis, significa enfrentar mudanças abruptas no microclima devido não apenas ao conforto térmico e estético, mas também para melhorar a segurança pública.

ACKNOWLEDGEMENTS

No one grows by her/himself.

I am very thankful for all the support received by a long list of contributors. First of all, I would like to thank my advisors Carlos José Sousa Passos and Marta Adriana Bustos Romero for the trust and all the knowledge sharing. To the team of the Laboratory for Urban and Architecture Sustainability – LaSUS at FAU/UnB, in special Caio Frederico e Silva, Valmor Pazos, Gustavo Baptista and Rômulo Ribeiro.

I owe many thanks to the Government of Brasília (GDF), in special to the team of Codeplan, Secretariat of Public Security and Social Peace (SSP/DF), to the Brasília's Environmental Agency IBRAM, Environmental Secretariat of State – SEMA, and the Research Foundation of the Distrito Federal FAP-DF.

I must thank my foreign partners at the Harvard University's Graduate School of Design, in special Mariana Guimarães, and the scholars from Erasmus University Rotterdam who hosted me for an insightful internship in the Netherlands, in special Rene van Swaaningen and Tim Boekhout van Solinge. To my scientist friends and co-authors of the articles Tito Nunes de Castro, Dani Werneck, Marcus Vinicius Souza, João Vitor Lopes Lima Farias.

The heart of this thesis I owe to the team of Universidade Federal de Feira de Santana, and the Geodatin staff who I thank by citing Rodrigo Vasconcelos that helped me with the big data programming task in spatial analysis.

And last but not least, many thanks to my family, friends in special André Cressoni, Osmar Tatsuo Katsurada, Vitor Saccon for all the support received from them. I owe special thanks to my beloved Graziela Velloso Mistura, and her kind family. Without you guys it would have been impossible to become a doctor.

Many thanks!

CONTRIBUTION TO THE ORIGINAL KNOWLEDGE

This is the first study assessing the influence of weather on the frequency of violent crimes in Brazil's capital, Brasília, and its Distrito Federal. Moreover, we adopted a wide range of methods to learn the extent of these influences. Besides heavy quantitative methods, this thesis embeds elegant spatial analysis relying on big data and remote sensing to overlap satellite thermal data to georeferenced violent crimes. Results are likely to facilitate planning for resilience towards a safer and sustainable future for the Distrito Federal.

CONTRIBUTION OF COLLABORATORS

This is an interdisciplinary study in its essence. Not only because it has had support from many hands, but also because we touch upon several segmented fields of knowledge such as climatology, criminology, geography, sociology, geoscience, social psychology, remote sensing, computational programming, landscape architecture, urbanism and others. To explore such issues in the urban tissue of Brasília, and on the Distrito Federal's territory, this study twofold temporal and spatial analyses. The temporal analysis approach critically investigated hypothetical seasonality in crime occurrence. Meanwhile, the spatial analysis brought us understandings on where in Distrito Federal there would be high incidence of violence in places where temperatures are also higher. To do so, many collaborators were engaged in this mission. As the principal investigator, I am very thankful to the partners cited below:

Abner Luis Calixter - Principal investigator

Caio Frederico e Silva - Thesis layout, graphics, and mentorship

Daniela Rocha Werneck - Mapping

Flávio Rodrigues Ferraz - Institutional affairs and data gathering

João Vitor Lopes Lima Farias – Graphic design and illustration

Marcus Vinicius Souza - Spatial analysis design and mapping

Mariana Pereira Guimarães - Field research, data management & compilation, mapping

Rodrigo Vasconcelos - Geostatistics, big data, programming

Tito Nunes de Castro - Data management, programming, statistical modeling

INTRODUCTION

The premise behind weather, specifically heat, posing direct implications on mood and social behavior is not new. Links between heat and aggression are noticeable since Cicero (106 - 43 B.C) in Ancient Greece to Shakespeare's poetry, or in sayings steaming out of customary laws (ANDERSON, 1989). It is common to hear expressions about the aggravation of conflict in the heat of emotion. Metaphorically speaking - heat is aggression. At the same time, while witnessing a growing number of studies reflecting upon the prevention of violence, many questions remain open due to the multifaceted complexity of this phenomenon (DAVIS, 2012; LEE, 2016). For instance, does really the weather increase the willingness to aggress? If that is true, in terms of urbanism, does it happen homogeneously on the territory?

Researchers and practitioners are challenged at most of their knowledge to understand such complexities. It is widely diffused that socioeconomic inequalities, cleanliness and conservation of urban tissues do play a role in the physical environment where violence occurs (JACOBS, 1961; KELLING e WILSON, 1982; ABDULLAH, RAZAK, *et al.*, 2012; ROMERO, 2015). On the other hand, a thorough understanding of non-obvious elements that potentially spark-in fluctuations of violence have not been widely disentangled. Thus, we investigated patterns of violence occurrence by looking at weather variables as potential drivers affecting human behavior. To date, a miscellaneous of methodologies and datasets have been used in several studies having the same goal of demonstrating commonalities in human behavior when exposed to extreme weather conditions (ANDERSON & ANDERSON, 1984; ANDERSON, 1987; COTTON, 1986; FIELD, 1992).

Seeking this understanding at the city-scale must imply on coding, modeling, downscaling and interpreting a massive amount of data from several interdisciplinary sources. When one succeeds, the result should be a small and fragmented sample of reality, which in turn, requires refined interpretation to inform science, public policies, and managerial actions. By conducting this study, we aimed to shed light at questions such as how sensitive are humans to the stimulus received from the surrounding built and natural environments? Is that true that we become more prone to aggress according to extreme heat, seasons and weather variations? Similarly, we sought to spatially understand if the more projected, greener and wealthier neighborhoods would perform differently in terms of hosting violence in comparison to other more “spontaneous” cities. These were the main research questions that have inspired this investigation.

However, boiling down these questions to reach consensus seems quite challenging, especially in developing countries like Brazil, where research struggles due to investments' cutbacks and cities lack of basic data for accurate decision-making. As the globalized world becomes more urbanized, subtle negative impacts of urbanization on climate, especially warming at the city-scale should not be neglected. Especially in developing countries which are, in general, more vulnerable to extreme weather events. Over the four last decades, several studies have mostly been undertaken in northern countries to analyze the influence of weather on the occurrence of violence, under different scenarios and circumstances. Nevertheless, empirical evidence in this field of study concerning tropical weather remains scarce.

After all, the way cities are developed makes the local climate a mosaic. Thus, avoiding abrupt warming and heat islands effect in cities should be within the reach of urban planners and designers. Haphazard urban layout, poor urban materials, and green areas' deficits make these neighborhoods vulnerable to the negative impacts of intra-urban heat island effects (ROMERO, 2015; OKE, MILLS, *et al.*, 2017; LOMBARDO, 1985). Exacerbated impervious, black or reflective surfaces, inappropriate urban materials, lack of green and open space are some of the problematic design elements that constitute a bad urban morphology (ROMERO, 2015). Prejudices at the microclimate level drive the population towards an overall decrease in their wellbeing (OKE, MILLS, *et al.*, 2017). Access to better quality dwellings and public spaces does matter for climate justice. Moreover, well-designed spaces inspire their inhabitants whilst badly designed ones brutalize them

Today, Brazilian cities host more than 84% of its population, and most of this population living in such cities are poor, or in other words, vulnerable (IBGE, 2019). As urban areas grow at the same time which local temperatures rise, it is our duty as sustainability scientists and development practitioners to assess the effects arising from overlaps between haphazard urban layouts, their microclimates, and what the impacts are over the dwellers. The number of people already living at some degree of exposure to climate risks should be enough to justify cities in Brazil leading actions towards leveraging climate adaptation and resilience. There are indicators of heat-related mortalities in affluent cities such as New York (ROSENTHAL, KINNEY & METZGER, 2014). From this perspective of heat stress, could you imagine the feeling of a strenuous hot day in the *favela?*

As concerns our study design, it is important to highlight that this study does not aim to draw upon causality, but rather to investigate the extent at which the violent crimes are tied (or not) to climate variables. Such a questioning illustrates our general research goal which, in other words, is to understand to what extent does weather influence the frequency of crime and in positive case, how is it distributed in the territory of the Distrito Federal.

More specifically, we aim to make clearer a few specific issues, oriented by the following questions:

- First, is there a seasonality for the occurrence of violent crimes in Distrito Federal?

- If so, does violence pike when the weather is harsher? We aim to understand if the frequency of violent crimes increases when the weather is more severe. In other words, is there a positive correlation between the weather dataset and the crime dataset?

- In addition, we sought to understand if the places hosting higher violent crimes are the harsher ones in terms of built and natural environments. In our scope, hasher means a neighborhood having its urban tissue of less morphological quality in terms of the amount of green, exposed soil, massive impervious surface or exposed soil, abandoned places.

- Is there a high correlation between high surface temperatures and places hosting higher numbers of violent crimes?

- Are there similarities in terms of harshness among the neighborhoods hosting a higher concentration of violent crimes? In other words, what are the morphological similarities between places hosting higher number of violent crimes?

The City of Brasília, in the Brazilian Distrito Federal, gave us the opportunity to go through such research questions. This research takes the acknowledged project "*cidade-parque"* (city-park), by Lucio Costa as concept in order to highlight the importance of well-designed public spaces. This topic is core of the research group "The Sustainability in the Architecture and Urbanism" from the Laboratory for Urban and Architecture Sustainability LaSUS (FAUUNB), registered at the National Council for Scientific and Technological Development - CNPq. The work from Primo (2020), Salles (2007), Carpaneda (2008) among others, have also investigated the relationship of the urban form for the development of safer public spaces.

Thus, when looking at thermal features on the territory, we bared in mind that one of the human body's expressions able to show that something is wrong is temperature.

Furthermore, if not properly tackled, feverish temperatures may cause bad sequels in the human body. Similarly, the landscape also has a voice (DOHERTY, 2017). In this sense the interactions between urban landscape and humans must be a statement. We do expect that this study helps to decode a little bit more of the message stated by these numbers of violent crimes, paying attention to its seasonal behavior and its spatial coordinates, accordingly. By decoding this message, we dedicate this effort towards contributing to the Sustainable Development Goals (SDGs), in particular the 11^{th}, that foresees making cities and human settlements more inclusive, safer, resilient and sustainable.

THEORETICAL LANDMARKS: a comprehensive review of the relevant literature

Most of the literature embracing the combined keywords violence, weather and climate is covered in the following literature review. This section begins by discussing the idea behind the theme and also what type of analysis was conducted by the authors. Then it starts narrowing towards cities covered by this type of study in the world (vast majority in the United States), and cities covered by the literature in Brazil. Furthermore, this section brings hints about the evolution of science and the trends in geopolitics and climate diplomacy that have also influenced this research field. Then, the second part of the review introduces Brasília, the formation of the Distrito Federal, and its history narrated from the perspective of its urban development and sprawling. Telling the history is important since it has directly shaped the territory. In turn, the shape of the territory influences its microclimates. The side effects of such urban development are expressed in this study by the overlap of violence and weather. We consider that these overlaps may also be products of Brasília's recent and vibrant historical landmarks.

The potential influence of weather towards violent behavior

It has long been assumed that weather somehow exerts influence on violence, especially regarding violent crimes. According to (TENNENBAUM & FINK, 1994), since the standard version of the Christian Bible, in the Old Testament, there are mentions about the propensity to the punishment that arises from hot anger in Deuteronomy 19:6. Furthermore, the questionably and unreasonable argument of "violent" heat some centuries later was used to endorse slavery in a horrific way; for instance, Montesquieu in *The Spirit of Law* argued that people from the tropics are "entirely removed from the verge of morality" (MONTESQUIEU, 1750).

Voltaire, on the other hand, stated that not all human behavior can be explained by climate events, opposing thus Montesquieu (HARRIES , STADLER & ZDORKOWSKI, 1984). It is common to hear, in Brazil, sociologists properly blaming of deterministic the 19th-century criminologists and sociologists such as Cesare Lombroso; Adolphe Quetelet, M. Champneuf and Enrico Ferri due to the lack of empirical evidence regarding their exaggerated positivist theories related to heat influencing the tempers and crime (TENNENBAUM & FINK, 1994; ANDERSON, 1987).

In 1830, Kropotkin conducted what is considered the first quantitative analysis relating humidity and temperature to crime rates using a formula (HARRIES , STADLER & ZDORKOWSKI, 1984). Kropotkin's study opened the avenue for a number of writers in the 19th century, who indeed perceived that summertime peaks the number of violent crimes. Another research milestone in terms of climate-related criminality comes from the author Dexter, E.G (1904) who analyzed 44.000 cases of police arrests in New York City by the end of the 19th century (1891 to 1897), and his time series analysis pointed out temperature as a conducive element to violence (LEBEAU, 1994; HARRIES , STADLER & ZDORKOWSKI, 1984). The literature of this historical period of the 19th century informs that climate theory has played a big background-role to the Geography of the United States, which has Ellsworth Huntington (1876-1947) as the most preeminent climate-deterministic author that approached in a racist fashion the theory about the environment imposing effects on the character of societies in the beginning of the 20th century (HARRIES , STADLER & ZDORKOWSKI, 1984).

Advancing the historical aspects concerning this literature, contemporary criminologists and sociologists started to investigate the crime-weather relationships more empirically. Most of the studies conducted between 1970 and 1990 have also considered the “negative affect escape model” from Bell & Baron (1976), which posits that aggression in function of temperature is NOT a J curve, but instead, a U-inverted shaped model, meaning that beyond certain point of excessive heat it becomes so extenuating that motivates to escape such adverse situation, thus, decreasing aggressiveness (BELL & BARON, 1976). This U-inverted shaped model was conceived after empirical tests, which have assessed and controlled in laboratory the willingness to aggress amidst comfortably cool to uncomfortably hot situations (GRIFFITT, 1970; GRIFFIT & VEITCH, 1971; BARON, 1972; BARON & BELL, 1976; BARON & RANSBERGER, 1978; CARLSMITH & ANDERSON, 1979).

Outside laboratory, few studies relating temperature and violence started to be published such as Lewis and Alford (1975) who associated the incidence of assaults to longitudinal differences, and Baron and Ransberger (1978) who linked public riots and collective violence to higher temperatures (HARRIES , STADLER & ZDORKOWSKI, 1984). Anderson (1989) highlights suspiciousness about the statistical techniques of Baron and Ransberger (1978).

The 1980’s had also Michael & Zumpe (1983) assessing the occurrence of rape, as a category of aggressive behavior, in 16 different locations in the United States of America (USA). They adopted statistical modeling as well, to best fit their significant rhythm comparing monthly mean temperatures and the occurrence of 50,000 rapes in 2 year-period of their data spam (1975-1979). Results out of Spearman rank-order correlations showed maximum values of seasonal patterns in summers. To the authors, rapes and assaults have shown similar seasonal patterns differently from murdering trends, which have had no correlation between murder and weather variables (MICHAEL & ZUMPE, 1983). Similar results were found by Perry & Simpson (1987) using Pearson correlation and multiple regression analysis. They figured significant positive influences on rape and aggravated assaults of environmental variables (rain and minimum average temperature) but with lesser significance to murder rates. As the temperature increased rape and aggravated assault also increase. Homicides were found as happening more during the winter. (PERRY & SIMPSON, 1987).

Oppositely, DeFronzo (1984) obtained very weak correlations in the statistical tests comparing one year (1970) of climate variables among 11 other socioeconomic independent variables that could influence violent crimes. The dependent variables were rates per a thousand people of major street crimes. Independent variables cover a wide range of social aspects such as gender, race, unemployment rates, poverty, income inequalities, conditional cash transfer programs, etc. According to the author the “explanatory variables of central interest” were maximum temperatures and rainfall in the year of 1970. He got inspired to empirically downscale a “deterministic-oriented” report launched in 1981 by the U.S. Federal Bureau of Investigation - FBI, stating that invariably, with exception of burglary and robbery, violent crime indexes present seasonality and are higher in the West and South where annual temperature levels are higher and precipitations are lower in comparison to the rest of the country (FBI, 1981 *apud* (DEFRONZO, 1984). Defronzo’s results show that most of the climate variables were weakly or not correlated to crime rates and types but slight positive associations were found to “hot days” on burglary and homicide (p.186).

Harries et al., (1984) moved forward with the analysis by looking at violent crimes in Dallas and contrasted neighborhood density, alcohol consumption, holidays, and neighborhood context, and its takeout message emphasized the need for more accurate investigation about environmental influences on crimes, since other variables presented weak statistical associations as well.

Anderson & Anderson (1984) predicted more prevalence of violent crimes in the hotter quarter of the year and hotter years, and compared violent (murder, rape, assault) to less violent crimes (robbery and arson) pointing out that violent crimes pike in uncomfortably hot temperatures, coining therefore the Temperature-Aggression Model (TAM). The TAM theory was coined to contrast the Routine Activity Theory (RAT) from Cohen & Felson (1979) which predicts more violent crimes in warmer weathers due to the social routine that warmer weathers allow northern societies to experience. For example, when the weather is nicer, more people go out, alcohol intake increases and therefore, the chances of disagreements are also higher.

Another interesting approach is noted in the work of Rotton & Frey (1985) in which 2 year-period data compiled in daily, weekend, holidays and seasonal basis assessed violent crime episodes and meteorological variables, including ozone levels. Their results obtained through the use of two-stage regression showed positive associations between assaults against persons and daily temperature, and negative associations for wind-speed and levels of humidity (ROTTON & FREY, 1985)

The work of Anderson (1987) compared different cities highlighting more incidence of violent crimes in cities that had higher temperature records. The analysis comprised crime data from the FBI and Climatological Data from the National Summary, both from 1980. In addition, socio-economic variables were incorporated into the model to mitigate confounding factors (e.g., income, schooling, unemployment rates, demography, age, gender, number of law enforcement employees, etc.). The method consisted in testing through regression analysis for the 14 socioeconomic variables and looking at the extent to which these variables could contribute in predicting the occurrence of crime, before testing weather variables. Results have shown that the number of hotter days had stronger positive associations to the adjusted model and then by using a variance test (ANOVA) and regression. The author presented results having the average of hotter days positively associated with the occurrence of rape, assault and murder in hotter cities in the USA (ANDERSON, 1987). The number of black people living in a city also is associated positively with higher violence, whereas high schooling and income are related negatively (ANDERSON, 1987).

By the end of the 1980s, Cheatwood (1988) tested if there was a season for homicide in Baltimore by analyzing a 10 year-period of homicides. Cheatwood (1988) brought, however, a list of local studies in the USA that failed to find homicide seasonality, as follows:

> “Studies in Tallahassee (LaRoche and Tillery, 1956); Philadelphia (Wolfgang, 1958); Cleveland (Bensing and Schroeder, 1960; Deutsch, 1978; and Hirsch et al., 1973); Houston (Lundsgaarde, 1977; Pokorny and Davis, 1964); Atlanta (Munford et al., 1976); San Francisco (Michael and Zumpe, 1983a, 1983b; Roberson, 1976); St. Louis, Portland, Los Angeles, Kansas City, Atlanta, Denver, Dallas, Cincinnati (Deutsch, 1978); Boston (Block, 1984b; Deutsch, 1978); Alabama,

> Arizona, Georgia, Honolulu, Los Angeles, Maine, New Mexico, North and South Carolina, Oregon, Puerto Rico, Tennessee, Texas, Utah (Michael and Zumpe, 1983a, 1983b); West Germany (Lamp, 1983); Illinois (Block, 1984b; Michael and Zumpe, 1983a, 1983b); Chicago, Canada, California, New York City (Block, 1984b; Messner and Tardiff, 1985); Miami (Wilbanks, 1984); and Erie County, New York (Abel et al., 1985)" none of these found significant associations in terms of seasons and homicide (CHEATWOOD, 1988; p. 290).

Cheatwood (1988) attempted to refine data aggregation and used ARIMA to revisit the issue of weather influencing violent crimes in Baltimore, and his new sample had negative correlations when crossing official homicide data and seasons. Nevertheless, a study conducted in the very same city of Baltimore, but in 2016, showed the contrary. Results came out from multivariable and negative binomial regressions to analyze over-dispersed data from weather variables and intentional trauma admissions at the Johns Hopkins Hospital. The maximum daily temperature appeared as the most important weather variable influencing admissions related to violence and trauma in the hospital (MICHEL, WANG, *et al.*, 2016)

The 1990's brought reviews and quite a few more studies dedicated to advance the knowledge regarding weather-violence discussion. For instance, Cohn (1990) conducted a literature review systematizing the theoretical background of forecasting crime rates based on a wide range of weather variables. The author concluded that all that had been published before 1990 had few firm conclusions, and most obtained simply slight tendency for increases in violent crimes such as assaults, rape, collective violence in warmer weathers (COHN, 1990). Robbery, larceny and motor-theft did not seem to relate to temperature and homicides. At that point, there were just uncertainties Cohn (1990), and later on in 1992, Bell launched a manifesto in defense of the negative affect escape model of heat and aggression (BELL, 1992).

One may note the scarcity of papers in these fields of study, concerning the analysis of crime and aggression against women, and an example dating from the early 1990's calls the attention. Cohn (1993) assessed the short-term effect of temporal weather variables cross-checking against calls for police service in Minneapolis, Minnesota. She found relations between temporal variables (day of the week, time of the day, etc.) for domestic violence, but regarding rape results have generated no firm conclusions (COHN, 1993). Tennenbaum & Fink (1994) emphasized that perhaps untangling the research question of whether influencing crime is more sophisticated than simply understanding crime seasonality. So, in order to advance this question, they used dummy variable regression, Box-Jenkins (ARIMA) regression and sinusoidal curve fitting to identify seasonality, general autoregressive process and the presence (or not) of a sine-wave cycle in the dataset. By adopting these strategies, they have found homicide's curve having peaked in July, August and September (TENNENBAUM e FINK, 1994, p.328). Another interesting approach was taken by Vrij et al. (1994) which results confirmed the influences of hot temperature positively influencing an increase in the aggression of police officers (VRIJ, VAN DER STEEN & KOOPELAAR, 1994).

The psychological perspective yielded some papers to the scientific literature such as Anderson (1989), Anderson & Anderson (1984) and Anderson & Anderson (1998). In the trilogy, the authors advocate consistent results after adopting a general model affecting aggression for hot temperatures in experiments. They have set several kinds of associations such as the arousal in the context of video games, violent crime arrests and the approach to heat and the southern culture of violence in the USA. In addition, they have looked for relationships between property crime rates following shifts in temperatures. Nevertheless, Rotton & Cohn (1999) pointed out errors and omissions in the work of Anderson & Anderson (1998), arguing that the routine activity theory (RAT) would better explain the occurrence of violence in a midwestern city than Anderson's general affect model of aggression (ROTTON & COHN, 1999). In comparison to the Temperature Aggression Model (TAM) from Anderson & Anderson 1984 which foresees violent crimes increasing in function of temperature increases, the routine activity theory (RAT) is already very familiar - good weather invites people to remain outdoors and engage in social interactions. As social encounters are higher in good weather conditions, conflicts are also likely to get increased, consequently (ROTTON & COHN, 1999).

Collective violence is another approach assessed by scholars aiming to advance research regarding the impacts of weather on human behavior. Aristoteles in political theory argues that our society consists of humans who actually are political animals living in a *polis*. Thus, Van de Vliert et al. (1999) examined associations between air temperature and political violence in 136 countries in a time-series period of 30 years (1948-1977), finding that warm countries have hosted more frequently armed attacks and political riots (VAN DE VLIERT et al., 1999).

Socially speaking, the work of Rotton & Cohn opened the first decade of the 2000's bringing emphasis towards a combined approach for explaining fluctuations in the occurrence of violent crimes. These authors, therefore, urge for research relying on both; the *routine activity theory* (RAT) from Cohen & Felson (1979) and over Baron and Bell's (1976) Negative Affect Escape (NAE). Basically, they criticize the common sense that social contact by itself would increase violence, arguing that it somehow seems as a misanthropic view of human interaction that criticizes the popular recommendation to "avoid places and people who get hot under the collar" (ROTTON & COHN, 2000). For them, anything that would keep people apart would reduce violence and aggression such as extreme weather, and thus a U-inverted shaped model from Baron and Bell (1976) would be more suitable to explain such relationships. Their exploratory analysis of a two-year dataset (1987-1988) from Minneapolis, Minnesota, has shown that most of the assaults (44.67%) and almost 50% of the disorderly-conduct calls to the police were received between 9:00 p.m. and 2:59 a.m. (ROTTON & COHN, 2000). For the regression, a Prais-Wisten's algorithm was used to obtain generalized least squares. In addition, four weather variables (i.e., temperature, relative humidity, wind speed and sky cover) were used in the model and following the work of Rotton & Frey (1985) seasonal trends were considered by dividing the year into four quarters.

Results from Rotton & Cohn (2000) regarding our thesis' scope covers the following: Disorders were negatively related to wind speed and humidity but positively to temperature in an inverted U-shaped curve. In this sense, by measuring disorderly conduct they could re-emphasize the weight of the Routine Activity Theory (RAT), and temperature according to them seems to be the peppery element related to social interactions, and that is why assaults were positively correlated to higher temperatures. The authors argue, however, that this model should be expanded to include the avoidance behavior (scape model), and by doing so the model should get more calibrated (ROTTON & COHN, 2000, p. 667).

The concern behind global warming and a potential increase in hostility has firstly been addressed by Anderson (2001). He argued that since hot temperatures increase aggression, more moderate climates may reduce weather-related violence, so measures should be taken with the aim of avoiding increases in violent crime rates. Later efforts from Rotton & Cohn (2004) corroborated with Anderson (2001) by suggesting friendly temperatures to avoid hostility. Through multivariate analysis, Rotton & Cohn (2004) conducted a temporal-spatial analysis in Dallas – State of Texas, to understand the risks of assault victimization in places having air-conditioner versus others without air-conditioning, and controlling for temporal variables such as weekends, holidays, night and day. Results out of their analysis showed again an inverted U-shaped function curve, which suggests an increase in assaults up to a certain point then declining in extreme temperatures. In addition, “Fewer assaults occurred in settings that probably had climate control than the ones that did not” (ROTTON & COHN, 2004 p. 287).

It is important to highlight that not only negative effects are associated with warmer temperatures. For instance, Keller et al. (2005) presented a study demonstrating how good weather contributes to a higher mood, better memory and well-being. However, this healthy condition was not perceived under extreme hot or cold temperatures, which denotes a curvilinear effect (KELLER, FREDRICKSON, *et al.*, 2005). In the literature, much is discussed about the best model to measure potential associations between weather and violence. A study from Bushman et al. (2005) has contested curvilinearity, and they cite (ROTTON & COHN, 1997) arguing that it fails to consider the time of day, and thus it can potentially mask a positive linear relationship between weather and assault (BUSHMAN, ANDERSON & WANG, 2005)

In this sense, Bushman et al. (2005) actually shed light on the role and importance of data-aggregation when assessing potential associations of weather and violent crimes. The authors also call attention about generalizing too much the data to describe general trends, which may have side-effects such as masking outliers that, otherwise, if considered could give emphasis to escape alternatives (BELL, 2005). In addition, Bell (2005) argues that although Bushman et al. (2005) might have been well statistically supported, more caution is required for the data-aggregation for moderating the results. Then, Bell (2005) modeled again the same dataset of Bushman et al. (2005) but moderating hour of the day and seasons. Besides finding negative relations for humidity, curvilinearities were found for temperature and aggravated assaults between 9:00 p.m. and 8:59 a.m. (BELL, 2005, p. 1078).

Findings from (MARES, 2013) suggest that neighborhoods in St. Louis, MO (USA) with higher levels of poverty “are very likely to experience higher levels of violence as a result of anomalously warm temperatures” (MARES, 2013, p.768). Similarly, a study from Fay & Maner (2014) provides evidence that heat promotes social hostility, but the strength of this effect depends on a wide range of factors (FAY & MANER, 2014).

At this point, it becomes perceivable the massive number of scholars who have studied these associations based in the U.S territory. It follows the aforementioned tradition in the American geography, criminology and psychology to figure causal relationships that sometimes get controversial due to excessive levels of determinisms

(HARRIES et al., 1984). However, DeWall & Bushman (2009) showed advances on the way that there might be something more than determinisms in the approach of weather influencing violence by testing through experimental social psychology. The authors pointed out evidence that mental states precede aggression. They observed it when exposing people to words related to hot temperatures in two participatory experiments. By doing so, they were able to figure an increase in aggressive thoughts even in the absence of heat (DEWALL & BUSHMAN, 2009). McCarthy (2014), however, by replicating DeWall & Bushman (2009) analysis, concluded that there is no robust evidence that related constructs affect hostile perceptions (MCCARTHY, 2014).

Global studies on violence, aggression and weather: Climate change as the protagonist of the new fashion in scientific trend

With the election of Barack Obama for the presidency of the USA in 2008, there were high hopes about a climate treaty finally to be ratified. Meanwhile, discussions towards climate change related to this field of studies (weather vs crime) also bloomed up to inform international climate policies. This historical momentum has therefore shifted and broadened the focus of scientific literature trends, most likely due to the increase of research funding to attend the demand behind climate change issues. Thus, from 2008 onwards, research has clearly focused more on global climate change and given space for the analysis of weather potentially influencing geopolitical violence outbreaks, rather than the "old-fashion" analysis of weather variables influencing violent crimes by looking at the number of crimes against the individual.

The contribution of Salehyan (2008) with a categorical "no consensus yet" regarding the pretty deterministic approach over the effect of climate change, especially global warming, towards leading armed conflicts reinforced the need for research (SALEHYAN, 2008). Meanwhile, an eastern paper assessed relations between weather and crime in Tokyo, Japan, where the number of cases analyzed in the work of Ikegaya & Suganami (2008) picks the attention because it is such a small number (262 cases - 204 cases of murder and 58 deaths resulting from hit-and-run car accidents) that have happened in a 5-year period, from 1998 to 2002. This might translate outstanding safety standards in the country (IKEGAYA e SUGANAMI, 2008). The time of the crime was unknown, but they measured a discomfort index regarding humidity and temperature on the date of the criminal record. They controlled for types of weather such as sunny day, cloudy day, snowy day, etc., so they could run the Poisson regression model which revealed a majority of cases happening in sunny days and sunny-cloudy days, having no significance for rainy or rainy-cloudy days, snowy days and seven other weather categories (IKEGAYA & SUGANAMI, 2008).

Later efforts from Hsiang et al. (2011) support a positive statement which “directly associates planetary-scale climate changes with global patterns of civil conflict by examining the dominant interannual mode of the modern climate”. In this work authors have analyzed the trends in civil conflicts in face of ENSO cycles (rapid annual climate shifts between *El Niño* and *La Niña*), building a linear multiple regression model for nonparametric data from an annual conflict risk report and using geostatistics related to pixels with surface temperatures, then positively relating them to datasets with ENSO cycles (HSIANG , MENG & CANE, 2011 p. 439).

Notwithstanding, Slettebak (2012) named his paper “*Don't blame the weather! climate-related natural disasters and civil conflict*”. He considered sociology and political science perspectives to criticize the conflict-risk model from (FEARON e LAITIN, 2003). Tests were conducted by (SLETTEBAK, 2012), controlling for other non-climate factors to assess weather and crime associations in the global context, having the USA, China and India as the most disaster-prone countries. Results indicated strong positive influence of climate-related disaster towards the risk of civil conflict outbreaks, since victims of disaster could, maybe, react insurgently (Slettebak, 2012, p. 174). Theisen (2012) used a similar approach and methodological strategy that enabled the author to be emphatic on saying that climate factors do actually influence risks of conflict and violent events in Kenia, according to the 15 years data - 1989-2004 analyzed by the author (THEISEN, 2012).

Ambitiously, Ranson (2014) analyzed a 30-year panel of monthly crime and weather data for 2,997 U.S counties. The author aggregated monthly and yearly crime records and controlled per county. Results show that temperature had a strong positive relation to criminal behavior. In addition, Ranson’s (2014) study predicts future crime levels downscaling the IPCC’s A1B scenario. Predictions suggest that between 2010 and 2099 climate change would result in additional 22,000 murders, 180,000 rapes and 1.2 million aggravated assaults among other crimes in the USA (RANSON, 2014).

With regards to global investigations still, higher bets to estimate the impact of climate change towards violence were given by Mares & Moffett (2016). They analyzed 57 western and non-western countries using a multilevel ARFIMA regression and found out that each degree Celsius increase in annual temperature may increase homicide rates by almost 6% (MARES & MOFFET, 2016). Yet, according to the authors’ results, the African countries have more likelihood to witness a surge of violent crimes as a function of warmer temperatures. In Europe, Asia and former Soviet countries, however, the temperature does not significantly influence violence, suggesting that climate impacts are not homogeneous across nations when regarding violence occurrence (MARES & MOFFET, 2016, p. 298). Jacob et al. (2006) presented out similar results suggesting that "each 10°F increase in average on weekly temperature was associated with a 5% increase in violent crime" (HU, WANG, *et al.*, 2018) p 962). Further still, Mares & Moffett (2019) explored monthly and yearly data aggregation, finding substantial seasonality in the monthly variation among the 648 months analyzed. Results allowed them to categorically affirm that there is out there a positive association between climate change and crime (MARES & MOFFET, 2016).

The capital of the most populous nation in the globe - Beijing, China, had its levels of robbery assessed by (HU, CHEN , *et al.*, 2017). The authors have looked at violent and non-violent data ranging from 2005 to 2014. They also contrasted violent crimes in comparison to heat stress (in a formula of combined effects of heat and humidity). According to Hu et al (2017), aside the abrupt change in robbery rates due to the Olympic Games in 2008, non-violent robbery presented seasonality and was positively related to heat stress using daily data aggregation (HU, CHEN , *et al.*, 2017). South-East Asia is still covered in the work of Yu et al. (2017). Besides climate variables, the authors' assessed the impacts of extreme weather events under the form of typhoons influencing violence in Taiwan. Typhoons had a negative relation to violent crimes and car thefts, unless the typhoons having of longer duration. Warmer temperatures had a strong positive correlation to all types of crimes in Taiwan (YU, MU, *et al.*, 2017).

Van Lange et al. (2017) assessed violence and aggression around the whole globe. To do so, the authors built a "CLASH Model - climate aggression and self-control in humans" and figured in sum, that aggression and violence are higher in countries situated near to the Equator line (VAN LANGE, RINDERU & BUSHMAN, 2017). In another interesting approach for crime-weather time series analysis, negative binomial and Poisson multivariate regressions were used to evaluate a very hot issue: The impact of heatwaves and the occurrence of intimate partner violence (IPV), femicide in special. In Madrid, for instance, results suggest that heatwaves are positively associated with a lagged increase in IPV up to five days after temperatures surpassing the threshold of 34°C (SANZ-BARBERO, LINARES, *et al.*, 2018). Mondays are the days having a higher incidence of police calls/helplines to denounce intimate partner violence. According to the authors, "Higher temperatures increase aggressiveness, but the effect is not immediate, rather it is delayed in time" (SANZ-BARBERO et al., 2018, p. 416).

With the aim of breaking the monopoly of research based on the northern hemisphere, Stevens et al. (2019) produced for Australia temporal and spatial models that investigated the relationship between crime and temperature in New South Wales. The study analyzed 11-year data and results out of a linear regression model show daily assaults and thefts have seasonality and counts increased with rising temperature. More interestingly, the rate of increase slowed as temperatures exceeded 30°C (STEVENS, BEGGS, *et al.*, 2019, p. 747).

After all, by reviewing the scientific literature versing on investigations of weather influencing violent human acts, we can draw upon two intertwined basic premises shared among all the authors as the following: The first believes the environment does play a major role on the mood, and secondly, the mood heights significantly in the decision-making process. However, this is not the only factor to determine the final outcome of such a complex being like the human. From this perspective, uncountable types of relationships can be investigated, or in other words, a wide range of methods can be used to assess what Fishman, Carrillo and Russ, call *“adverse contemporaneous impact”* from weather anomalies (FISHMAN, CARRILLO & RUSS, 2019)

For instance, a few authors assumed that it might also be a sensitive matter for justice. The extent to which weather may influence sentencing based on the premise that different extralegal factors have a role in decision making (DRÁPAL & PINA-SÁNCHEZ, 2019). They acquired data from 12 different district courts in Prague - Czech Republic and modeled it against weather variables such as temperature, wind, sunshine, barometric pressure and humidity, and compared on the decision and duration of the prison sentences, finding no meaningful influences caused by the weather (DRAPAL & PINA-SANCHES, 2019, p.1). A recent methodology from Fishman, Carrillo and Russ (2019), in an astonishing ambitious fashion, had its results published which established that long-term impacts at heat anomalies at birth would pose negative impacts in human’s socio-economic development. On their study, they analyzed temperatures on the day of birth 30 years ago of all 1.5 million formal employees in Ecuador, and results concluded that individuals who faced in-utero temperatures of 1°C above average earn 0.7% less and are less formally educated in comparison to other adults (FISHMAN, CARRILLO & RUSS, 2019, p. 221).

Above all, after reviewing the literature we feel comfortable to state that it is justifiable more empirical research, since consensus seems far to be reached on the assumption that hotter weather makes us more irritable. Heat itself might be a less obvious driver for disasters when looking at social well-being and public safety. What is kept into our minds after reviewing the literature is the biggest challenge of designing and applying the most accurate methodology in order to empirically demonstrate the extent to which weather, and more specifically, heat is related to violent behavior. Such relationships must be unveiled, especially for those seeking for more inclusive, just, safer and resilient cities as depicts the 11th Sustainable Development Goal. Beyond that, this is a matter of climate justice and human rights.

Another study recently published assessed multiple decades and verified that suicide rates rise 0.7% in the USA and 2.1% in Mexican municipalities in warmer seasons (BURKE, GONZÁLEZ, *et al.*, 2018). Yet, Burke et al. (2018) projected that "unmitigated climate change (RCP8.5) could result in a combined 9–40 thousand additional suicides (95% confidence interval) across the USA and Mexico by 2050" (BURKE et al., 2018, p. 723).

In this sense, we believe to handle our contribution with this research towards more innovative empirical efforts to advance knowledge on potential negative impacts of harsh weather over human health and behavior that can overcome academic boundaries, inform urban policy and potentially benefit people on the ground, once it is acknowledged that "theory and policy rest on clear perception of the empirical world" (CHEATWOOD , 1988)

Assessments of Urban Heat Islands (UHI): a refined framework for modeling potential weather and crime associations

Urbanization and land-use change cause environmental impacts to a certain degree, and therefore sustainably projected development plans tend to minimize negative effects in addition to mitigation and some remediation (CALIXTER *et al.*, 2015). Moreover, we already mentioned that well-designed spaces inspire people (DAVIS, 2012).

Furthermore, cities certainly are the history of the 21st century, and nowadays cities are hosting the large majority of people in vulnerability to negative effects of climate extremes - as 55% of the global population lives in cities[6]. From this perspective, heatwaves and heat islands represent major climate threats for tropical countries such as Brazil (MMA, 2016). The mosaic of "climatically-active surfaces" such as geometry and capacity of heat storage and reflection, wetness, albedo, roughness, aerodynamic, porosity and greenery inform the intensity of urban microclimates (OKE, MILLS, *et al.*, 2017). Therefore, tackling heat managing climate property of materials such as absorptivity, reflectivity for instance, must be within the reach of urban planners and designers.

Globally, the common-ground for delineating studies related to Urban Heat Islands (UHI), relies on the 200 years-exercise of depicting differences between the surrounding natural against the more densely built environment. Launched in 1818 by Luke Howard, his essay might be the first register highlighting differences in the

---

[6] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html accessed on December 26th, 2019 at 3:18 pm

temperatures of cities when compared to rural areas (AMORIM, 2019). In Brazil, the leading study in terms of urban climate dates from 1976 and was published by Monteiro and his thesis has forged the topic “Urban Climate System” in the country.

Oke (1978) versed about the magnitude of the UHI phenomena as something critical to be observed, thus recommending comparisons among different regions, distinct cities, and distinct climates as well (GOMES , AMORIM & DEBREUIL, 2017). Lombardo (1985) is another leading author on the UHI investigation in Brazil. She was the first author to adopt remote sensing to measure intra-urban differences in temperature in the city of São Paulo, finding differences of about 10°C in different regions of the city (LOMBARDO, 1985). Yet, according to Romero (2011), heat absorption or release depends also on the format and materials that constitute the urban tissue (ROMERO, 2011). Similarly, land-use change, and socioeconomic dynamics play a major role over the urban climates (AMORIM, 2019). Further still, Romero (2015) contributes to the thermal resilience of public spaces by providing guidance for bioclimatic assessments design of public spaces (ROMERO, 2015). She highlights the role of design to empower the ethos or the *genius loci*[7] of the space in order to inform the planning for resilience in climatic, cultural, technological and historical aspects (ROMERO, 2011)

Furthermore, in terms of measuring heat islands in cities, OKE (1978) has been considered another preeminent author to this subject. He brings 3 layers of energy balance that constitute the heat-trap to be measured being the first - the urban canopy layer (OKE, 1978), which is the low atmosphere; in other words, the layer that goes from the soil up to the average height of roofs. The second is the urban boundary layer (OKE, 2004) or superior atmosphere, and the third comes from a more recent study and adopts the use of the land surface temperature (LST) in remote sensing (OKE, MILLS, *et al.*, 2017). We do adopt this third methodology in this present work.

According to Oke *et al.,* (2017), the heat island detected through remote sensing is called surface urban heat island (UHISurf), which consists of:

> “temperature differences at the interface of the outdoor atmosphere with the solid materials of the city and equivalent rural air to ground interface” (OKE, MILLS et al., 2017, p.198)

Furthermore, Baptista (2012) argues that thermal remote sensing has variations across seasons due to differences in biomass measured throughout the year. In other

[7] NORBERG-SCHULZ, Christian. *Genius loci. Towards a phenomenology of architecture*. London, Academy Editions, 1980.

words, a vegetated area during the dry season may present higher temperature due to the foliage and the augment of exposed soil (BAPTISTA, 2012). In this sense, fires can also disturb data. Nevertheless, similarly to the concept of sustainability, the methodology of UHI assessment is a field of study which is still evolving. To date, no consensus yet has been reached about one single specific best method of evaluating the impact, scale and magnitude of this phenomenon. According to Amorim (2019), modelling together daily air and land surface temperatures and on top of it measuring it in different locations through sensors and transects would provide more accurate results (AMORIM, 2019).

Brazilian studies assessing the influence of weather on violent crimes

As aforementioned, the model of Urban Climate System, proposed by Monteiro (1968) is considered the starting gun and the basis for research of weather assessments in Brazilian cities (MONTEIRO, 1968, *apud* AMORIM, 2019). Notwithstanding, the very first analytical study conducted in Brazil to relate air temperature and urban criminality is reported by Mendonça (2001) book entitled “*Clima e criminalidade*”. In this book, the author consolidated and analyzed data from the Ministry of Health reporting the occurrences of homicides, hanging, suicide, and assaults in 10 Brazilian capitals located in different regions, and thus having different climate standards due to its geographical location and biomes. Cities covered in this study were: Manaus (AM), Belém (PA), Teresina (PI), Recife (PE), Goiânia (GO), Cuiabá (MT), Rio de Janeiro (RJ), São Paulo (SP), Curitiba (PR). The methodology encompassed simple linear regression to relate a time series of violent crimes data (1979-1995) and the maximum mean temperatures registered at each city, using however a time series that partially matches with the criminality records (1961 up to 1991 - 12 years, coinciding consecutively) (MENDONÇA, 2001).

Following Monteiro’s advice to alleviate possible deterministic blames, Mendonça (2001) crosschecked air temperature against criminality and other indicators such as the human development indexes for each city and other socio-economic indicators. Mendonça (2001) results show a seasonality for the occurrence of violence such as summer and national holidays like Christmas, New Years and Carnival (annually held between February and March). More specifically, Mendonça (2001) data analysis has shown a positive relation between maximum mean temperatures and criminality in Rio de Janeiro, Recife, Manaus, Porto Alegre and São Paulo. Non-evident or absent relations were observed in Belém, Teresina, Goiânia, Cuiabá and Curitiba (MENDONÇA, 2001, p.121).

Further efforts from Ceccato (2005) assessed spatial-temporal and weather variations in relation to homicides in the city of São Paulo. She tested the routine activity theory (RA) to check the extent to which the weather influences the temporal variations of homicides in the largest city of South America, by adopting 3 different models of analysis. In one of the models she incorporated as dummy variables weekends, pay day, holidays, wind speed, among others (CECCATO, 2005, p. 315). Her results suggest that in the three models, temporal variables (weekends, night times, payday) were "far more influential" than the weather ones (temperature, relative humidity, wind speed, cloud coverage, visibility and air pressure). The author did not discard the low possibility of homicides being influenced by both (weather and temporal variables). The temporal-spatial analysis conducted by (CECCATO, 2005)) using GIS showed that the size of the hot spots of crime in the intra-urban area of São Paulo changes seasonally. In summer the hot spots increase in size, shrinking afterwards. In her point of view, it happens because people remain more time outside in crime-prone areas (CECCATO, 2005, p. 317). With concerns to the city of São Paulo still, Bando & Volpe (2014) measured the seasonal variation of suicide in this city using a time series from 1996 to 2010, and finding seasonal patterns increasing in spring/summer and decreasing in fall/winter (BANDO & VOLPE, 2014)

The state of Minas Gerais has been addressed again in the literature, by Brito and Ferreira (2013) while investigating the city of Juiz de Fora by using a time-series data ranging from 2010 up to 2012 (BRITTO & FERREIRA, 2013). Their results showed no connection of homicide peaks to the warmer months of the year. In addition, crime frequency decreased in February and the spring in the city (September through December) concentrated more homicides.

Recife in Pernambuco is the latest Brazilian capital having its associations of weather influencing crime investigated (PEREIRA, ANDRESEN & MOTA, 2016) conducted a temporal and spatial analysis of homicides, and similarly to CECCATO (2005) the routine activity theory is what better explains seasonal patterns of crime in Recife. In this case, the authors investigated homicide in the city of tropical climate aggregating data in seasons, months, days of the week and periods of the day by using ANOVA in a time-series ranging from January 2009 through December 2013. According to the authors, results cannot be considered statistically significant with season (since temperature does not vary too much in Recife) and with rainfall. In addition, by looking at daily data aggregation, weekends concentrated more than 40% of crimes (PEREIRA, ANDRESEN & MOTA, 2016).

Urban centers in Brazil faced a vertiginous process of massive population growth and sprawling in the past few decades (IBGE, 2019). With regards to the scope of this current doctoral study, besides being a global reference to urbanism - climatically speaking, the place of Brasilia was chosen by the end of the 19th century, mainly due to its friendly weather (ROMERO, 2011). The tropical climate of the Distrito Federal has a very perceivable and demarcated seasonality (rainy and dry seasons), featuring large daily thermal amplitudes throughout the whole year (SEMA, 2016). From this perspective, Brasília's fairly regular climate has allowed us to observe and contrast potential influences of weather influencing violent human behavior by looking at Distrito Federal crime records and the seasonality in which those crimes happen. The bioclimatic characteristics of the projected centrality *Plano Piloto* may have a wide range of lessons to be taught towards planning the built environment. Thus, understanding the urban metabolism of the Brazilian Distrito Federal from the perspective of weather potentially influencing crime rates may bring valuable lessons for planning more resilient and safer cities elsewhere.

Brief characterization of Distrito Federal's climate patterns

For the four seasons set to our analysis, we took in consideration the peculiar climate patterns from the Cerrado biome in which the Brazilian Distrito Federal is located. Distrito Federal's climate can be classified as Tropical of Altitude belonging to Köpper's Aw, Cwa and Cwb categories, which correspond to the mesothermal climate marked by two distinct periods or two well-defined seasons: humid hot and cool summer. However, there are nuances in terms of extreme heat between the two seasons which deserve attention: the hot drought (August - October) (E SILVA, 2013).

• **Hot-humid period** - rainy summer, from October to April, with an average temperature of 22ºC. During the spring, a hot air mass from the Amazon plays a major role over Brazil's Midwest and brings moisture to Distrito Federal, covering the city with clouds and generating heavy rainfall. The peak of the action of this mass occurs in the months of December and January, and due to the constant rain, the temperature is milder (E SILVA, 2013).

• **Hot-Dry Period** – Although paradoxically, it consists of dry winter from May to September, having the lowest temperatures from May through July, with an average of 19ºC, but rising sharply over the period. Then in August, a hot and dry mass of tropical air coming from the Paraguayan extension of the Brazilian Pantanal reaches the Midwest, blocking the cold air masses from the South (Argentina and Uruguay). Due to insufficient water vapor present in the atmosphere, the sky is consistently blue, cloudless and the hot drought sets in September, which is the hottest month with an average temperature of 23ºC for its minimum and an average of 30.4ºC for its maximum temperatures that occur around 15 hours. Thus, between August and October Distrito

Federal faces the warmest and driest months. July is considered the coolest month with an average temperature of around 18ºC (E SILVA, 2013).

HISTORICAL LANDMARKS

In this thesis, the author attempts to interpret the language of the territory translated into levels of violent crimes. Therefore, the following paragraphs seek to summarize how the history of Brasilia has been intrinsically shaping the territory as we know nowadays.

Brasília 60 years: From design to the metropolis

Although young, Brasília, Distrito Federal, is today the country's third largest metropolitan region, hosting about 3 million inhabitants (IBGE, 2019). In 2020, the metropolis is completing 60 years of its inauguration and its overall socio-political aspects dictating the shape of the city. Somewhat like a feedback loop - the shape and the city inner's morphology also influence social behavior (HOBSBAWN, 1977; HOLANDA, 2010, p. 234; CASTELLS, 1978; FERREIRA, 2010).

Differently from what the popular story tells, Brasília did not simply emerge from an impetuous entrepreneurial speech made by the so candidate Juscelino Kubitscheck - JK in campaign for the country's presidency (CEBALLOS, 2005). However, it is also true that JK's election (1956-1961) started to materialize the city. Right after the election, the quest for the urban development of Brasília was kicked off through the urban design contest held by the Brazilian government in 1957. At the same time, the transfer of Brazil's capital from Rio de Janeiro to the country's interior - a promise made by JK during his campaign, also got started.

According to Gomes (2008), Brasilia already existed in the Brazilian imaginary since late 18th century, something that goes backwards to the "*Inconfidentes"* (movement for Brazil's independence from Portugal). A century later, with the Proclamation of Republic in 1889, the willingness to build a new capital got substantially strengthened (GOMES, 2008). Paviani (2007), asserts that the first Republican Constitution from 1891 clearly stated transferring the capital to the interior of the country and, in May of the following year, president Peixoto appointed a team of experts to define the site of the future Distrito Federal. This group of investigators, known as the Central Plateau Exploration Commission of Brazil, was headed by Luiz Cruls. Then, after 4 years of geological, astronomical, botanical studies, among others, it has been demarcated in 1896 the future territory of Distrito Federal: An area of 14,400km2 nicknamed as "Quadrilateral Cruls" (PAVIANI, 2007).

The early twentieth century marks perhaps the largest demographic transformation in Brazil. The country faced massive migratory flows from large portions of the population from the countryside to cities, which resulted in 85% of Brazil's population currently living in urban areas (IBGE, 2019). During that time, new Brazilian cities were absorbing imported new practices and techniques in terms of urban development, specializations and aesthetic inspirations. Ceballos (2005) states that the urbanism of the twentieth century in Brazil was strongly influenced by the French progressivism, whose bases were tied to modernity, rationality and effectiveness (p. 4).

In urbanistic terms, Schaeffer (2003) highlights a peculiar difference in Brasilia's DNA: "In general, urban development is driven by its inhabitants, but Brasília instead, had its conception promoted by the State" (p. 238). Thus, under the sign of French modernism (and not the Portuguese style as the usual) and mainly inspired by Le Corbusier, the designer and urbanist Lucio Costa developed the proposal of the *Plano Piloto*, which was the winner of the aforementioned 1957's design contest (SCHAEFFER, 2003).

Yet, according to Ceballos (2005) "Brasilia was built under the signs of equality, modernity and progress" (p. 4); precepts very much Besides land-use planning, tremendous efforts were employed to the landscape architecture of the *Plano Piloto*, but not much emphasis was given to social planning in regional scale (CEBALLOS, 2005). This perception is also highlighted by Ferreira & Steinberger (2002) when they mention that the construction of Brasília had **no** explicit urban policy (neither national nor local). In this way, the development of the city followed the same *status-quo* of a regular Brazilian city, which is unequal, of selective nature and unfortunately having a systematic social-spatial exclusion (FERREIRA & STEINBERGER, 2005). It was given for granted that architecture and urban design would themselves be capable of leveraging social justice. It did not! (HOLSTON, 1989).

On top of it, massive influxes of low-skilled workers were attracted from many parts of the country towards the heart of Brazil (BÉU, 2013). Appealing publicity has been widespread aimed to recruit people for the construction works and those seeking for better life conditions. The construction of Brasília promoted the 1950s as the "Golden Era" under JK administration (HOBSBAWN, 1993 *A era dos extremos*). The first constructive efforts started in November the 3rd of 1956 with 232 workers and by May of 1959 the number of people living in camps surrounding the construction sites summed more than 64.000 people (SOUSA, 1983).

It is quite intriguing though that such renowned urban planners (Lucio Costa and Oscar Niemeyer who were already famous at that time) have not incorporated in their master planning a destination of the employees who were being attracted to the central highlands in order to execute their project. In fact, worse than a lack of a proper plan was the lack of acceptance of these migrants to remain in Brasília. According to Holanda

(2010) this is a serious portrait of the “underdevelopment reality”. The author adds: “denying them, in the name of a 'determined urban concept' is a concrete exclusion conceived by the project itself” (HOLANDA, 2010, p. 62). It is noteworthy to highlight and strongly emphasize that the call for design proposals of the 1957 contest did not require a detailed planning of a social aspect of the “to be built city”, thus, this is a crucial aspect to be understood in regards to the lack of regional planning in the winning project. In other words, was the Brazilian Government who failed to ask for a regional plan on its request for proposals.

The endeavor of building a modernistic city from scratch in the middle of nowhere had, not-surprisingly, negative side-effects to the country’s economy. A huge external debt and dramatic internal inflation were pumping up the dissatisfaction of many sectors of civil society (DE LIMA REIS JÚNIOR, 2008). Just before the inauguration of the city on the 21st of April 1960, several forecasted buildings and developments were cancelled, driving the workers to flagellating conditions. In addition, the early 1960s were marked by political instability and uncertainty which culminated in the military coup *d’état* in 1964 against the president João Goulart (BÉU, 2013). The military regime considered JK and its political allies as enemies. In this way, the coup meant the burial of a worker’s dream for a better quality of life in the capital (DELGADO e FERREIRA, 2003). Prior to, and after the inauguration of Brasília, most of the camps where hosting the poor working class were demolished and people removed to the outskirts of the newly developed city which they had built, and the dreamed to live in (BÉU, 2013). The periphery of the Distrito Federal started to bloom at this time.

Furthermore, Ribeiro, Holanda & Coelho (2012) states that the locations where displaced workers have gone had the status of invasions and later these invasions constituted the so called “satellite cities” (p.3). In this sense it is noticeable that, historically, Brasilia repels the smaller income population through removals to demarcated areas with precarious or non-existent infrastructure. Such disfranchised conditions are hard to overcome due to the lack of social security provided by the state (MOURA, OLIVEIRA & VASCONCELOS , 2015, p. 3404). This urban dynamic forged part of Brasília’s identity - tied to a social-spatial segregation ethos.

Nowadays, when walking around the outskirts of Brasilia and talking with the periphery residents, it is possible to perceive the sense of exclusion they express when referring to the *Plano Piloto*. The way eventually someone from the periphery refers to the projected centrality makes reference to the “fancy city”, where “everything gets there first”... or they make sure to explicit the sense of exclusion such as: “We can only remain in the *Plano* during the day, because after work, we must to get out so you residents can enjoy the city" (notes from the author in interviews held in August 2017, at the *Estrutural* Administrative Region).

Similarly, Holanda, Mota, *et al.*, (2002) states that there is a reasonable consensus that socio-spatial segregation reaches perverse levels posing high social costs on the poorest of Distrito Federal. The author further argues that there is no consensus whether Lucio Costa's project implicitly embraced this segregation, something that is quite paradoxical to his "socialist" discourse (HOLANDA, MOTA *et al.,* 2002, p. 60). Again, it is important to highlight that the Brazilian Government received exactly what they have ordered for the 1957 contest. A city that had more emphasis in its physical-spatial design, rather than on its regional socio-spatial aspects.

The urban development and sprawling

In Brasilia's historiography, it is perceivable a latent social hierarchy, since the beginning of the construction works of the capital. The terms "*pioneiros"* (pioneers in English) and "*candangos*" were used to socially distinguish individuals, being the first term devoted to members of the elite (technicians, engineers, authorities, politicians) and the second term to the unschooled and poor workers (LEMOS, 2017).

Nowadays, approximately 9% of the population of the Distrito Federal lives in the *Plano Piloto* (RIBEIRO, HOLANDA & COELHO, 2012). According to Ribeiro, Holanda e Coelho (2012), "segregation is quantifiable by the simple high correlation between income and distance to Brasília's downtown. In other words, income and job opportunities directly decrease as you go far from the projected centrality - the *Plano Piloto*. This central area where most of public authorities are concentrated, accounts for 82% of formal and informal jobs of Distrito Federal, resulting in intense unilateral commuting flow and intense traffic congestion in the rush hours (RIBEIRO, HOLANDA & COELHO, 2012). Still, according to Ribeiro, the sprawled urban tissue of DF entails a high cost of public transportation and maintenance of infrastructure that, besides being expensive is inefficient (RIBEIRO, HOLANDA & COELHO, 2012). This spatial configuration is probably one of the most important drivers regarding violence. Temperature and weather variables should be a small piece in the puzzle.

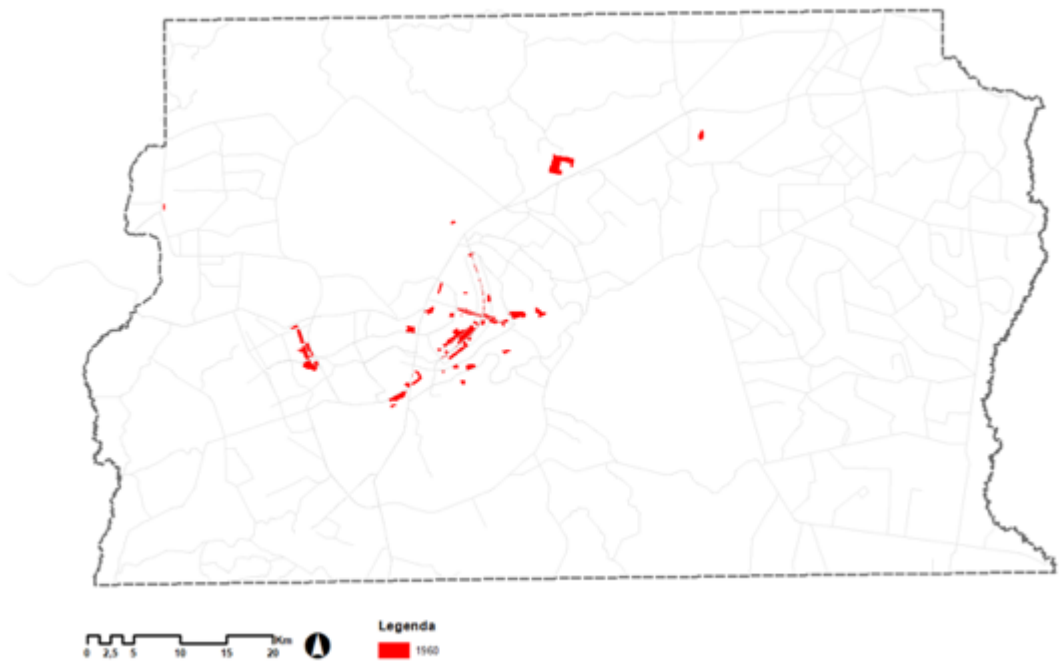
The socio-spatial segregation happens mainly due to the absence of conurbation between the regions, **resulting in a fragmented urban area, composed of "polynucleated" urban occupations** (HOLANDA, MOTA, *et al.*, 2002, p. 74). This fragmentation has a high cost (tangible and intangible) for people who have to cross Distrito Federal seeking to sustain their livelihoods and to the government to spread access to infrastructure and public services (MOURA, OLIVEIRA & VASCONCELOS , 2015).

The following maps visually demonstrate the history of Distrito Federal's urban sprawling. Through the past 6 decades, the urban tissue of Brasília has been formed in a fragmented fashion having plenty of urban interstices, discontinuities, and emptiness which according to Brighenti (2013) are spaces prone to violence and synonyms for unhealthy city-spaces (BRIGHENTI, 2013). The following set of maps (map 1 to 8) was developed by the author having the shapefile downloaded from the Geoportal website[8] from the Government of Brasília. It shows the fragmentation happening over time on the territory.

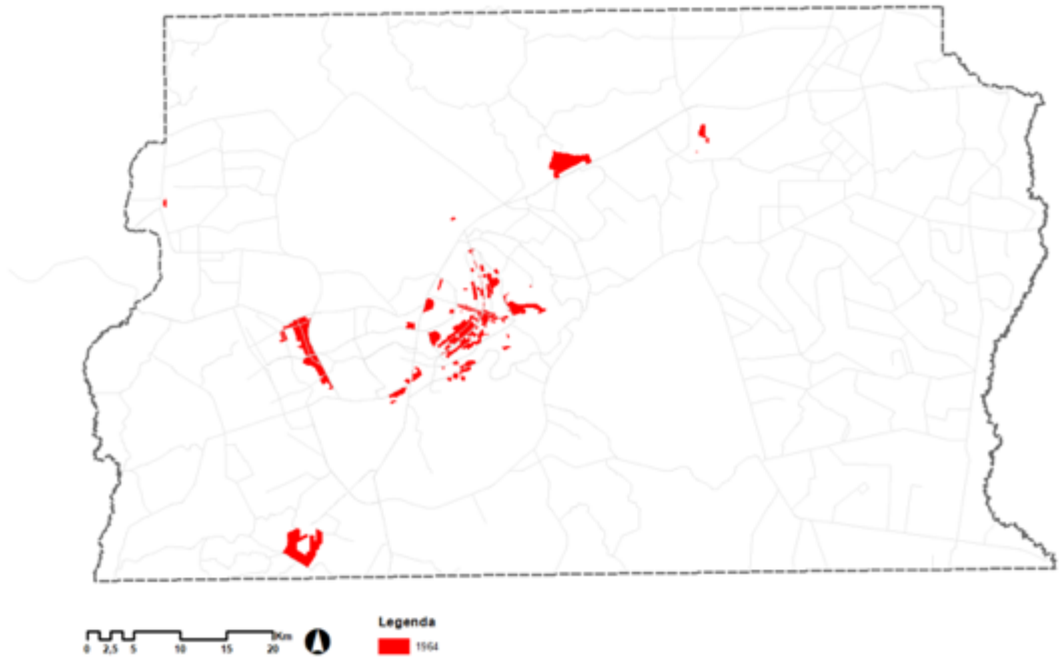
[8] https://www.geoportal.seduh.df.gov.br/mapa/

Map 1 Brasília, Distrito Federal in 1958 in its first year of construction, right after the urban design contest (Adapted from Geoportal – SEDUH)

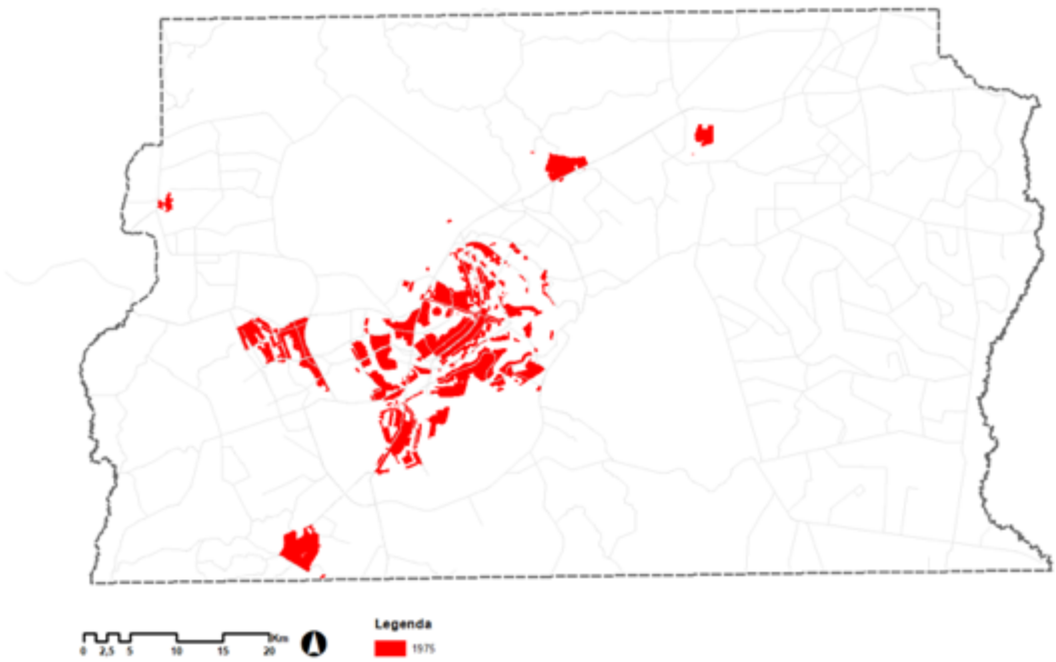
Map 2 Brasília, Distrito Federal in 1960. Rapidly urban growth during the construction works in its first year of construction after the urban design contest (Adapted from Geoportal – SEDUH)



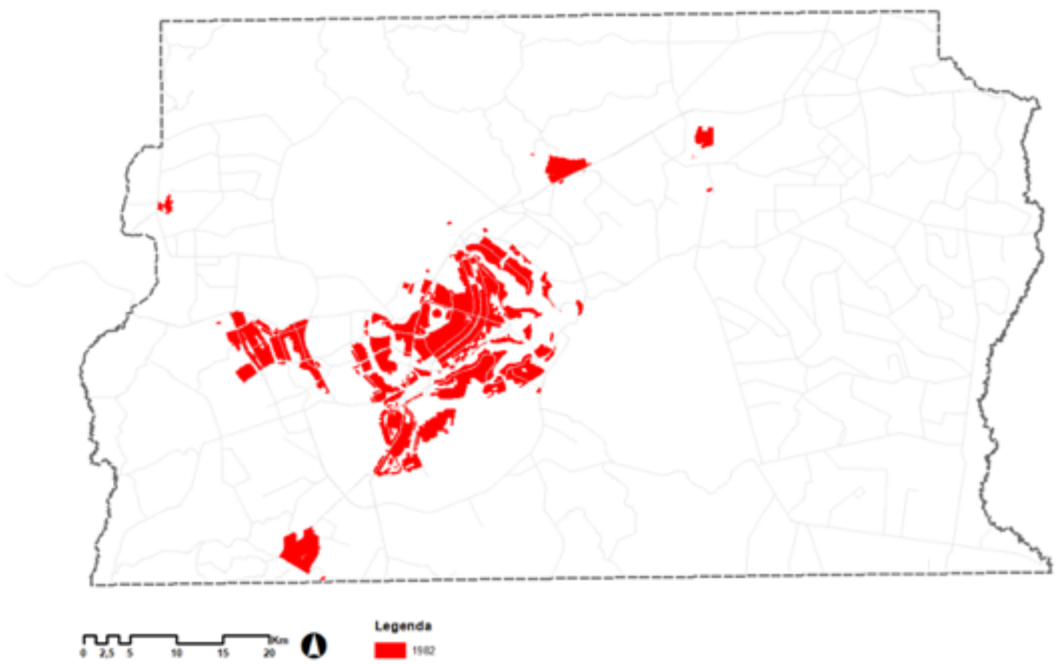
Map 3 Brasília, Distrito Federal in 1964 (Adapted from Geoportal – SEDUH)



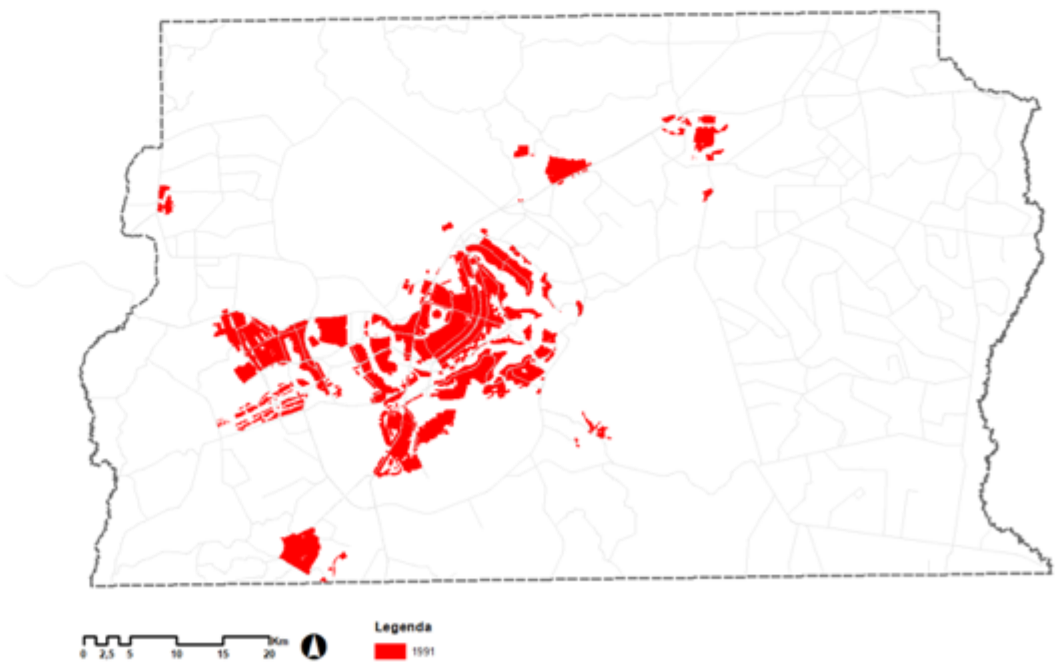
Map 4 Brasília, Distrito Federal in 1975 (Adapted from Geoportal – SEDUH)



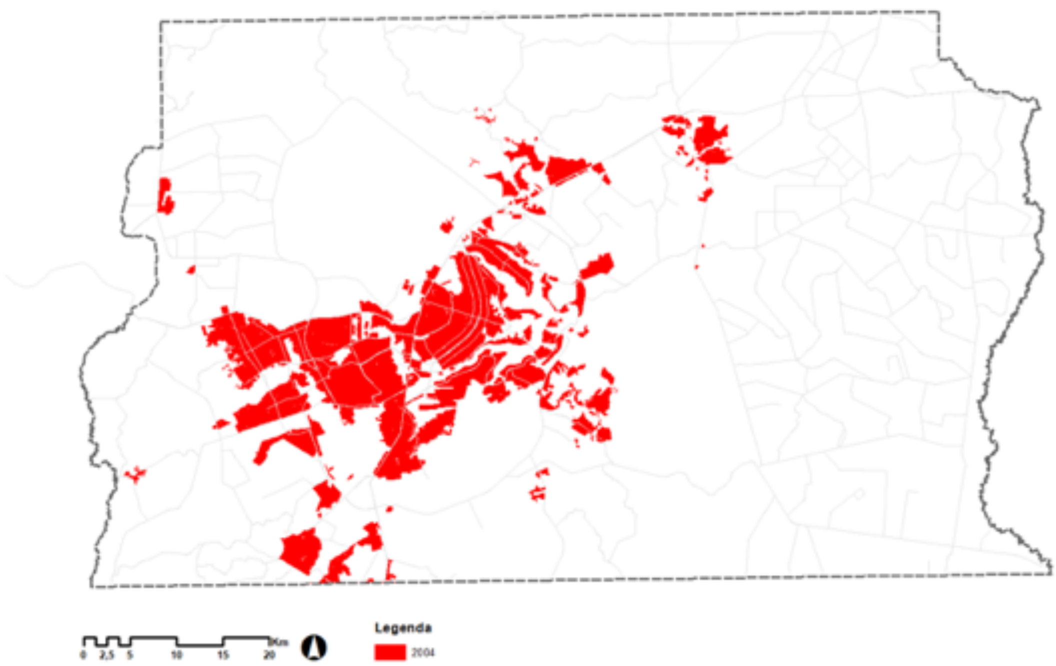
Map 5 Brasília, Distrito Federal in 1982 (Adapted from Geoportal – SEDUH)



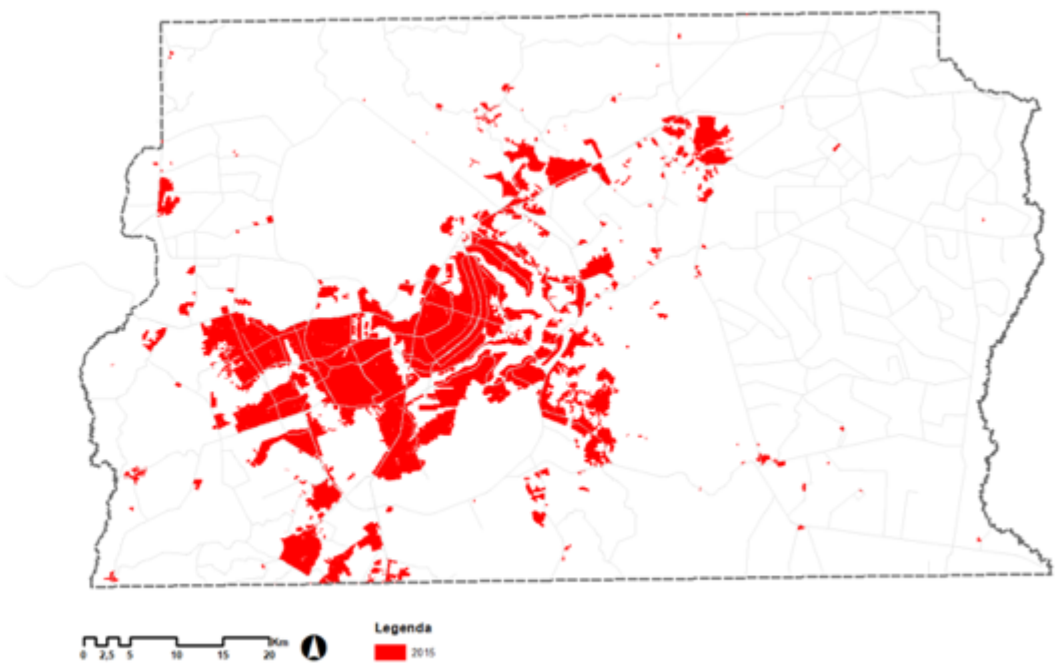
Map 6 Brasília, Distrito Federal in 1991 (Adapted from Geoportal – SEDUH)



Map 7 Brasília, Distrito Federal in 2004 (Adapted from Geoportal – SEDUH)



Map 8 Brasília, Distrito Federal in 2015 (Adapted from Geoportal – SEDUH)



In environmental terms, this type of diffuse, disorganized territorial occupation, inefficient and highly car-dependent demands large amounts of fossil fuels and consequently releases greenhouse gases in the atmosphere, proportionally (RIBEIRO, HOLANDA & COELHO, 2012). Regarding occupations in this frayed urban fabric, many are irregular or illegal, suppressing environmentally protected areas and water springs (PAVIANI, 2007). Even the *Plano Piloto* does not escape of environmental attacks, having the *Lago Paranoá* (lake) being violated by illegal water pumping and physical barriers surrounding the waterfront criminally occupied by mansions, private swimming pools, piers and walls where should be a public space, and in fact it is (PAVIANI, 2007).

In addition, the uncontrolled urban sprawling attacks the ecosystem of the Distrito Federal through indiscriminate deforestation, waterproofing the surface and overexploiting groundwater (RIBEIRO, HOLANDA e COELHO, 2012). In this sense, weak or non-existent public policies for affordable housing linked to environmental preservation are still shaping the format and the morphology of Distrito Federal. Brasília, when viewed in terms of metropolis, repeats the same urban patterns of any other big city in Brazil, with similar suburbs and spatially well-demarcated living standards. Violence in this sense gets also territorialized as we demonstrate further. Further still, according to (Holanda, Mota, *et al.*, 2002), in Brasilia the State was the responsible for this institutionalized segregation. Furthermore, this model of segregation happened due the land concentration on the hands of the State, which in practice does not guarantee a more democratic spatial structure (HOLANDA, MOTA, *et al.*, 2002, p. 74).

Above all, in Brazil, the State is kidnapped by the ruling classes that operate in defense of their own interests, thus, it is not surprising that the spatial organization of the Distrito Federal - home of the Federative Republic Government - constitutes a space structured in such strong segregating basis" (HOLANDA, MOTA, *et al.*, 2002, p.74). Thus, the socialist "utopia" of Lucio Costa has fallen apart and for urban designers and planners a lesson is given as legacy: Just providing people with different apartment layouts is not enough for social justice (HOLANDA , 2016).

HYPOTHESES

The weather exerts somehow influence on violence especially violent crimes. This weather influence on violence is not held homogeneously over the whole of the Distrito Federal.

PREMISES

Similarly, to the human body, temperature is an indicator of a good balance between the morphology of the built environment and natural landscape.

Within our timeframe and budget limitations we found statistical modelling (descriptive and inferential) in addition to GIS, remote sensing and big data processing as the most suitable and affordable methods to showcase our hypotheses in Brasília and the Federal District.

As previously stated, the way cities are developed makes of local climate a mosaic. From this perspective, the low morphological quality of a neighborhood might inform local higher temperatures, which in turn badly affects human's behavior, locally.

OVERALL METHODOLOGICAL APPROACH

In this section we describe all the methods taken with the aim of testing our hypotheses and measuring the extent to which the weather influences violent crimes in the Distrito Federal. In this sense, we present such methods divided in two major arrangements: the temporal and the spatial analyses. The temporal approach aimed to identify patterns of crime frequency tied to our analytical temporal scales, and the spatial analyses were devoted to better understanding on the territory the places hosting violent crimes that would potentially show associations to weather, in special heat. First, we started by conducting the temporal analyses that were divided into 5 steps, which are described in Figure1. The spatial analyses will be presented further.

Figure 1 Methodological approach used for the temporal analyses

Data gathering, management and aggregations

Access to public data in Brazil is a delicate issue. After the military dictatorship (1964-1985) the government on several levels has been slowly implementing efforts to produce data and make them accessible. At the same time, pushbacks have been recently witnessed in Brazil, negatively impacting research as a whole. To have an idea about how challenging it is to get access to public data in Brazil, the Law of Information Access nº 12.527/2011 was put in place only on the 16th of May, 2012. Thus, releasing government's data is a new fashion in Brazil. For this reason, researchers facing resistance to gather data with bureaucrats is a very common situation. Moreover, not all kinds of public data are actually covered by this law. So, the government itself has the "right" to keep undisclosed the data they judge politically sensitive, for instance.

Such a situation makes data gathering a diplomatic mission. In order to advance with this study and have access to public data, it was first crucial to build up a network within the Government of the Distrito Federal (GDF). Countable meetings were held in several GDF's agencies to present the research design, the premise we wanted to investigate, and more importantly, showcase the relevance of the study besides how it could inform more sustainable urban planning. Once reached support and agreements to move on with the research and official data requests (*oficios*) were issued by the UnB Faculty of Architecture and Urbanism for accessing the violent crime records. A similar effort was made to request and get access granted to climate data from public environment bureaus (e.g., Environmental Institute of Brasília - IBRAM, National Meteorology Institute - INMET, Environment Secretariat of the Distrito Federal- SEMA, Government of Brasília - GDF). The letters requesting on behalf of this thesis' author, signed by Professor Marta Adriana Bustos Romero (thesis co-supervisor), were written based on the Law of Information Access nº 12.527/2011. After one year of bureaucratic procedures (mid 2017 up to mid 2018), we finally received all the requested data in a “raw format”; thus, long sessions of data editing were required, which were actually really important to maintain research integrity and allow us to scrutinize and organize data into various temporal aggregations. In this sense, acquiring raw official data may be considered the first milestone of this doctoral dissertation. Right after receiving the secondary public data from, respectively, the GDF Public Security Department and Environmental Agencies, we started to assemble the two datasets (violent crimes and weather). All these efforts were conducted in order to have enough elements for statistical tests and more importantly, to have time series datasets that could be comparable and manageable between them, according to our study design. Having comparable datasets is quite challenging in Brazil, therefore assembling the two datasets of climate and weather was the first milestone achieved in this research.

We began by managing the crime records having an extensive time series from January 1st, 2009 through December 31st, 2017. This dataset having registries for 22,218 crimes has been gently granted by the State Department of Public Safety and Social Peace from Distrito Federal (SSP-DF) as Microsoft Access® database format. The first step was therefore to convert the database into a Microsoft Excel® pivot table. While doing so, we excluded all crime records that were not aligned to the scope of our analysis. For instance, although burglary, robbery, larceny and house/vehicle theft do constitute violence, our tests aimed to measure variations upon the willingness to aggress in comparison to weather conditions, and neighborhood microclimates. In addition, those aforementioned are not considered violent crimes. Therefore, entries that were not related to violent crimes against a person in Distrito Federal were excluded from the database. By doing this selection, we ended up having four variables of aggression against a person analyzed in this study, which are: **rape, rape attempt, homicide, and homicide attempt.**

We also excluded the time at which the crime was registered at the police station. Thus, we kept only the actual date and time at which the crime had occurred. Hour adjustments were made using the “round” function. By applying the round formula for adjusting the hour we established half hour as tipping points for every crime entry (thus, if the crime occurred until half past hour, e.g.,7:17, this entry was converted to 7:00 o’clock; similarly, for crimes registered after half past hour - it was rounded to the following hour, e.g.,7:36 to 8:00 o’clock).

The second main dataset was composed of meteorological data covering exactly the same time spam from the criminal dataset (i.e., January 2009 up to December 2017), and it was provided by the Environmental Institute of Brasília (IBRAM) from the automated weather station (AWS), a property of the Brazilian National Institute of Meteorology (INMET) containing the weather variables (maximum, mean and minimum air temperature (°C); rainfall (mm), relative humidity in %, barometric pressure, sun radiation, wind (direction/speed) and dew point. The selected variables were **accumulated rainfall, air temperatures (mean and max) and relative humidity,** due to the consistency of data.

It was told to me at the IBRAM that I would find many pitfalls and blanks on the weather data table due to technical issues, such as consecutive forced stops of the automated weather station located in the *Sudoeste* neighborhood**.** Therefore, problematic weather datasets were not included in this study. In addition, the selection of the aforementioned weather variables has followed the study design of a good number of published papers cited in the previous literature review section.

For both criminal and weather data on the Excel®, we converted the textual description of crimes' frequency into a countable fashion - from text to numbers (count). Weather and crime data were initially displayed on an hourly basis, but we have aggregated the weather variables to overlap the same time scale of the criminal dataset. Also, to increase statistical power of our selected variables we also have managed to aggregate data from hourly to daily, monthly, and quarterly basis. The last aggregation also follows the four seasons of the year, but note on Table 1 that the 1st and 4th quarters of the year have the same weather characteristics

1st quarter - February to April - **wet mild**
2nd quarter - May to July - **dry cool**
3rd quarter - August to October - **dry hot**
4th quarter - November to January - **wet mild**

Table 1 Seasonal data aggregation for statistical purposes (trimester time scale)

Statistical Analyses

Descriptive statistics

Criminal counts for all temporal scales were calculated and analysis of the criminal dataset to the 9-year period was carried out by using the aggregate function in the R Studio version 3.6.2®. It has allowed us to initially scrutinize both datasets at a descriptive level. As a result, we obtained the average of crime frequency and their trends in terms of days of the week, periods of the day (night, day), as well as which weather conditions had a higher propensity to the occurrence of violent crimes. Using the same function, we managed to make the temporal aggregations displaying each of the crime variables in hours, days, months and trimesters.

Inferential Analysis

We have checked for data distribution patterns through normality testing for both datasets using the Shapiro-Wilk test. The distribution patterns of the crime database had discrete variables and showed a not normal distribution. Similarly, we tested for normality of the weather database which had normal distribution. Following this, a non-parametric analytical approach (Spearman) was adopted for correlation testing since the crime dataset distribution was quite skewed and the weather, as aforementioned, had normal distribution. It is important to highlight that testing normality is a crucial step for the selection of a proper statistical model in order to establish accurate correlations. Since our data did not meet normal distribution, which invalidates the use of a parametric test, we selected the Spearman’s correlation test as it requires no distributional assumptions for our numeric observations (CHAVAN & KULKARNI, 2017).

Further to the nonparametric Spearman correlation test, the significant relations were submitted to regression model adjustments. In the R Studio, through stepwise (both directions), the best-fit variables were chosen to compose the model aiming to achieve the better answer of the dependent variable regarding the independent ones. The stepwise selection model criterion was the AIC.

Afterwards, a VIF test was run so we could exclude multicollinearity factors. The parameters left having no multicollinearity were again modeled using a negative binomial regression, which aimed not only to understand linear correlation between two variables but also the behavior of our variables (residuals) regarding our research questions.

Negative Binomial Regression

Therefore, to better examine the possible associations between crimes and weather variables, beyond the correlation analyses, we have adjusted Negative Binomial Regression Models in GLM technique (Generalized Linear Model) using a number of pre-selected variables whose Spearman’s correlations revealed to be the most promising ones. In addition, the nature of our variables (e.g., over dispersed, discrete counts instead of continuous variables) informed the suitability of our regression models.

To the negative binomial regression only monthly and quarterly time scales were incorporated to the models, to be tested with the independent variable “accumulated rainfall (mm)” and “mean average temperature (°C)” since these previously presented a more satisfactory correlation (Spearman). Table 2 shows the regression models accordingly to its temporal aggregation:

Aggregat	Crime variable	Model
Month	Homicide	$\ln(\hat{Y}) = \beta_0 + \beta_1 r + \beta_2 t + \varepsilon$
	Homicide	$\ln(\hat{Y}) = \beta_0 + \beta_1 r + \varepsilon$
	Rape	$\ln(\hat{Y}) = \beta_0 + \varepsilon$
	Rape Attempt	$\ln(\hat{Y}) = \beta_0 + \varepsilon$
Quarter	Homicide	$\ln(\hat{Y}) = \beta_0 + \beta_1 r + \varepsilon$
	Homicide	$\ln(\hat{Y}) = \beta_0 + \beta_1 r + \varepsilon$
	Rape	$\ln(\hat{Y}) = \beta_0 + \varepsilon$
	Rape Attempt	$\ln(\hat{Y}) = \beta_0 + \varepsilon$

Table 2 Selected model for each crime variable and aggregation strategy. For β, please read: parameter's value, where r represents "accumulated rain (mm)", t represents "mean average temperature (°C)", and ε represents the model error.

The results section brings coefficients from the Spearman correlation's test illustrating the selection criteria for the models, according to each of the data aggregations. Results out of this model will demonstrate, for instance, how different are the patterns of violent crime occurrences between weekdays and weekends. In terms of data analysis, the plots presented below (figures 2, 3, 4, and 5) of predicted values and residuals show that monthly and quarters (trimester) models are the ones having the best fit. Further still, according to the fit graphics (figures 2, 3, 4, and 5) indicate that our models are enough to explain the associations between the variables under analysis, but those are not suitable for predictive models.

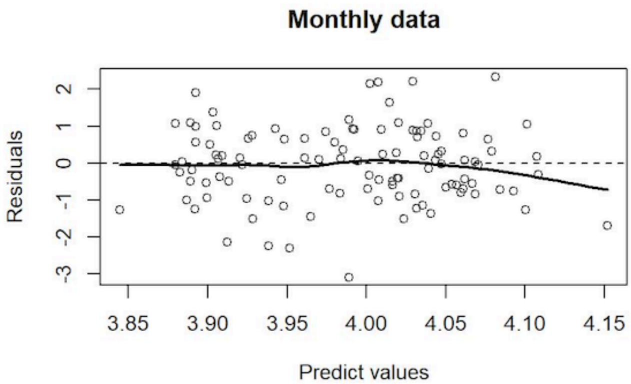


Figure 2 Homicide monthly residual plot

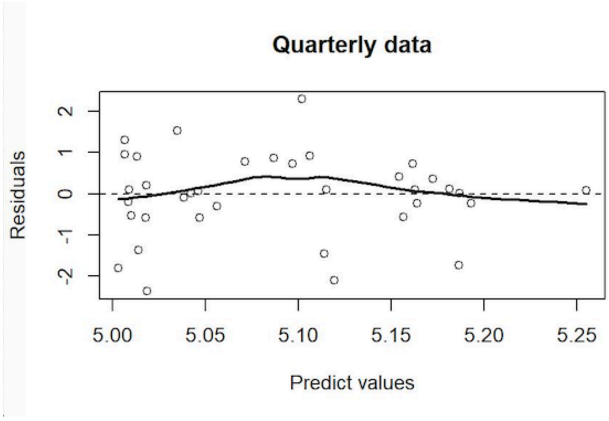


Figure 3 Homicide Trimester Residual Plot

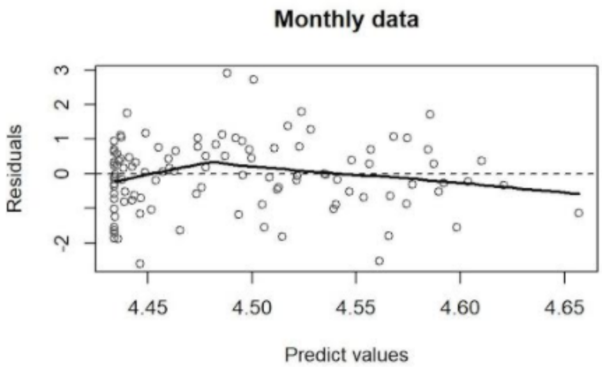


Figure 4 Homicide Attempt Monthly Residual Plot

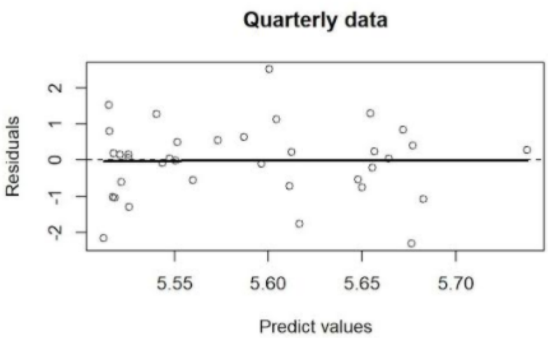


Figure 5 Homicide Attempt Trimester Residual Plot

Spatial Analysis

By the time this analysis was run, the Brazilian Distrito Federal was composed by 31 Administrative Regions (RAs), or as popularly known, *31 satellite cities.* Each of DF's RA has a very distinct shape, embedding different demographic densities, income levels, and abrupt differences in percentage of urban green whether in public or private spaces (CODEPLAN, 2017). Moreover, up to date, temperature data do not cover these neighborhoods individually. In other words, since ever, just a single air temperature value exists to the whole territory of Distrito Federal.

To overcome such limitation in terms of lacking local data to each RA, we decided to acquire open-source big data from satellite imagery. Our main outcome from the following methods were maps of local temperatures extracted from the radiometric temperature-data embedded in pixels of orbital image capture by the ETM+ and OLI sensors carried by the Landsat satellites overlapping the geocodes of crime, which have informed the geographical coordinates of places that have registered violent crimes. Therefore, with the support of geostatistics we could spatially correlate high surface temperature and violent crimes occurrence. The chart below summarizes the main steps taken to overlap the geography of violent crimes to high land-surface temperature:

Figure 6 Spatial Analysis' steps diagram

According to Viana (2018), Werneck (2018) and Amorim (2019), temperature maps can be produced by daily collecting air temperature data - using fixed points (stations) or mobile transects. Either way would require time and budget that this study had no available, unfortunately. Thus, the manner we found feasible to overcome such limitations and measure local temperature for each RA was using remote sensing relying on in-cloud processed big data[9]. We have done that retrieving from the cloud-based platform Google Earth Engine - GEE. Such technology from GEE, state Gorelick, Hanche, *et al.*, (2017):

> “is a cloud-based platform for planetary-scale geospatial analysis that brings Google's massive computational capabilities to bear on a variety of high-impact societal issues including deforestation, drought, disaster, disease, food security, water management, climate monitoring and environmental protection” Gorelick, Hancher *et al.*, 2017, p. 18)

In the GEE’s code editor, a command script was written describing decimal geospatial coordinates Lat: -15.7801 and Long: -47.9292 (to process only the territory of the Distrito Federal), and we chose the type of satellite image we needed (For the complete script please refer to the Appendix 1). Within GEE code editor we acquired and processed imagery having thermal bands of Land Surface Temperature (LST) from the satellites Landsat 7 and Landsat 8. These two satellites were required in order to match and cover the research time spam (2009 through 2017). Data output came out in the format of a raster geo.tiff (data matrix) Datum Sirgas 2000, UTM 23. The image below graphically illustrates the data format of a raster.

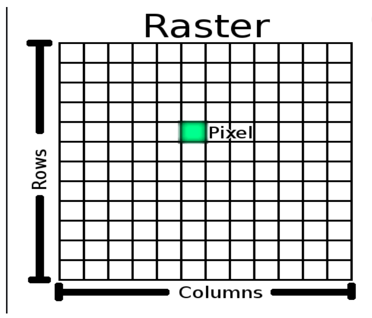


Figure 7 The raster’s concept

Source:https://docs.qgis.org/2.14/pt_BR/docs/gentle_gis_introduction/raster_data.html accessed on January 25th 2020 at 0:30 am

[9] Big data - new technologies to collect, manipulate, analyze and exhibit data (HEY et al., 2009)

LST data had its radiance in Watts/m².sr.µm - converted into temperature in Kelvin, and then from Kelvin to Celsius degrees. Pixels captured by the Landsat 7 sensor have a definition of 60 meters and from Landsat 8 of 100 meters x 100 meters, which has a dimension larger than Distrito Federal´s territory. We adopted thus a collection of images resampled to 30 x 30 meters, and by doing so we considered minimizing correlation risk error. In addition, imagery collection from Landsat 7 and 8 OLI/TIRS provided to GEE by USGS EROS (https://earthexplorer.usgs.gov/) had spatial resolution resampled to 30 meters and radiometric resolution of 16 bits. Data were converted on Google Earth Engine to TOA (Top Of Atmosphere) spectral radiance and subsequently transformed into atmosphere brightness temperature using scaling factors and the thermal constants provided by the metadata file (raster).

We processed the model following (PIRES e FERREIRA JR, 2015), which is described below. The first equation used to convert radiance was:

Eq. 1,

$$L_{\lambda} = M_L Q_{cal} + A_L$$

Where:

= TOA spectral radiance (Watts/m²srµm);

= Band-specific multiplicative rescaling factor the metadata (*RADIANCE_MULT_BAN*D_x), where x is the band number);

= Band-specific additive rescaling factor from the metadata (*RADIANCE_ADD_BAND_x*), where x is the band number;

= Quantized and calibrated standard product pixel values (DN);

The second step taken was to convert radiance into TOA as described on equation 2.

Eq. 2

$$TB = \frac{K}{\ln(\frac{K1}{K2} + 1)}$$

Where

T = Top of atmosphere brightness temperature (K);

= TOA spectral radiance (Whats/m² * srad * µm);

K1 = Band-specific thermal conversion constant from the metadata (*K1_CONSTANT_BAND*), where x is the thermal band number*;*
K2 = Band-specific thermal conversion constant from the metadata *(K2_CONSTANT_BAND_x),* where x is the thermal band number.

From Kelvin to Celsius degree (Eq. 3)

Eq. 3

$$TB = \frac{K}{\ln(\frac{K1}{K2} + 1)} - 273.15$$

Further, we calculated emissivity to understand the “climate-active surfaces”, and thus differentiating dark surfaces from exposed soil, or greenery or a water body. NDVI index which is the vegetation index is calculated together to inform the bright temperature, as follows:

Eq. 4

$$e = 0.004 * Pv + 0.986$$

Where:

e = emissivity
Pv = [(NDVI-NDVImax)/(NDVImax-NDVImin)]
NDVI = Normal Detection Vegetation Index obtained for equation 5

NDVI = Eq. 5

$$NDVI = \frac{Band5 - Band\ 4}{Band5 + Band4}$$

Once having NDVI and emissivity values we converted the bright temperature into temperature as follows:

Eq. 6

$$T = \frac{TB}{1 + \left(\lambda * \frac{TB}{C2}\right) * \ln(e)}$$

Where:

= wavelength of emitted radiance

C2 = h*c/s = 1,4388 * 10^{-2} m

h = Planck’s constant = 6,626 * 10^{-34} m^2Kg/s

s = Boltzmann constant = 1,38 * 10^{-23} J/K

c = velocity of light = 2,998 * 10^8 m/s

e = emissivity according to equation 4

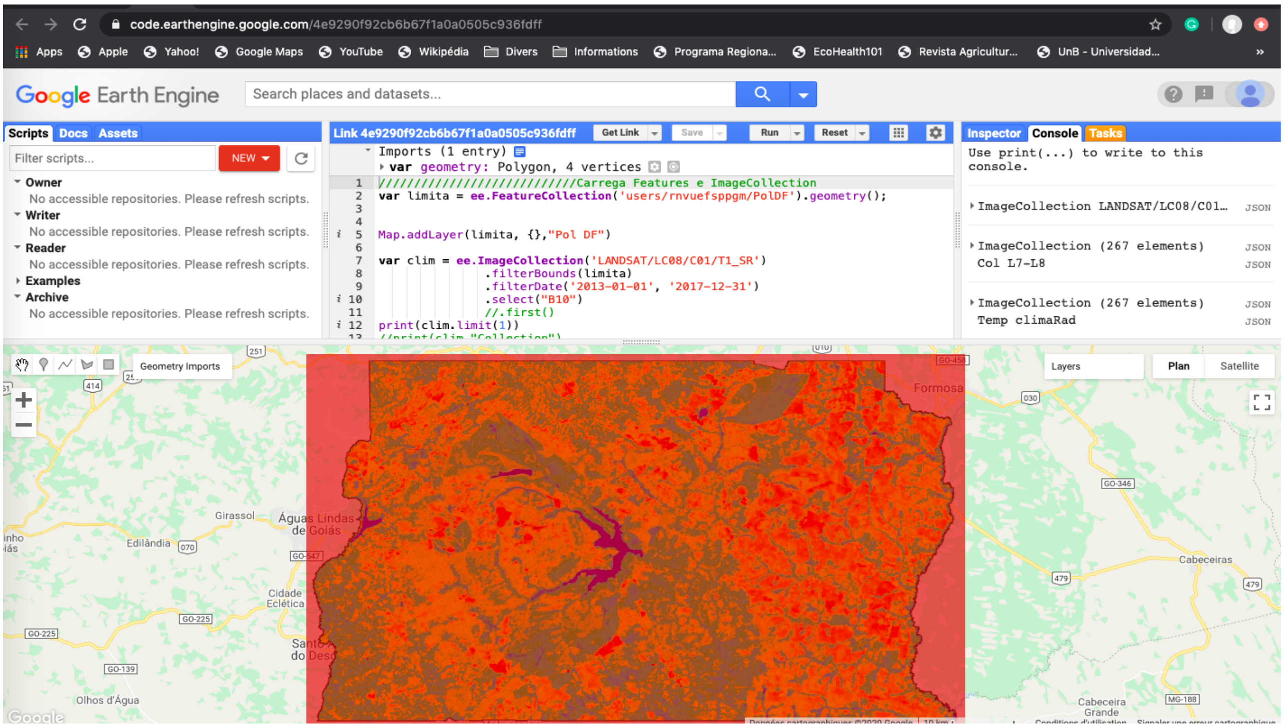
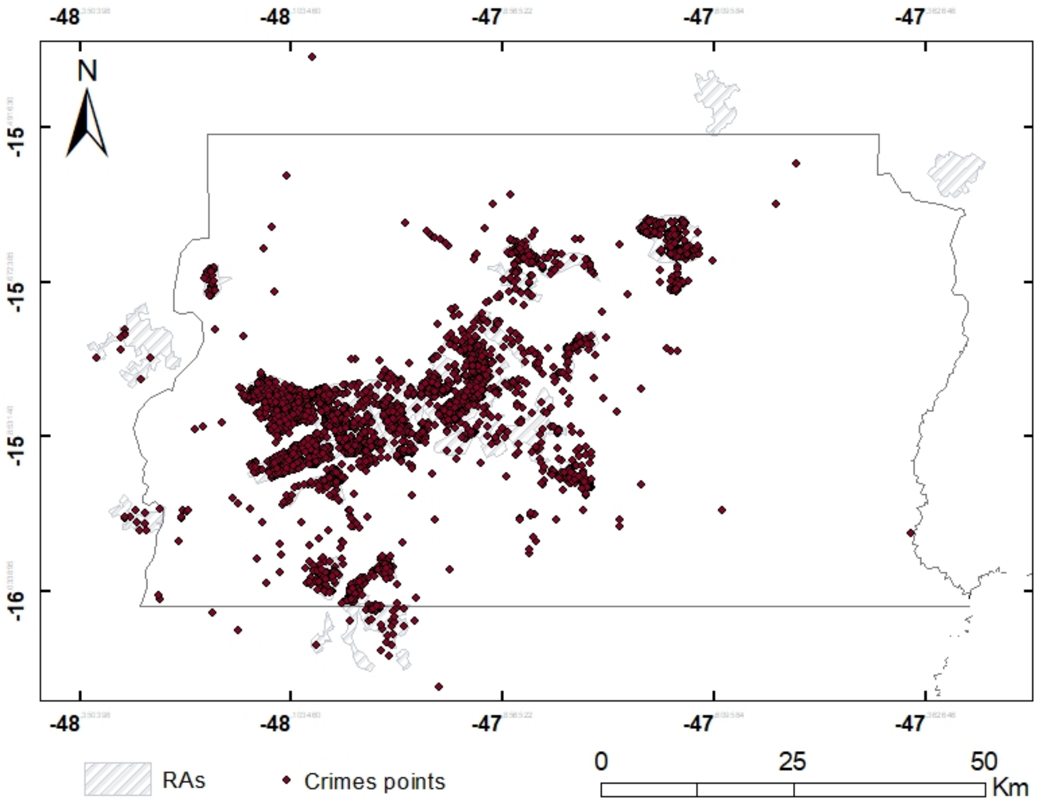


Figure 8 Google Earth Engine code editor (for Python script)

The raster of temperature, as the output from Google Earth Engine has 8.000 rows and 8.000 columns, similarly to the raster of violent crime created with the ArcGIS. The raster of crime - which encompasses the 4 criminal variables we have under analysis (Homicide, Homicide attempt, Rape and Rape attempt) was created in the ArcGIS after a period of programing efforts from CODEPLAN. It is important to highlight that our criminal dataset is basically a table having the compilation of crime occurrences registered by the policemen. CODEPLAN managed to provide us with the geocode - latitude and longitude for each of the 22.218 crimes, after cross-checking by similarities the addresses of our criminal database against other databanks of public utilities services in Brasilia, such as the electricity provider CEB, and the water and sewage company CAESB. Each of those crime records became a point in the geospatial dataset. Although we found no correlation between air temperature for rape and its attempts, we decided to keep the four variables for testing the criminal variables against land surface temperature, and by doing so it would keep the statistical power strong by conserving the same number of observations, and above all, we could see how these criminal variables are distributed on the space of the Federal District.



Map 9 Violent crime spatialized as dots in Distrito Federal - Source: CODEPLAN

Rasters were inputted into the R Studio software 1.1.456 and a geostatistics operator correlated pixels between the two rasters (data-matrices): the raster of violent crimes got aggregated into Kernel Densities, and the other of Land Surface Temperature (LST) had its daily maximum average calculated. By doing so we became aware about the locations that had been registering the warmest surface temperatures in the territory of Distrito Federal. We could not make a traditional correlation pixel by pixel, otherwise, we would look only at two values to correlate. Thus, we decided to apply the Kernel Density - which is a process of points' interpolation. The Kernel Density tool is a popular function to calculate the number of crime occurrences in a certain neighborhood. According to ESRI's website[10]:

> "Kernel Density calculates the density of point features around each output raster cell. The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance from the point. The calculated density is then multiplied by the number of points, or the sum of the population field if one was provided. This

[10] How Kernel Density works: https://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-kernel-density-works.htm accessed on May 28, 2020 22:23 pm

> correction makes the spatial integral equal to the number of points (or sum or population field) rather than always being equal to 1. This implementation uses a Quartic kernel (Silverman, 1986 *apud* ESRI, 2020). The formula will need to be calculated for every location where you want to estimate the density. Since a raster is being created, the calculations are applied to the center of every cell in the output raster" (ESRI, 2020)

Therefore, R Studio software 1.1.456 and a geostatistics operator correlated pixels between the LST raster and the raster having the geocode of crime. Each pixel had its *P* and *R* values calculated. The maps presented further bring only results from the correlation values that had significant parametric correlation between pixels having violent crime occurrences and pixels of high average LST (high average LST ranging from 20°C minimum to 55°C maximum). It is important to highlight that our criminal database after being transformed to geographic coordinates (points) had normal distribution in the normality test. Furthermore, we decided to concentrate all the four criminal variables (homicide, homicide attempt, rape and rape attempt) instead of analyzing each variable separately for a few reasons. First, to enhance the statistical power by increasing our sample size/ number of observations. Secondly, we have used high-definition images in our analysis, thus, to preserve the confidentiality of the data; and thirdly, for security reasons we did not split the crime variables. Moreover, the premise of our investigation was to understand spatial concentration of violent behavior in function of high surface temperatures.

In other words, we displayed in red and green colors on the geostatistical maps - only pixels having the correlation *p* value ≤ 0.05 of violent crimes and LST. Within this gradient of correlations (*p* value ≤ 0.05), we refined results and classified them into 2 scales: Medium-strong (0.50 up to 0.75) in green, and in red color all the strong correlation values (0.75 to 1.00). Shapefiles retrieved from the GDF's Geoportal – www.geoportal.sedu.df.gov.br - informed on the map limits of the territory, streets, and water bodies.

In addition to counts of pixels[11], each map has graphics with a combination of data adapted from Codeplan (2017) and Rodrigues et al. (2016), for comparison purposes. Primary data display the count of pixels having high correlations and medium-high

[11] Each pixel has the resolution of 30m x 30m (900m²)

correlations plotted for each RA. These results thus show the extent to which the territory of each neighborhood (RA) is affected by medium and high correlations of violent crimes in places having high LST. Furthermore, with regards to the primary data displayed in the aforementioned graphics, we calculated the demographic density in Km^2 of each RA and multiplied by the number of pixels that were similarly converted to Km^2. By doing so, we obtained the number of people affected by surface heat and violent crimes in each neighborhood.

Further still, comparisons between RAs were made possible by plotting secondary data describing amount of green in Km^2, published by (RODRIGUES, GONÇALVES e TEZA, 2016) The amount of green for each RA published by Rodrigues et al. (2016) was calculated through remote sense using the Normalized Difference Vegetation Index (NDVI) and Geographical Information System (GIS). Data adapted from Codeplan (2017) bring distance to downtown, population average for the years of 2015 and 2016, per capita monthly income for each RA in the year of 2015, and the foundation data of each Administrative Region of Brasília, Distrito Federal. A general table containing all these mentioned values is also provided in the following section. Samples of urban tissues affected by our correlations are displayed with the support of high definition imagery provided by Google Earth Pro and ArcMap.

RESULTS

In this section, results are presented following the same logic order aforementioned in the methodology

1) Descriptive Statistics showing the results of aggregation function in the R studio software and contains the amount of each crime variable per hour, week, month and trimester.

2) Inferential Statistics presenting results from Spearman correlation test, Variance Inflation Factor - VIF which is the factor that indicates multicollinearity, then the results from the Negative Binomial regression

3) Spatial Results – showing the coefficients of geostatistical correlation test, graphs having secondary data regarding population, green and income for each R.A and the hotspots figure maps.

Descriptive statistics

Counts for all temporal scales are presented in this section, concerning the exploratory analyses of our criminal dataset to the analyzed 9-year period (2009 - 2017). These counts show hints for patterns of crime occurrence regarding temporal dimensions. Discussion related to the concentration of crimes and patterns of occurrence during certain periods of the year, as well as the statistical significance to weather are presented.

Hourly aggregation

A total of 22,218 crimes were reported to the GDF Public Security Department (SSP-DF) between January 1^{st,} 2009 and December 31^{st,} 2017, which represent an average of 6.8 violent crimes per day. According to our primary exploratory analyses, our first findings indicate visual patterns of seasonality related to the occurrence of violent crimes in the Brazilian Distrito Federal. The first temporal scale was aggregated on an hourly basis. Figure 9 plots results showing patterns of crime occurrence over the 9 years analyzed for the four criminal variables (homicide, homicide attempt, rape and rape attempt) in terms of daylight, night-time, and the frequency rate of occurrence to each of them as follows:

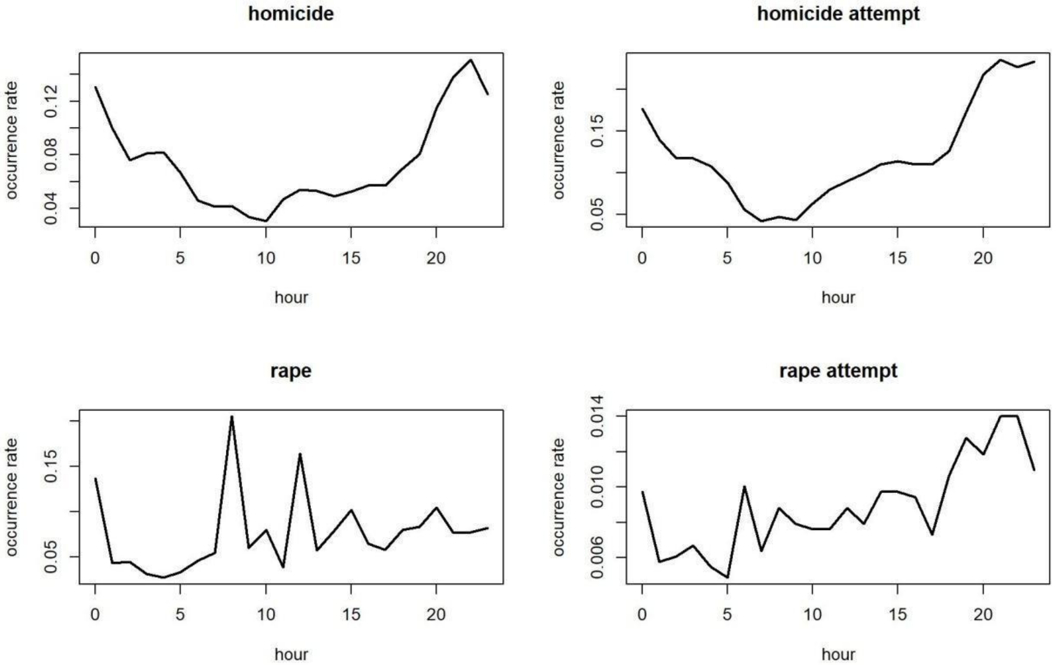


Figure 9 Exploratory analysis ran on an hourly basis arrangement

It is described below details regarding the hours having higher frequency of occurrences, divided by crime:

Homicide - Hour arrangement

According to the analyzed criminal records, 10:00 pm was the time registered as concentrating most of the homicide cases in Distrito Federal (DF). From a total of 5,850 cases, 10:00 pm has reached the number of 496 cases registered within the analyzed period. Murdering frequencies presented themselves as picking around 6:00 pm, summing 230 cases, going up to 378 cases at 8:00pm, and then slowly decreasing after midnight. Mornings show a descendent curve having the lowest rate of 101 cases at 10:00 am. However, this decreasing tendency is reverted around noon. Thus, afternoons present an increase in the homicide rates and nights concentrate the majority of murdering cases when compared to the other periods of the day.

Homicide Attempt - Hour arrangement

Assaulting, aggressing or trying to kill someone (which all of these are aggression), presented a similar pattern of homicides in terms of its frequency of occurrence, having between 8:00 and 11:00 pm the majority of cases registered. It counted 718 and 768 cases of homicide attempt registered consecutively, out of the 9,643 cases registered in total between 2009 and 2017. After midnight, the number of cases regarding homicide attempts decreases substantially, reaching its lowest level at 7:00 am with 120 cases reported. This tendency is reverted at 10:00 am when the rate of homicide starts to increase again; 10:00 am registered 187 cases.

Rape – Hour Arrangement

Counts have shown that in terms of hours, almost 75% of rape cases happened early in the morning or at night. In sum, the 9 years of criminal records showed a total of 6,021 cases of rapes and the majority of the episodes were reported as having occurred at about 8:00 am (673 cases counted), and at noon (539 cases summed), followed by 336 cases reported to have occurred at 3:00 pm and 345 cases around 8:00 pm. Figure 10, on the next page consolidates the hours having more frequency of rape.

Rape Attempt - Hour arrangement

From 2009 through 2017, 704 cases were registered. The analysis has shown 10:00 and 11:00 pm as having the major frequencies for the occurrence of rape attempt within the territory of Distrito Federal, computing 46 cases registered consecutively at these hours, followed by 19 cases computed at 1:00 am and 16 cases at 5:00 am.

Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
homicide	430	328	250	266	270	219	151	136	137	111	101	154	178	174	162	173	188	188	230	265	378	454	496	411
homi att	582	461	388	386	355	292	185	140	157	144	208	264	296	327	364	375	364	364	416	567	718	775	747	768
rape	448	142	148	104	90	111	152	180	673	198	264	128	539	189	260	336	212	190	262	274	345	252	255	269
rape att	32	19	20	22	18	16	33	21	29	26	25	25	29	26	32	32	31	24	35	42	39	46	46	36

Table 3 Sum of crimes per hour (2009 – 2017)

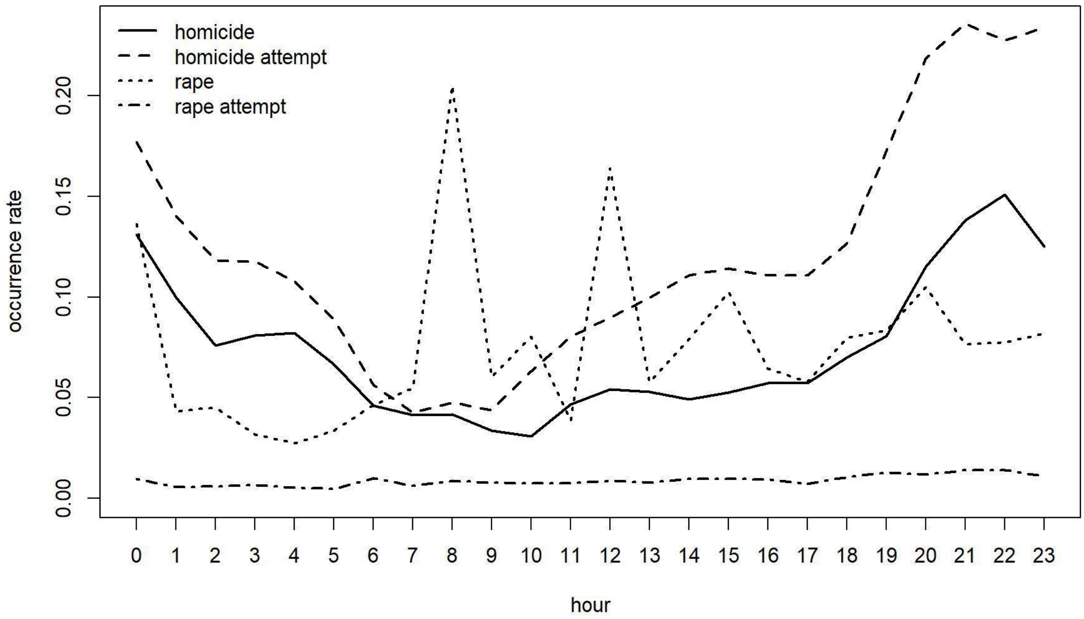


Figure 10 Consolidated frequencies of occurrence per hour and type of crime

Weekly aggregation

The second time scale aggregation used was the weekly basis. In this aggregation, we identified patterns of occurrence for the four criminal variables, mainly in terms of weekdays and weekends. Also, we could notice which weekday would be more likely to have the occurrence of a specific criminal variable, as described below and summarized on figure 11.

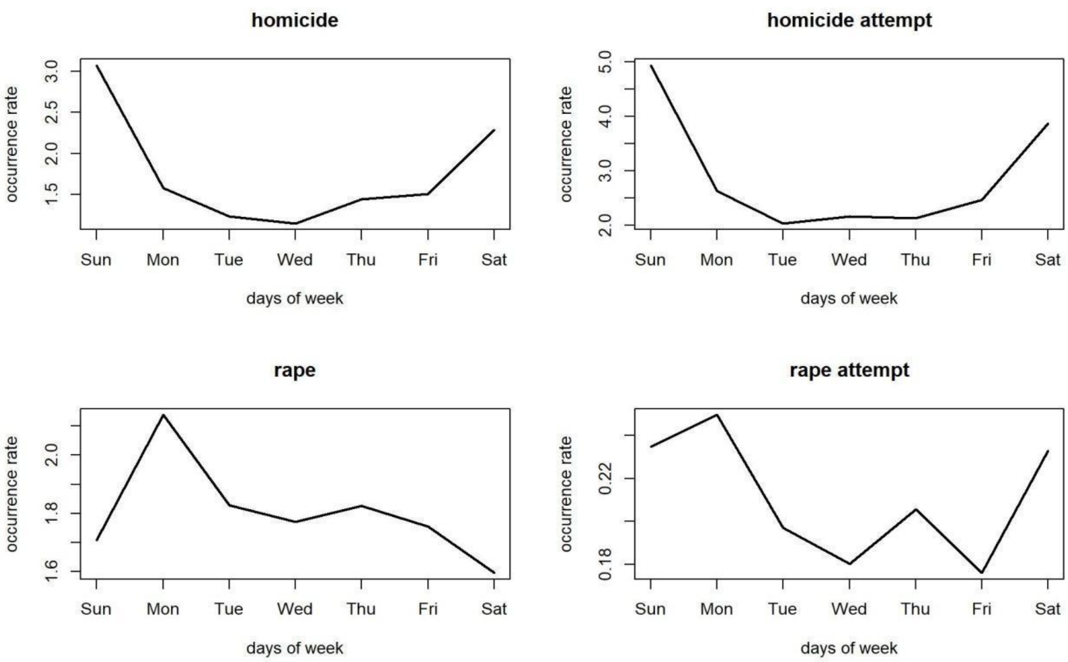


Figure 11 Exploratory analysis ran on a weekly basis arrangement

Homicide - Weekly arrangement

Wednesdays are the “calmest” days in terms of murdering, computing for 548 cases under the level of 752 presented on Mondays. From Wednesday on, homicide cases start to pike. Weekends are far more violent, with sums above 2000 cases being registered in such small periods such as 48 hours, from 0h of Saturdays (1,091 cases) through 23:59h of Mondays (1,466 cases).

Weekends (Sat-Sun)	Weekdays (Mon – Fri)	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
2,557	3,293	752	588	548	687	718

Table 4 Sum of homicides aggregated by days of the week

Homicide Attempt - Weekly arrangement

Attempting against someone’s life (or aggression-related injury) is the crime variable with the most significant amount of entries in the analyzed criminal records. Weekends constitute the period with larger numbers of homicide attempt occurrences, accounting for 4,199 cases registered in 2 days against 5,444 registered during the five weekdays. Weekdays have the majority of occurrences of this nature, being Mondays with 1,256 and Fridays with 1,174 cases. Tuesdays are the “calmest” days, having 970 cases registered. We also consider weekends from the 0h of Saturday until 23:59h of Mondays.

Weekends (Sat-Sun)	Weekdays (Mon–Fri)	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
4,199	5,444	1,256	970	1,031	1,013	1,174

Table 5 Sum of homicide attempts aggregated by days of the week

Rape - Weekly Arrangement

Mondays are for the day with significant rape registers occurrence in Distrito Federal (1020 cases in sum). Besides Mondays and weekends, the rest of the week holds a very regular occurrence number.

Weekends	Week (total)	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
1,576	4,445	1,020	872	845	871	837

Table 6 Sum of rapes aggregated by days of the week

Rape Attempt – Weekly Arrangement

Similarly, Mondays are the day as having more registries of rape attempt, computing 108 cases, followed by Sundays with 112 and Saturdays with 119 cases. Wednesdays are the calmest day in terms of criminal occurrences of this nature. Although the crimes of this nature are under-notified, in terms of days of the week it is perceivable that the occurrence of rape attempts follows the same pattern of rape cases.

Weekends	Week (total)	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
223	481	119	94	86	98	84

Table 7 Sum of rape attempts aggregated by days of the week

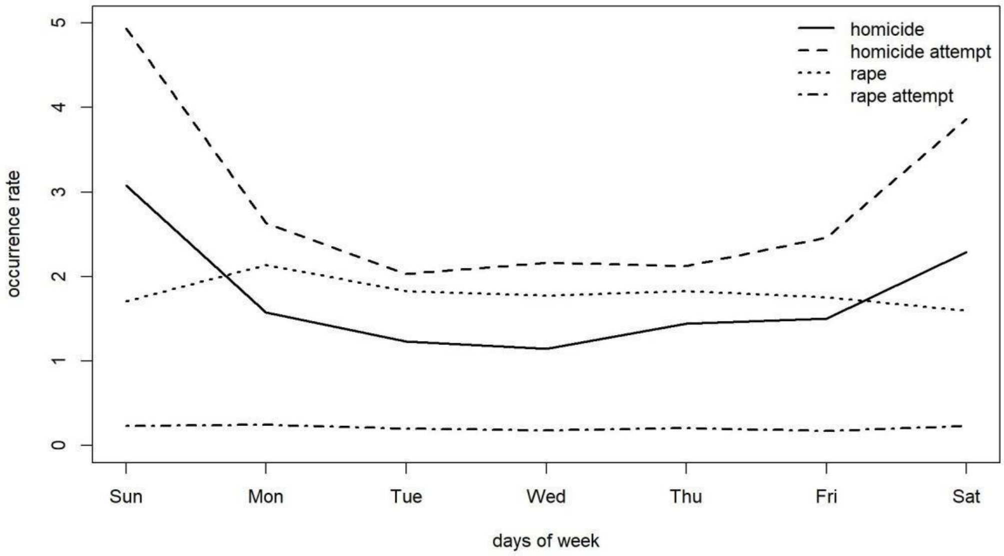


Figure 12 Consolidated frequencies of crime occurrence per day of the week.

Monthly aggregation

By looking at the year as a timeline, perceiving the nuances related to the months becomes easier. Mainly regarding holidays, vacations time, the busiest and calmest months of the year in terms of social routine, travels, etc. At the same time, common sense informs how the weather usually looks like each month, holding similarities in weather conditions. The following time scale shone light towards the fluctuations of violent crime frequencies across the year - having months as the background feature.

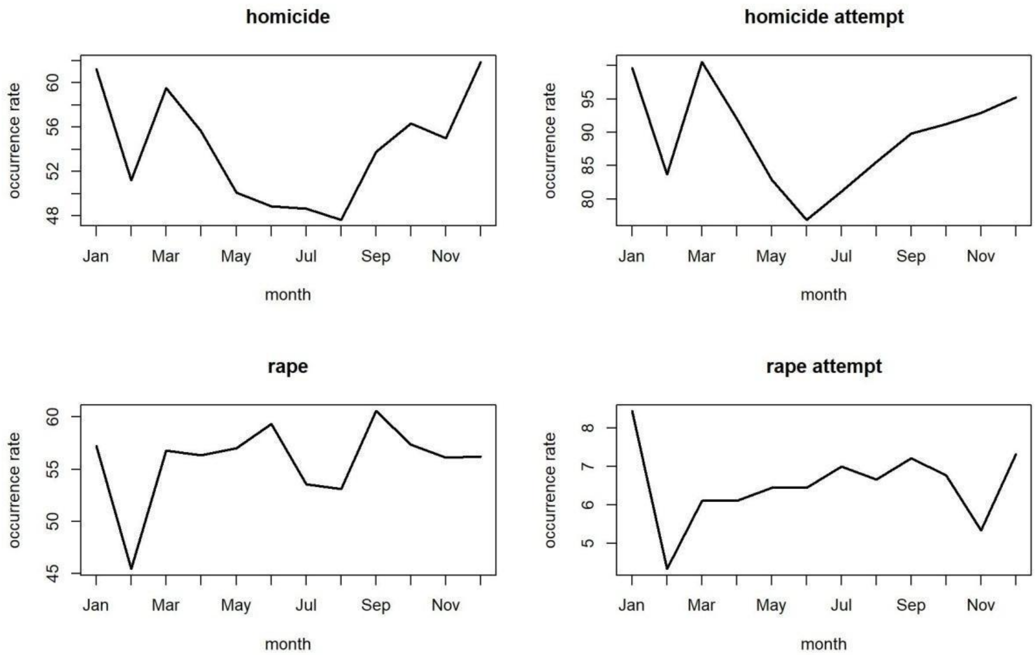


Figure 13 Exploratory analysis ran on a monthly basis arrangement

Homicide - Monthly arrangement

Throughout the months, the seasonal patterns of occurrence of homicides become clear. Homicides in the Brasília and Distrito Federal, therefore, by looking at the year is possible to perceive that crimes of this nature pike from December through March. In sum, February presents lower rates since those months are shorter.

It is possible to note that murdering holds its lower frequencies during the wintertime, with an average of 40 to 45 cases per month at the end of June/early July (cooler and dryer months of the year). Then, murdering frequencies drastically increased back in August, when temperatures inaugurate the warmest and driest periods of the year in Brasília.

The City of Brasilia has a fame of being a hot and dry city during the whole year. In fact, the drought lasts in general only from August through October. Then the rainy season brings a feeling of freshness to the local population. The first rain is expected to fall by the end of October, and when it comes, the rain is somehow celebrated by *Brasilienses.* Although the frequent rain cools down the weather from mid-October up to mid-April, homicide frequencies are consistently high in December.

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sum	551	461	536	501	451	440	438	429	484	507	495	557

Table 8 Sum of homicides aggregated by months of the year

Homicide Attempt - Monthly arrangement

According to the monthly arrangement, June is the month having the lowest cases of homicide attempt (622 cases) in the Brazilian Distrito Federal with an average of 25% fewer cases of this nature, in comparison to the end and beginnings of the analyzed years.

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sum	897	753	905	828	746	692	730	770	808	821	836	857

Table 9 Sum of homicide attempts aggregated by months of the year

Rape - Monthly Arrangement:

September and June are reported as the months with the highest frequencies of rape in Distrito Federal with a sum of 545 and 534 cases, respectively. January is the third month more dangerous for the occurrence of rape - 515 cases. February presents a fall in all violent crimes of our database, accounting for 409 cases.

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sum	515	409	511	507	513	534	482	478	545	516	505	506

Table 10 Sum of rapes aggregated by months of the year

Rape Attempt - Monthly Arrangement

January and September are the months having higher numbers of registers related to rape attempt with 70 and 61 cases in sum, consecutively. February also registered the lower frequency since those are shorter months accounting for 32 cases, November with 40 cases and October having 50 registries.

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sum	76	39	55	55	58	58	63	60	65	61	48	66

Table 11 Sum of rape attempts aggregated by months of the year

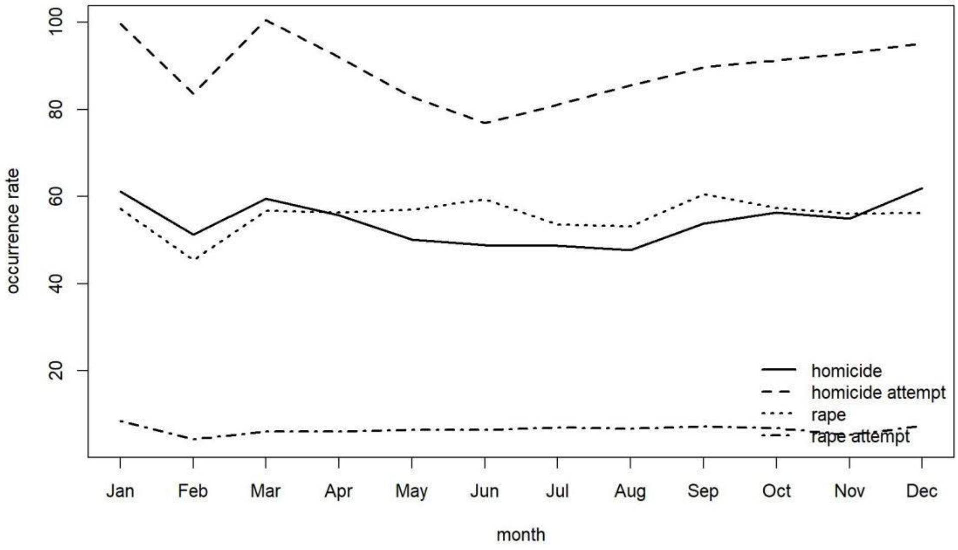


Figure 14 Consolidated frequency of crime occurrence per month and type of crime

Quarterly aggregation

Further still, regarding the temporal scales of data aggregation, since years are divided by four seasons that last approximately three months each, quarters are the aggregation that follows the seasonal patterns more accurately. We aggregated in such way to assess the occurrence of violent crimes per season, in other words, in the warmer rainy season (November through January), in the mild rainy season (February through April), in the dry and cold season (May through July), and lastly in the hot and dry season (August through October).

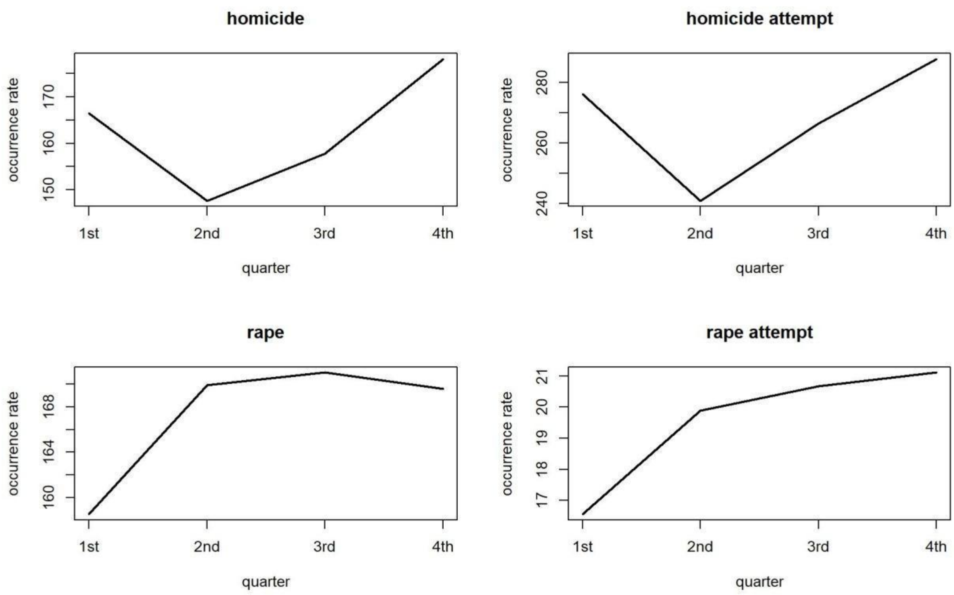


Figure 15 Exploratory analysis ran in quarters basis arrangement

Homicide - Trimester arrangement

When plotted in trimesters, homicide variables show the tendency of lower murdering rates in the second trimester of the analyzed years. However, the variation is very discreet when looking at the numbers which translate that killing throughout the year in Distrito Federal has a stable frequency.

Quarters (2009-2017)	1st Quarter (February-April)	2nd Quarter (May-July)	3rd Quarter (August – October)	4th Quarter (November-January)
Sum	1,498	1,329	1,420	1,603

Table 12 Sum of homicides aggregated by quarters

Quarters (2009-2017)	1st Quarter (February-April)	2nd Quarter (May-July)	3rd Quarter (August – October)	4th Quarter (November-January)
Sum	2,486	2,168	2,399	2,590

Table 13 Sum of homicide attempts aggregated by quarters

Quarters (2009-2017)	1st Quarter (February-April)	2nd Quarter (May-July)	3rd Quarter (August – October)	4th Quarter (November-January)
Sum	1,427	1,529	1,539	1,526

Table 14 Sum of rapes aggregated by quarters

Quarters (2009-2017)	1st Quarter (February-April)	2nd Quarter (May-July)	3rd Quarter (August – October)	4th Quarter (November-January)
Sum	149	179	186	190

Table 15 Sum of rape attempts aggregated by quarters

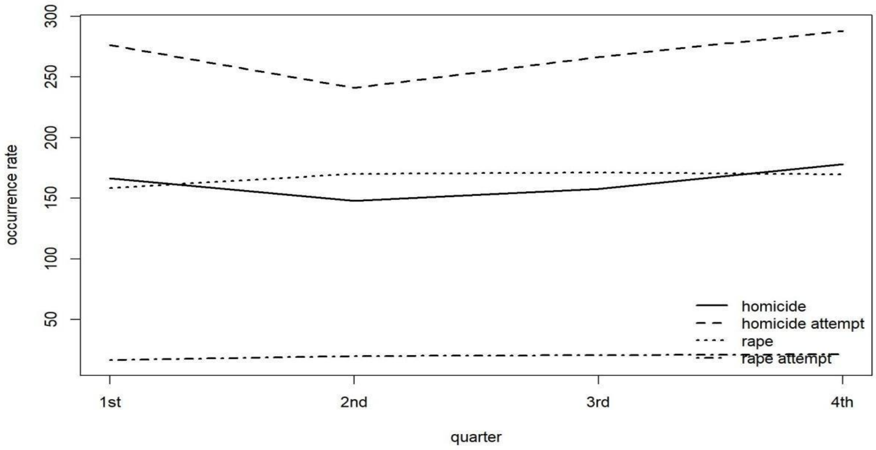


Figure 16 Consolidated frequency of crime occurrence per quarter

The last plot (figure 17) shows the behavior of violent crime variables year a year in Brasília. It was noticeable a pattern of frequency happening for every year during the analysis. A downward in February, a pike in March, a descendant curve in the middle of every year, then an increase in cases in September.

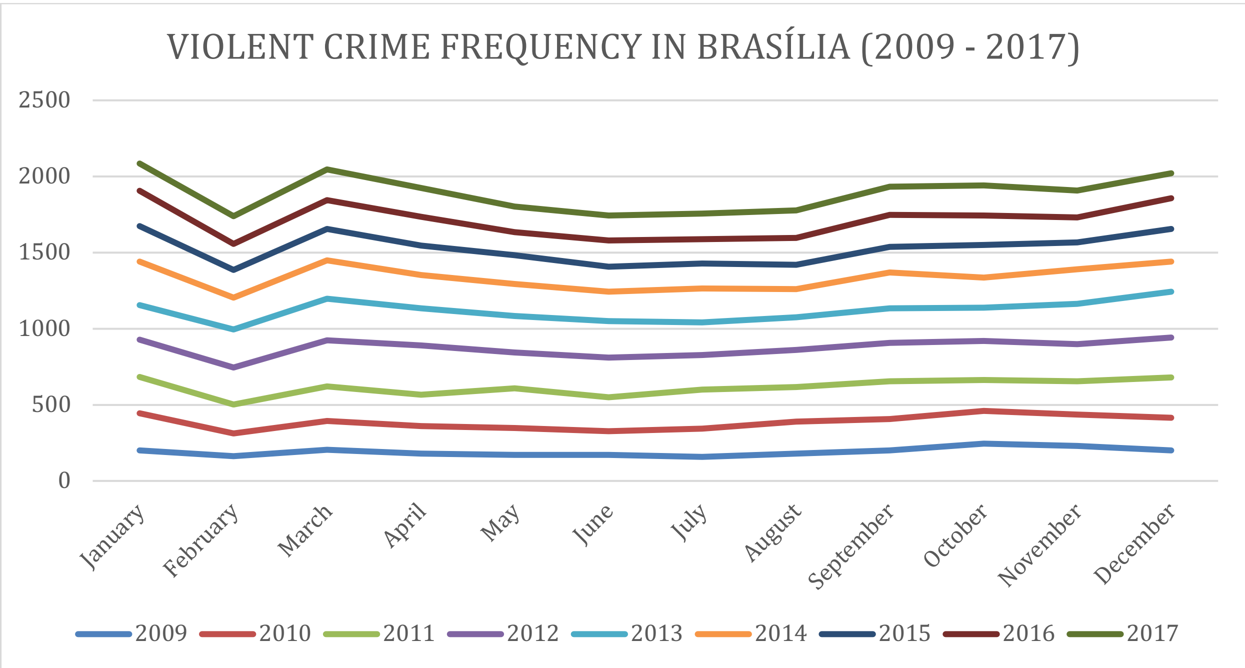


Figure 17 Yearly pattern to the frequency of crime occurrence (2009 – 2017)

Inferential Statistical Results

Table 16 shows that the majority of the correlation tests revealed significant associations among the weather variables and the criminal ones, and this for the different time scales under analysis. Despite the fact that the large majority of these analyses yielded weak correlation coefficients, one can observe a number of somewhat stronger, and, therefore, more relevant correlation values that were found for **homicide and accumulated rainfall (0,2810)**, as well as to **homicide attempt and accumulated rainfall (0,2955) over monthly and trimester aggregations only**.

It is important to highlight that both independent variables "maximum average temperature" and "average of relative humidity" were previously tested, showing no significant correlation with the crime variables, in all of our time scale data aggregation strategies.

	Spearman´s ρ rho	Rape	Homicide	Homicide Attempt	Rape Attempt
Hour	Accumulated rainfall (mm)	-0,0038 (0,2926)	-0,0040 (0,2644)	0,0002 (0,9547)	-0,0012 (0,7335)
	Mean average temperature (°C)	0,0185* (<0,0001)	0,0334* (<0,0001)	0,0812* (<0,0001)	0,0137* (0,0001)
	Average of relative humidity (%)	-0,0127* (0,0004)	-0,0133* (0,0002)	-0,0444* (0,0000)	-0,0119* (0,0009)
	Maximum average temperature (°C)	0,0055 (0,1241)	0,0108* (0,025)	0,0132* (0,0002)	0,0004 (0,9194)
Day	Accumulated rainfall (mm)	-0,0231 (0,0611)	0,0424* (0,0006)	0,0323* (0,0088)	0,0017 (0,8889)
	Mean average temperature (°C)	-0,0097 (0,4319)	0,0478* (0,0001)	0,0805* (<0,0001)	0,0025 0,8377
	Average of relative humidity (%)	-0,0125 (0,3094)	0,0167 (0,1758)	-0,0021 (0,8676)	-0,0117 (0,3445)
	Maximum average temperature (°C)	0,0225 (0,0681)	0,0283* (0,0216)	0,0348* (0,0048)	0,0005 (0,9678)
		0,1646*	**0,2810***	**0,2955***	**0,1316***

	Accumulated rainfall (mm)	(0,0006)	(<0,0001)	(<0,0001)	(0,0062)
Month	Mean average temperature (°C)	-0,0103	**0,1367***	**0,1248***	-0,0282
		(0,8302)	(0,0044)	(0,0094)	(0,5585)
	Average of relative humidity (%)	-0,0232	0,0441	0,0357	-0,0381
		(0,6303)	(0,3606)	(0,4596)	(0,4291)
	Maximum average temperature (°C)	0,0225	0,0298	0,0122	-0,0260
		(0,5368)	(0,8008)	(0,5895)	(0,6405)
Trimester	Accumulated rainfall (mm)	**0,1646***	**0,2810***	**0,2955***	**0,1316***
		(0,0006)	(<0,0001)	(<0,0001)	(0,0062)
	Mean average temperature (°C)	-0,0103	**0,1367***	**0,1248***	-0,0282
		(0,8302)	(0,0044)	(0,0094)	(0,5585)
	Average of relative humidity (%)	-0,0232	0,0441	0,0357	-0,0381
		(0,6303)	(0,3606)	(0,4596)	(0,4291)
	Maximum average temperature (°C)	0,0225	0,0298	0,0122	-0,2060
		(0,6405)	(0,5368)	(0,8008)	(0,5895)

(*p value* in parenthesis) - Significance 0,05 (*) - Select variable for the model **in bold**

Table 16 Correlation parameter values between crime and weather variables.

As anticipated in the section on methods, only those associations showing Spearman coefficients strong enough **(in bold)** to advise further and more robust analyses would be modeled in the second round of analyses by using Negative Binomial Regression based on generalized linear models (glm).

It is worthy to mention that before the regression we tested the Variance Inflation Factor - VIF which is the factor that indicates multicollinearity. In this sense, all variables presenting high VIF values (>10), that is, values presenting high multicollinearity and could confuse the analysis were taken out, and then new adjustments were done for the best fitting model of our variables, following the same logic: Dependent variables being the crime ones and weather variables being the independents. Table 17 shows the variables selected having lower factors of multicollinearity.

Aggregation	Crime	B_1	B_2
Month	Homicide	0.04286967	0.044116
	homicide attempt	0.02967529	-
Quarter	homicide	0.02275713	-
	homicide attempt	0.0175596	-

Table 17 VIF values of each selected parameter

Table 18 brings the results of our adjusted models in estimated parameters, where these results reflect 3 formulas, "B_0" as the intercept, *"r"* as the independent variable (accumulated rainfall), *b1 and b2* being the parameter values, *t* representing the independent variable (mean average temperature), and Sx the standard error. When measuring the Y (weather) having beta as reference value it is possible to determine the degree of sensitivity of y (crime) in relation to weather variables, which can be better visualized on the further Adjusted Model Graphics

Table 18 Estimated parameter values

Parameters having the (*) marks are the ones having significance levels (<0,05). (S_x) and its values within (parenthesis) are standard error values.

Intercept B_0

Crime	Time Scale	Intercept		Accumulated rainfall (mm)		Mean Average temperature (°C)		Standard Error (Sx)	Equation	R²	Number months/ quarters	n
homicide	month	ß0	3.444697	ß1	0.0005032	ß2	0.022677	9.740	1	0.093	108	5,850
		p	<0,00001	p	0.00379	p	0.13024					
		Sx	0.321873	Sx	0.0001738	Sx	0.014987					
		-	-	VIF	0.04286967	VIF	0.044116					
homicide	quarter	ß0	5.002	ß1	0.0002499	-	-	19.500	2	0.184	36	
		p	<0,00001	p	0.00494	-	-					
		Sx	0.03996	Sx	0.00008889	-	-					
		-	-	VIF	0.02275713	-	-					
homicide attempt	month	ß0	4.433951	ß1	0.0004924	-	-	11.500	2	0.092	108	9,643
		p	<0,00001	p	0.000663	-	-					
		Sx	0.023756	Sx	0.0001446	-	-					

		-	-	VIF	0.02967529	-	-					
homicide attempt	quarter	ß0	5.511	ß1	0.0002246	-	-	21.5	2	0.184	36	
		p	<0,00001	p	0.00402	-	-					
		Sx	0.03499	Sx	0.00007808	-	-					
		-	-	VIF	0.0175596	-	-					
rape	month	ß0	4.02088	-	-	-	-	2.230	3	-	108	6,021
		p	<0,00001	-	-	-	-					
		Sx	0.02955	-	-	-	-					
		-	-	-	-	-	-					
rape	quarter	ß0	5.11949	-	-	-	-	3.61	3	-	36	
		p	<0,00001	-	-	-	-					
		Sx	0.04616	-	-	-	-					
		-	-	-	-	-	-					
rape attempt	month	ß0	1.87465	-	-	-	-	9.950	3	-	108	704
		p	<0,00001	-	-	-	-					
		Sx	0.04373	-	-	-	-					
		-	-	-	-	-	-					

rape attempt	quarter	ß0	2.97326	-	-	-	-	11.4	3	-	36	
		p	<0,00001	-	-	-	-					
		Sx	0.05153	-	-	-	-					
		-	-	-	-	-	-					

Significance level * (<0,05)

Equation 1: $Ln(Y) = \beta_0 + \beta_1 r + \beta_2 t + \varepsilon$

Equation 2: $Ln(Y) = \beta_0 + \beta_1 r + \varepsilon$

Equation 3: $Ln(Y) = \beta_0 + \varepsilon$

* *r* = accumulated rainfall

t = mean average temperature

Averages Measured:

		Accumulated rainfall (mm)	Mean average temperature (°C)
Month	Min	0	17.6
	Avg	114.4	21.5
	Max	452.8	25.5
Quarter	Min	3.2	19.4
	Avg	343.2	21.5
	Max	1010.2	23.8

Adjusted Models (figures)

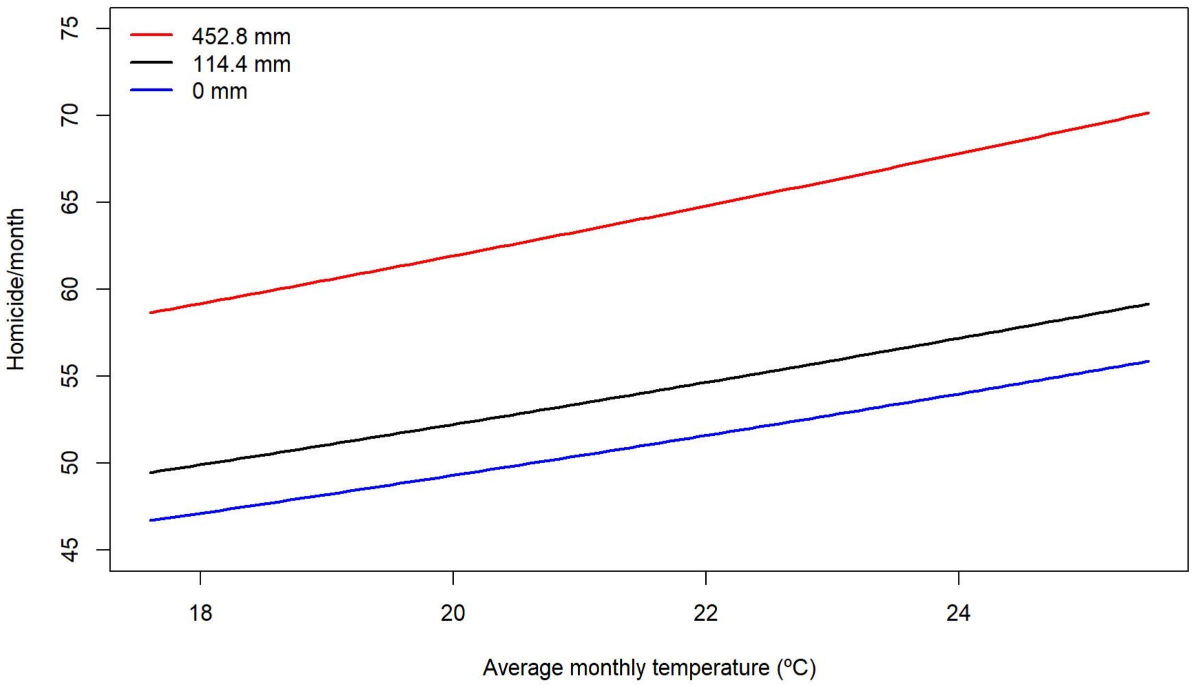


Figure 18 Homicide's frequency, monthly aggregation and mean average temperature

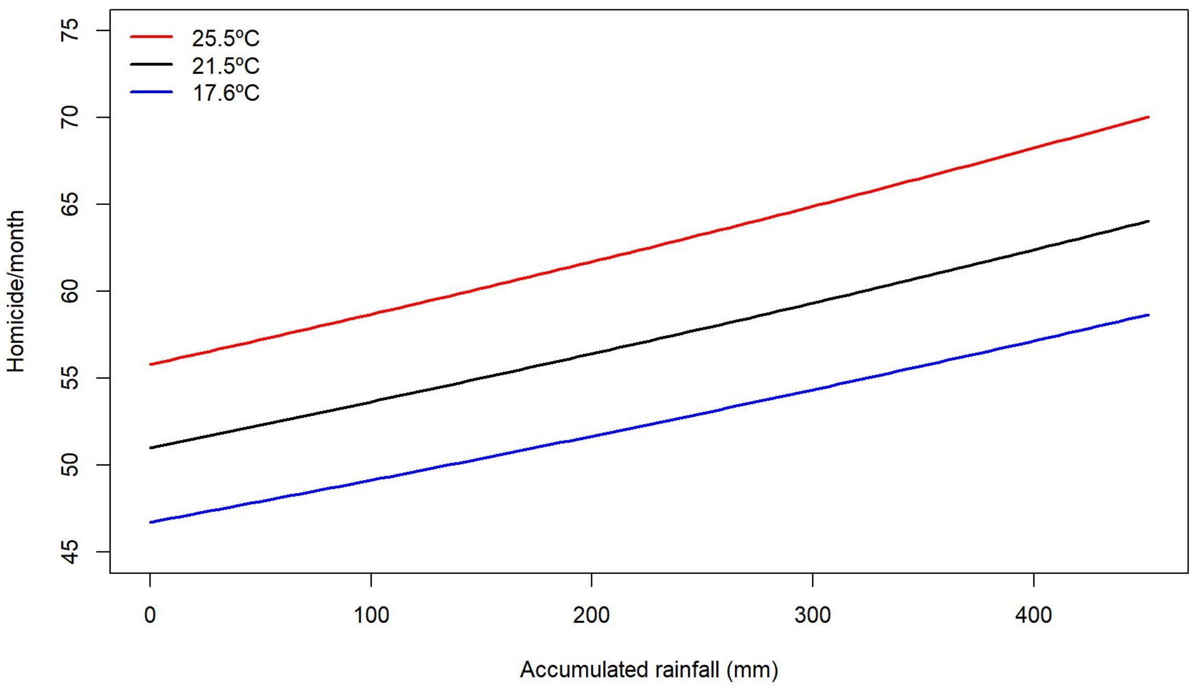


Figure 19 Homicide's frequency, monthly aggregation and accumulated rainfall

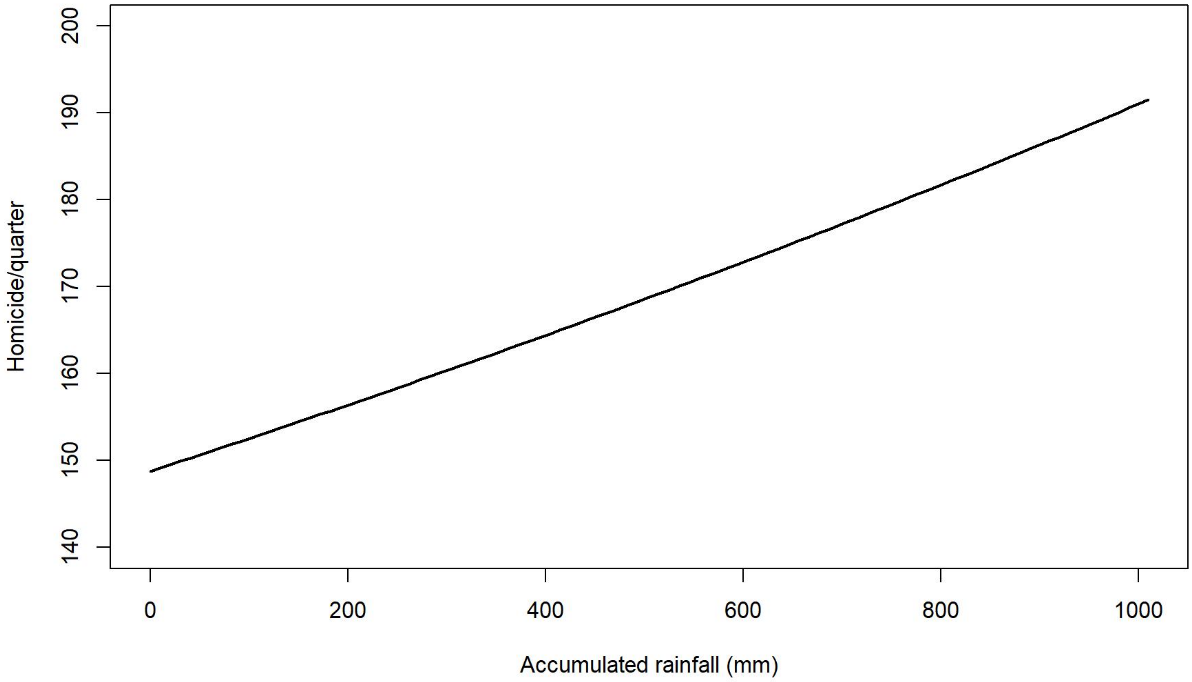


Figure 20 Homicide attempt frequency, monthly aggregation and accumulated rainfall

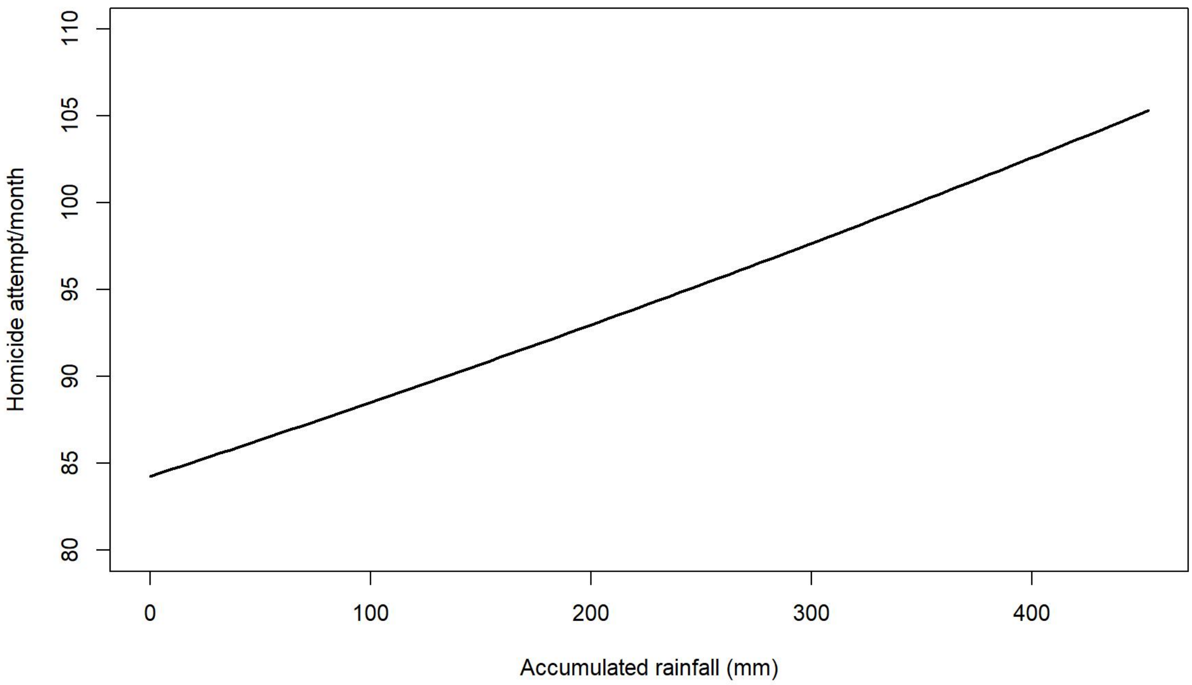


Figure 21 Homicide's frequency, quarter aggregation and accumulated rainfall

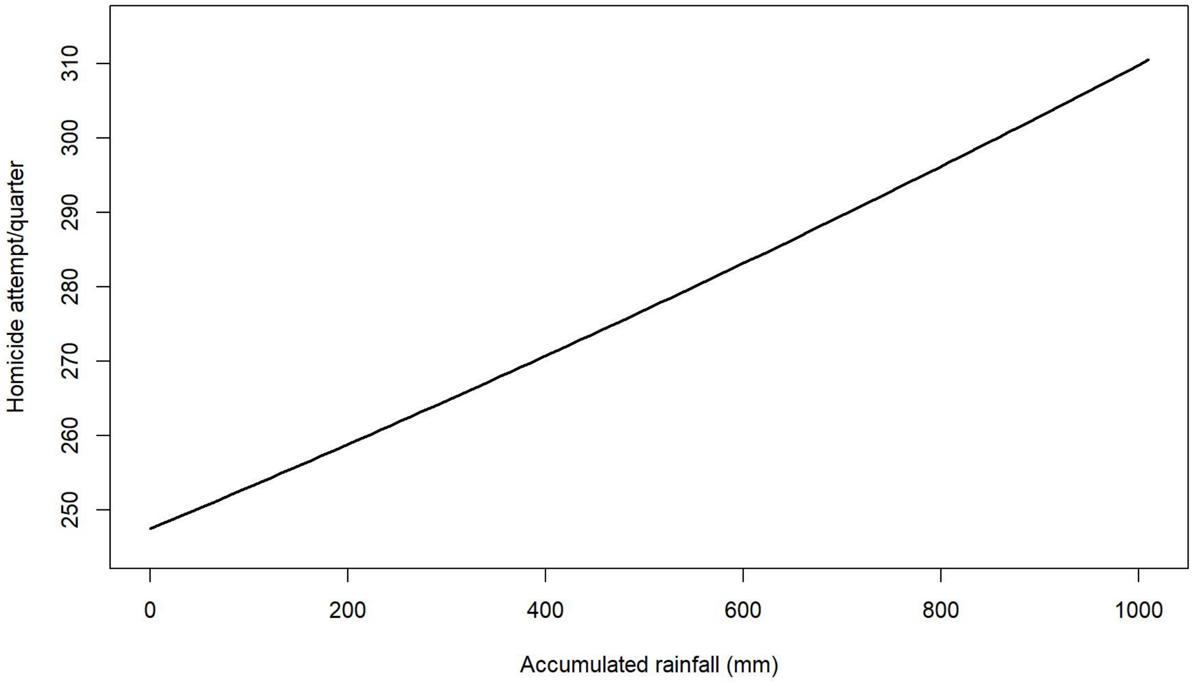


Figure 22 Homicide attempt frequency, quarter aggregation and accumulated rainfall

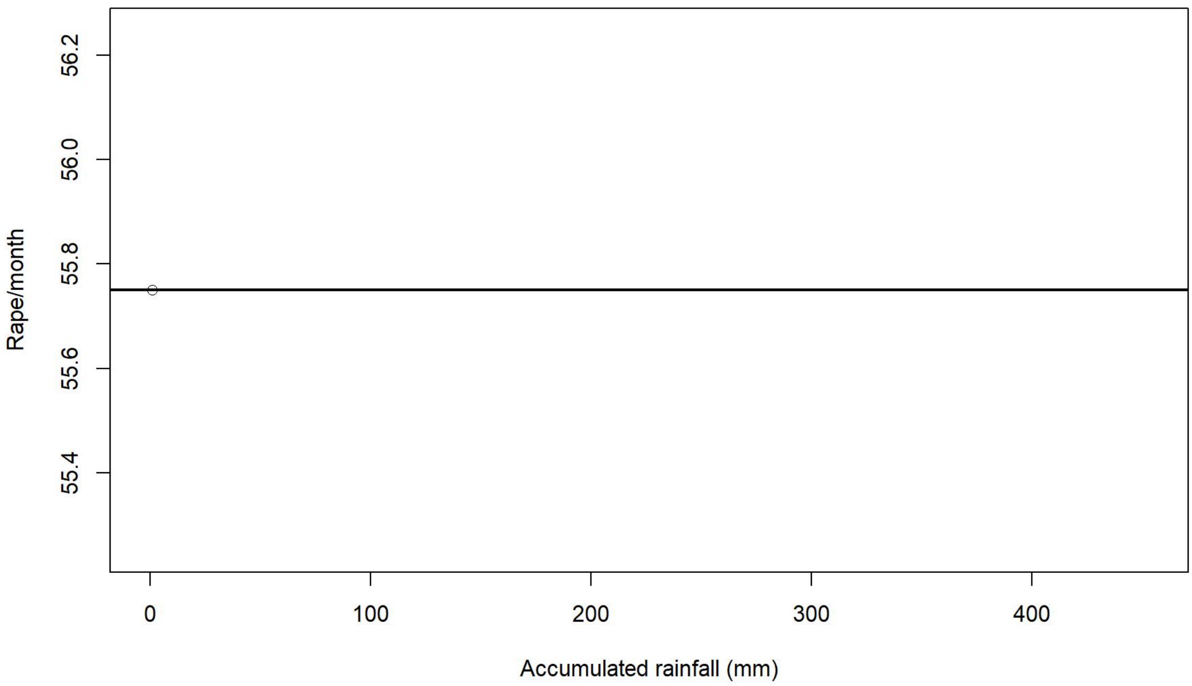


Figure 23 Rape's frequency, monthly aggregation and accumulated rainfall

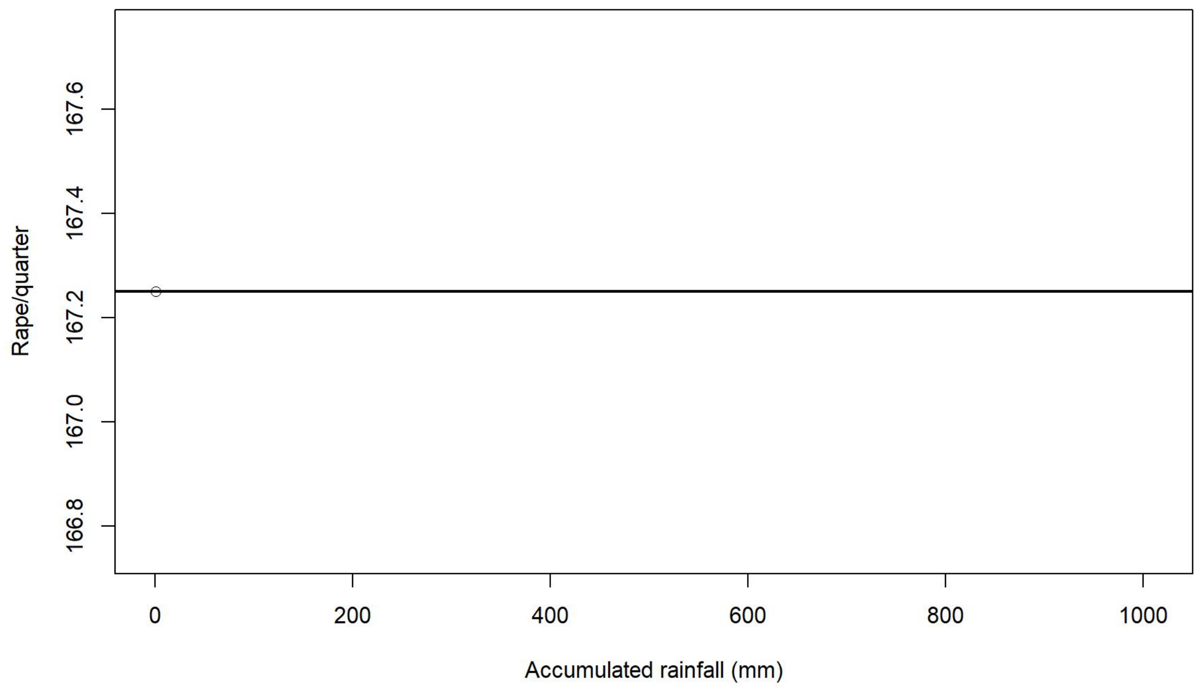


Figure 24 Rape frequency, quarter aggregation and accumulated rainfall

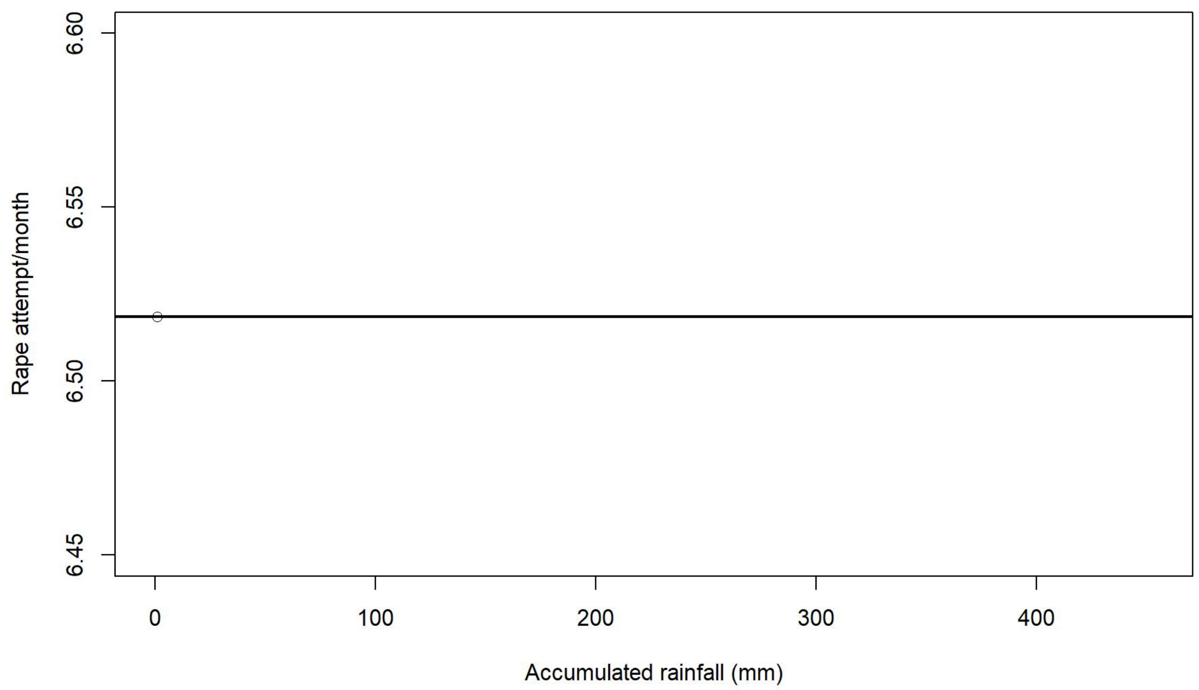


Figure 25 Rape attempt frequency, monthly aggregation and accumulated rainfall

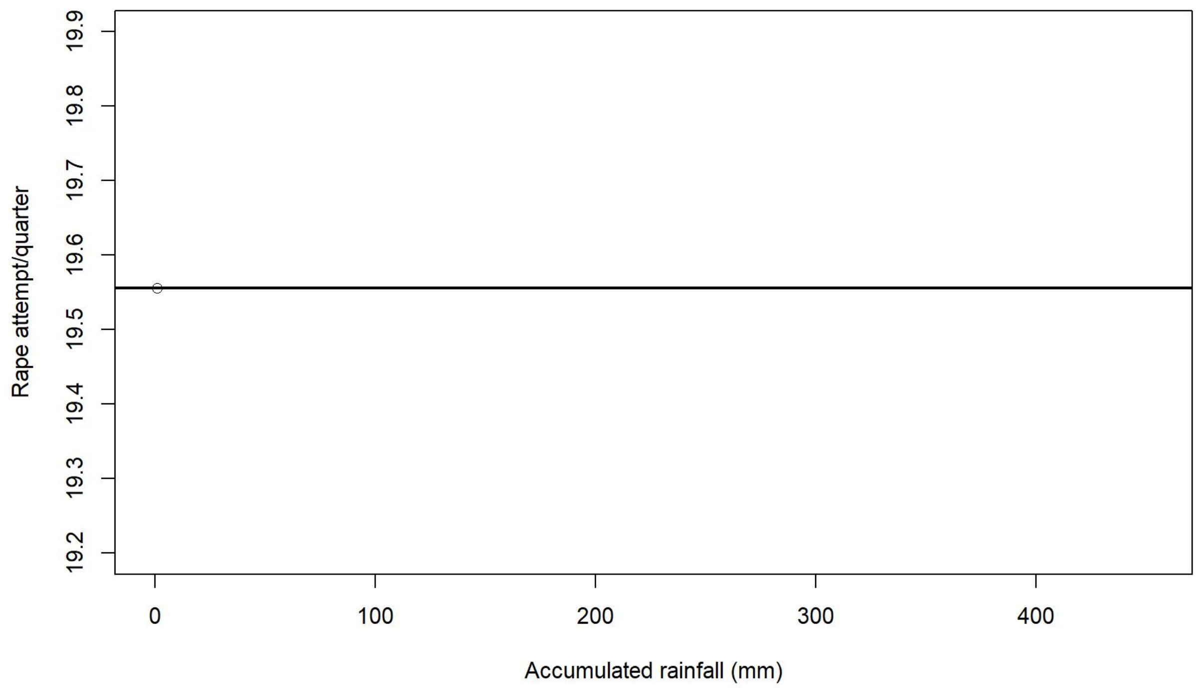
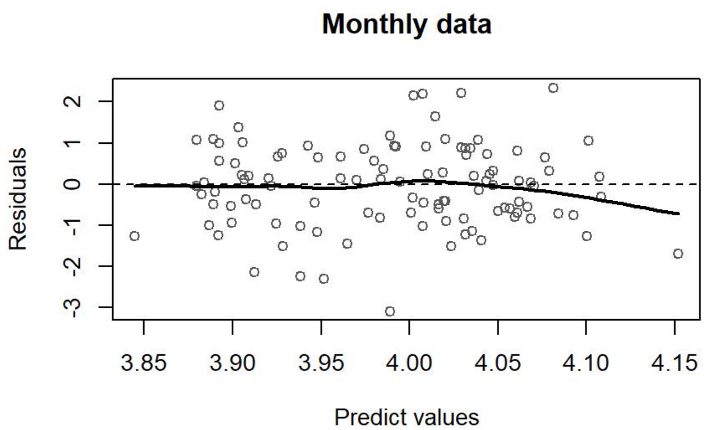
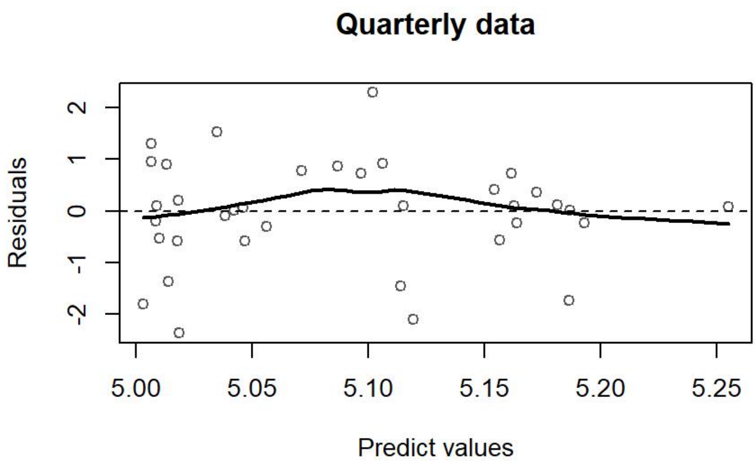


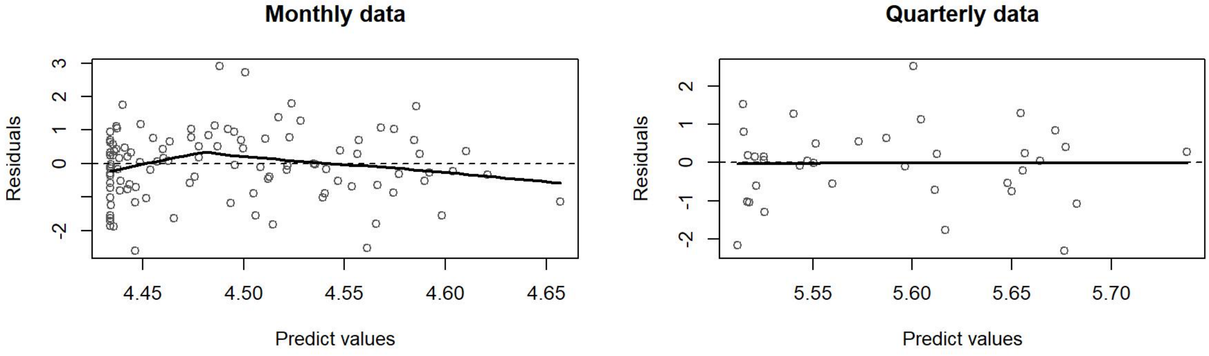
Figure 26 Rape attempt frequency, quarter aggregation and accumulated rainfall

Residuals, Homicide





Residuals, Homicide Attempt



SPATIAL RESULTS

Results derived out of the spatial analyses have two main outputs: correlation maps and graphs. With regards to the following series of graphs, it does plot secondary data to illustrate how each RA performs in terms of amount of crimes, number of correlation pixels of high LST and Kernel density of violent crime, green availability, income and population. The combination of these graphics gives the tune of the discussion about the territory of each RAs and their places hosting LST and numbers of crime.

Figure 27, for instance, brings a sum of cases registered at each RA comprising the 9 years of our crime dataset.

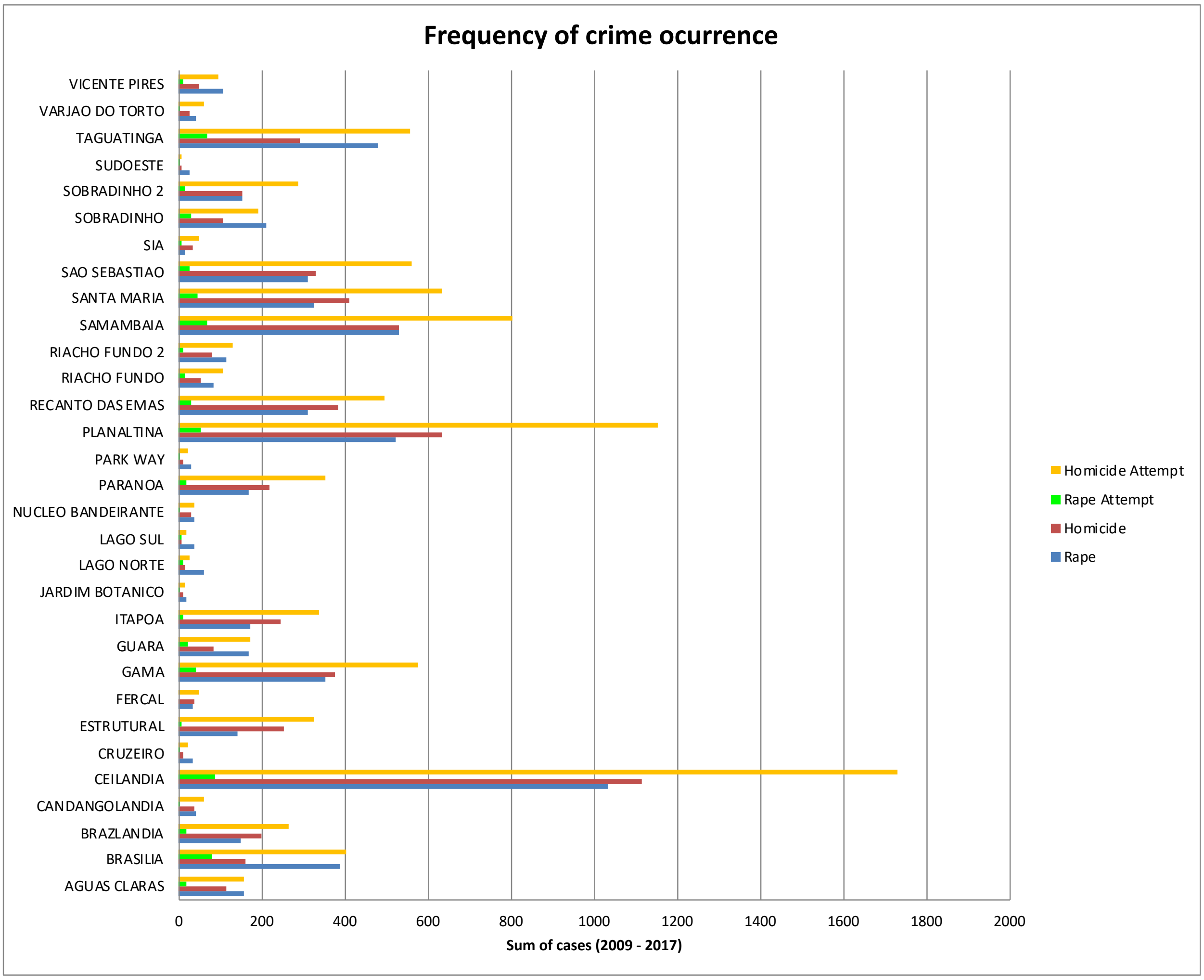


Figure 27 Sum of violent crimes by Administrative Region (2009 – 2017) Source: CODEPLAN (2017)

When applying the correlation script, the picture of violent crimes changes as shown on graph 10. Each pixel of our correlation maps has the definition of 30x30m or 900m^2 - overlapped in two matrix-layers. One matrix having the four dependent variables grouped together and the other matrix the average of high LST over the same latitude and longitude of our crime hotspots (determined by Kernel Density). Therefore, the size of the RA and the number of places within its boundaries are displayed on the next graph. In other words, Graph 10 shows the extent of the territory covered by pixels ($900m^2$) of medium-strong (0,50 to 0,75) and strong (0,75-1,00) correlations of LST and violent crime. These extents by each R.A are presented in percentage on figure 28 and on the maps displayed further:

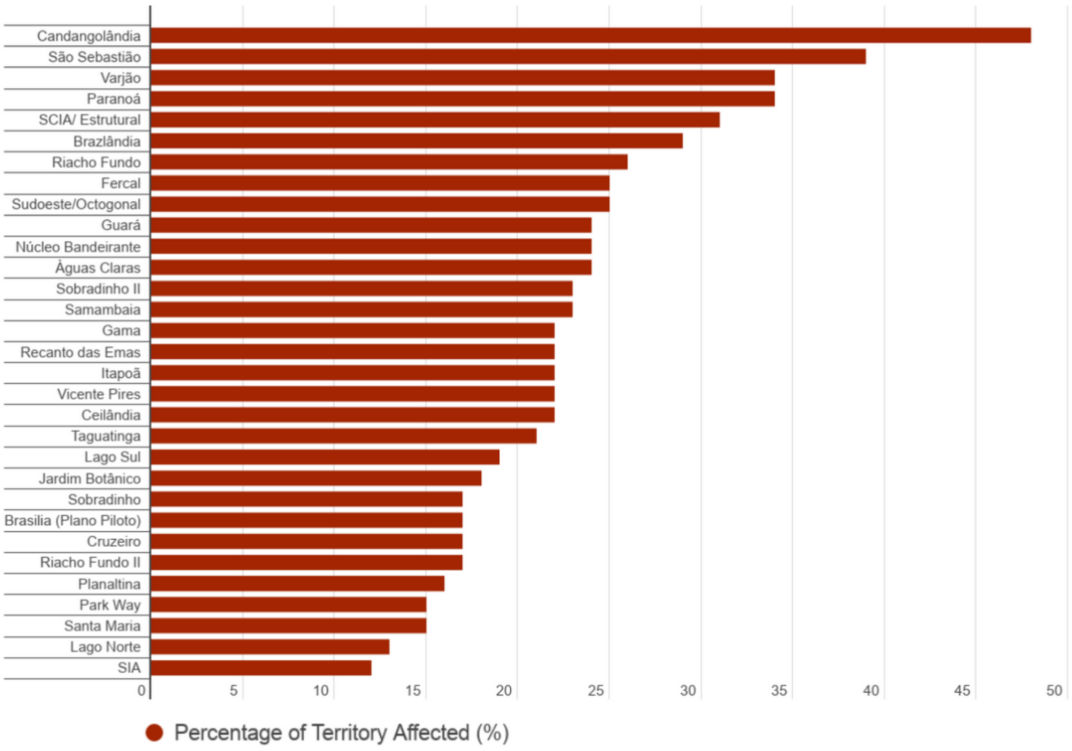


Figure 28 The extent of territory colored by correlations of high LST and violent crime
Source: CODEPLAN (2017)

Figure 29 brings the total number of people living in each RA in 2015 in green bars. Those purple bars were calculated having the sum of correlation pixels ($900m^2$) obtained to each RA, which was converted to square kilometers (Km^2) and divided by the demographic density also converted to (km^2) for each RA. By contrasting these two bars we have an estimate of how many people or parcels of populations are exposed to places having high LST and hosting violent crime at each RA.

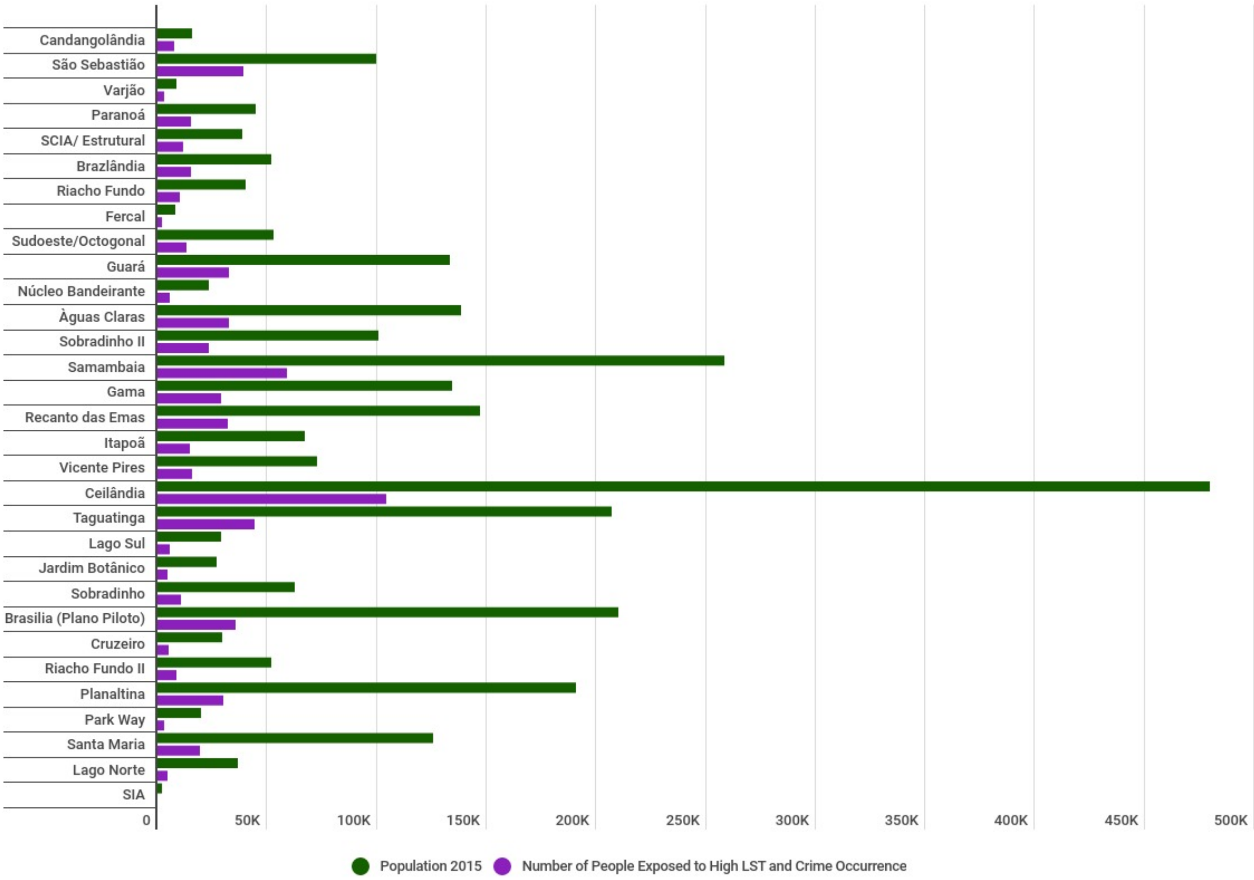


Figure 29 Total population by R.A and number of people exposed to high/ medium-high correlations - Source: Adapted from Codeplan (2017)

The study published by (RODRIGUES, GONÇALVES & TEZA, 2016) informed the green bars of figure 30, which displays the green availability at each RA. These results were calculated through remote sense using NDVI and GIS. We adapted from Rodrigues et al., (2016) the total amount of green in Km^2 measured by RA to the following graph.

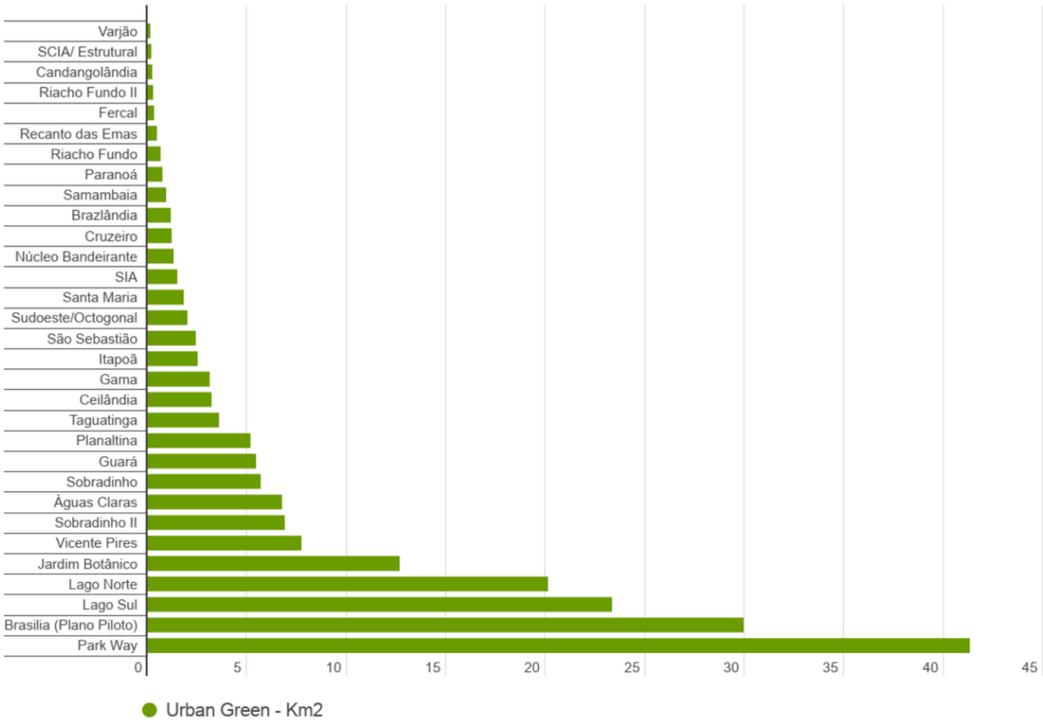


Figure 30 Total amount of green by R.A in Km2 - Adapted from (RODRIGUES, GONÇALVES & TEZA, 2016).

Figure 31 brings data adapted from Codeplan (2017) and informs per capita income in the year of 2015. Looking at both graphs (green – graph 12 and income - graph 13) we perceive that wealthier RAs are the ones hosting greener in Km^2.

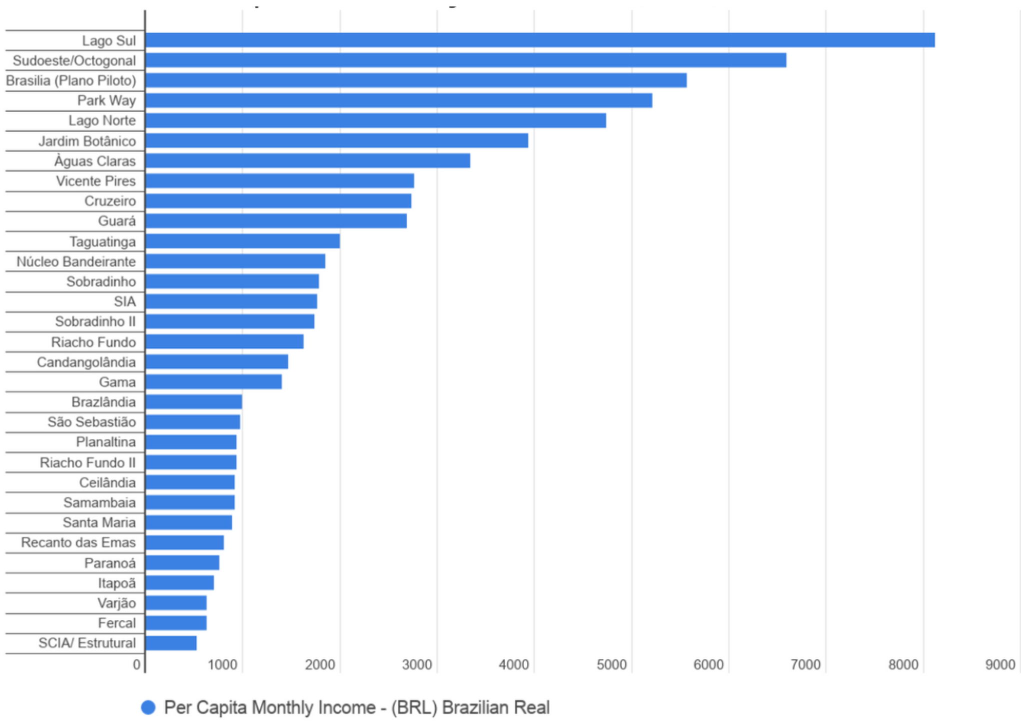


Figure 31 Monthly per capita income in BRL by RA (Adapted from Codeplan 2017)

Next figure 32 solely displays the population number in 2015 at each RA as well:

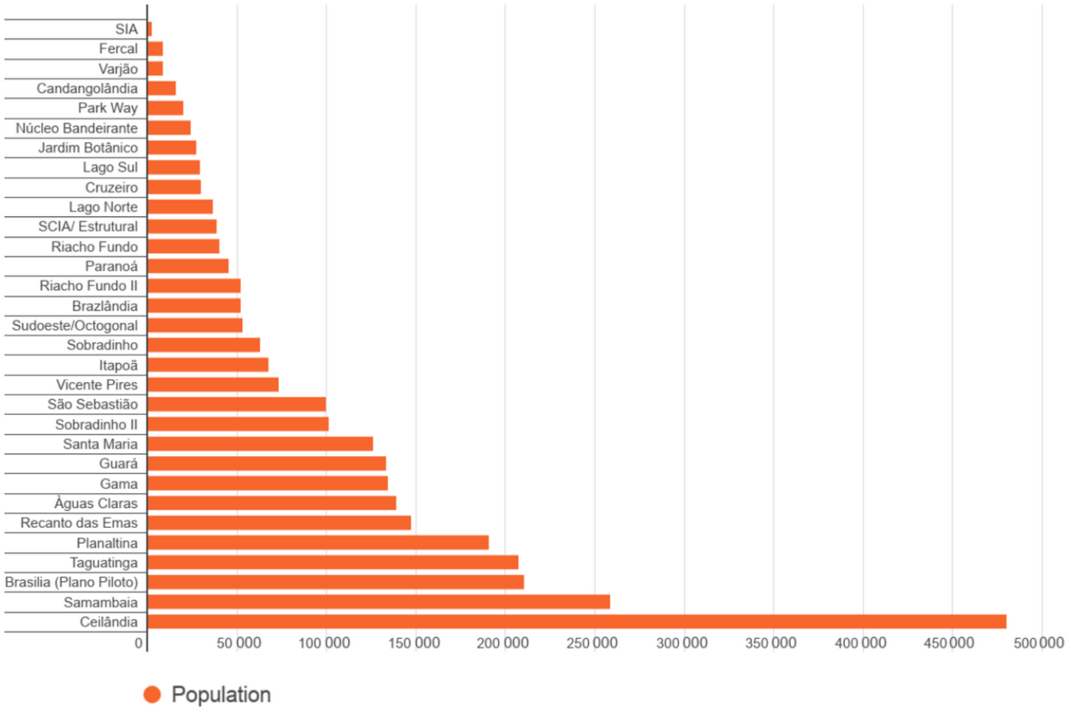


Figure 32 Population of each R.A in 2015 (Adapted from Codeplan 2017)

Geostatistical correlation maps and HD imagery

Moving further with the spatial analyses, 31 maps were produced in order to present the geo-statistically significant results (*p* value ≤ 0.05) between LST and crime geocodes for each Administrative Region (RA). These maps are classified into 2 scales and 2 gradient colors: **medium-high (0.50 up to 0.75) in green**, and **high correlation values (0.75 to 1.00) in red color**. Under the maps we display ranking bars extracted from the just above-presented graphs (graphs 9 to 14). We added these ranking bars for comparison purposes and to better visualize features of each RA concerning the percentage of territory covered by correlation pixels, urban green availability in Km^2, the per capita monthly income in Brazilian Real (BRL), and finally the total population of each RA. In addition, icons under each map bring descriptive information regarding downtown distance (*Plano Piloto*), foundation date, and the number of people affected/exposed to the places hosting correlations of high LST and violent crime.

Further still, for each RA, 3 high-definition zoomed-in samples should facilitate the identification of places hosting violence and high LST that are behind the red and green spots of correlations. Below maps are displayed at the same time ranking bars related to the top 2 RAs having more correlation pixels. The map of RA1 Brasília *(Plano Piloto)* is presented in this section as well. Readers are referred to the Appendix section for the whole map collection and HD imagery samples covering all RAs of Distrito Federal.

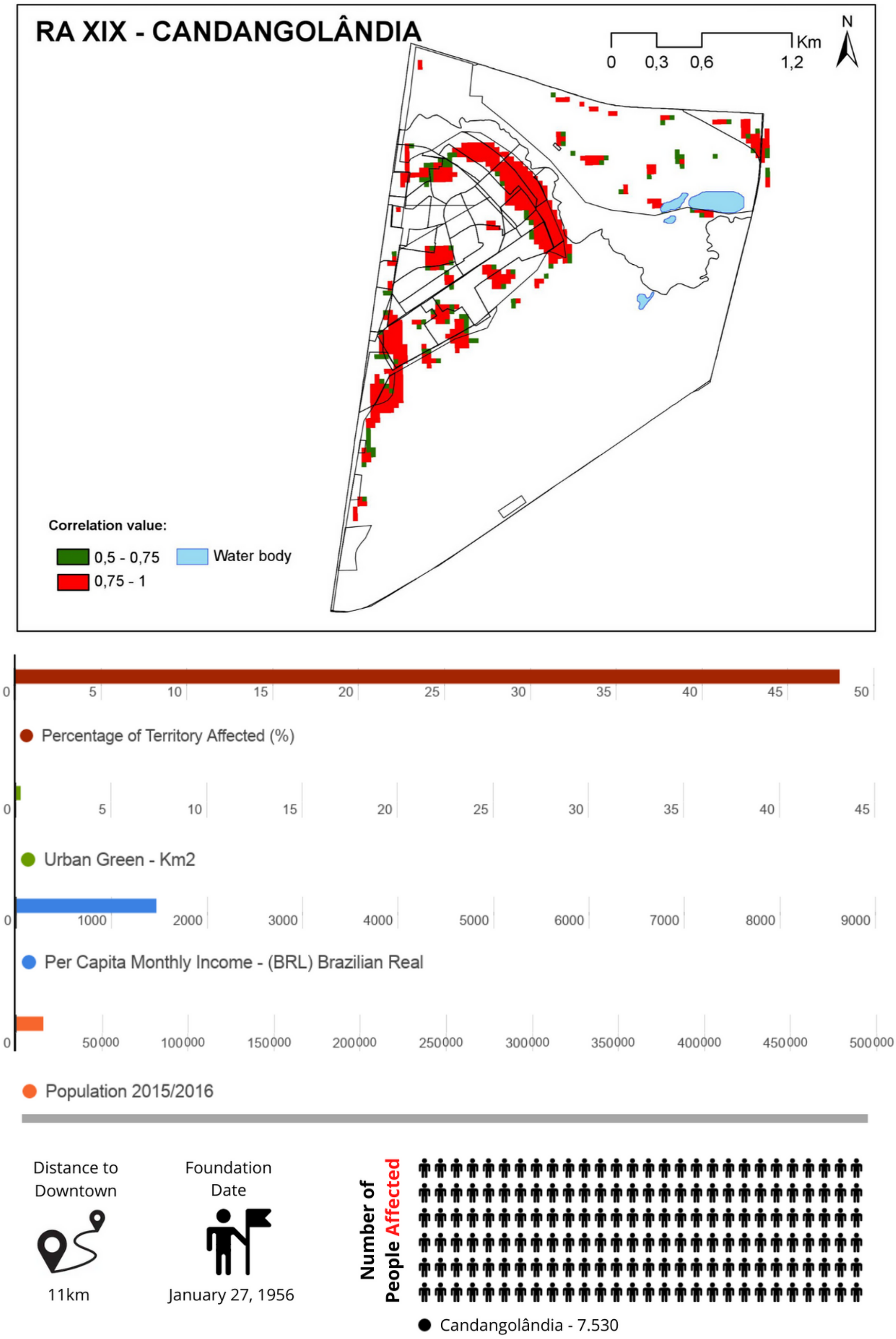


Figure 33 Candangolândia - Administrative Region concentrating major number of correlation hotspots

Candangolândia is a small neighborhood, having about 16.000 inhabitants composed of low income workers (please refer to Table 19 on page 106). The amount of pixels' correlation comprehends the dimension of 50% of its total land and similarly its demography, and thus it has been classified as having the largest amount of correlation pixels within its territory boundaries. A major correlations hotspot was found at its natural boundary, in the outskirts of the city. Other hotspots were found among its grey urban tissue (no trees).

As aforementioned, in this section besides the map for each RA there will also be 2 HD samples of each Administrative Region. By looking at these HD image samples, it becomes evident the different kinds of urban tissues that are hosting correlations of crime and temperature (red and green dots).

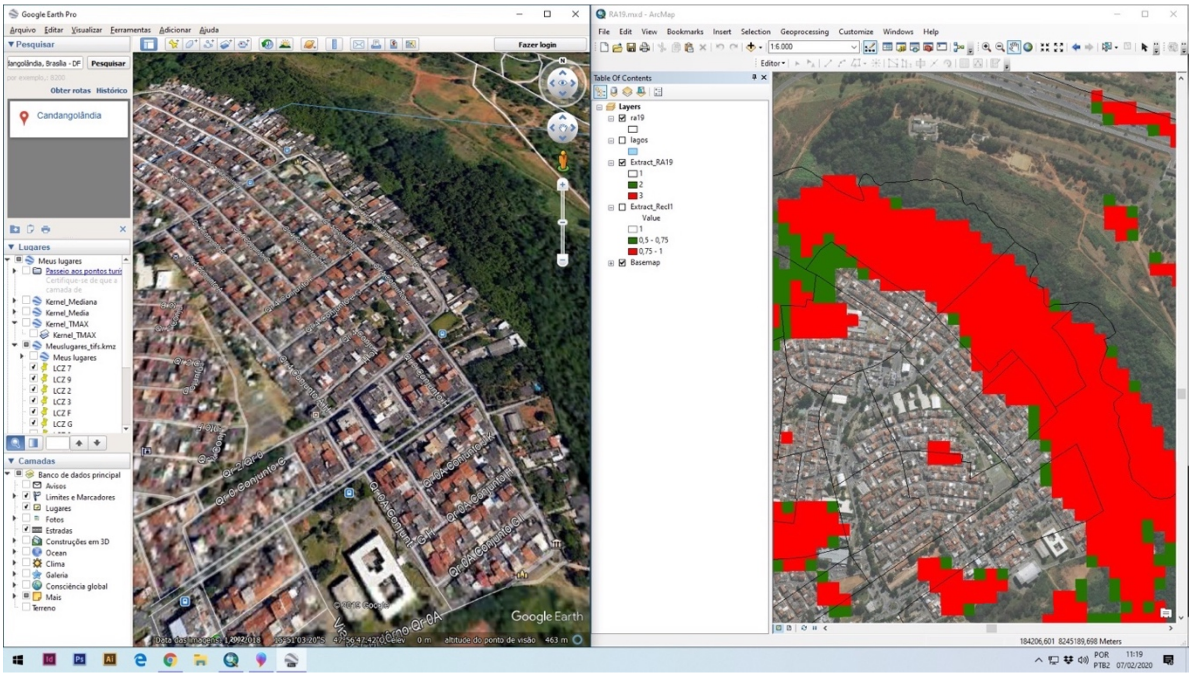


Figure 34 RA XIX Candangolândia – HD Sample

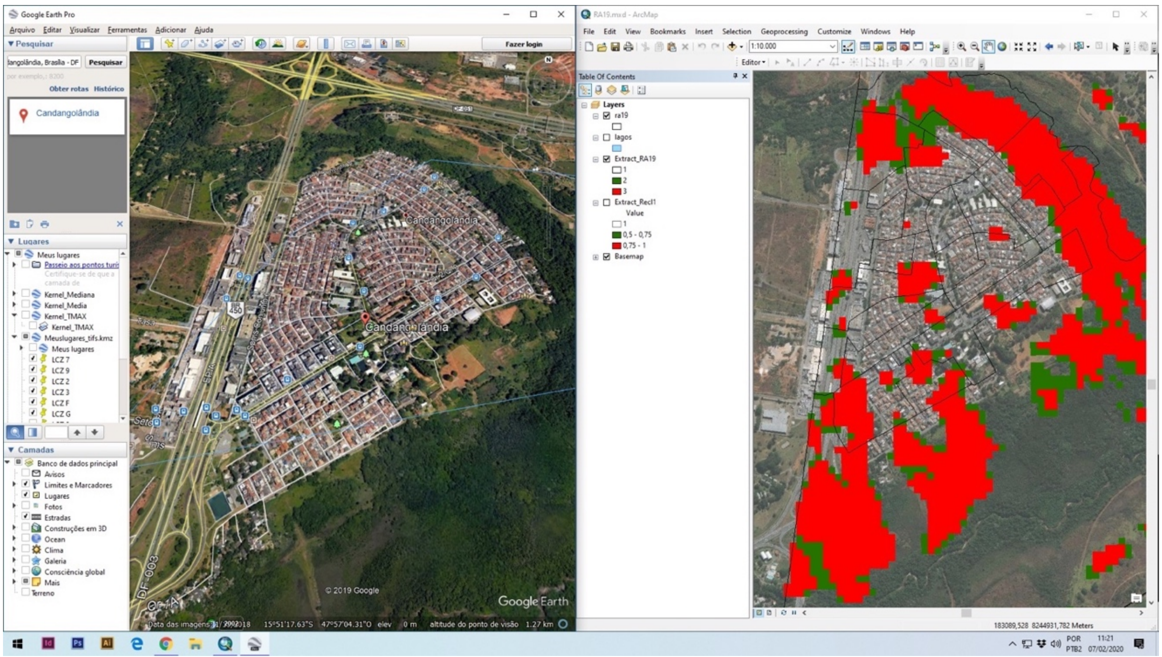


Figure 35 RA XIX Candangolândia – HD Sample

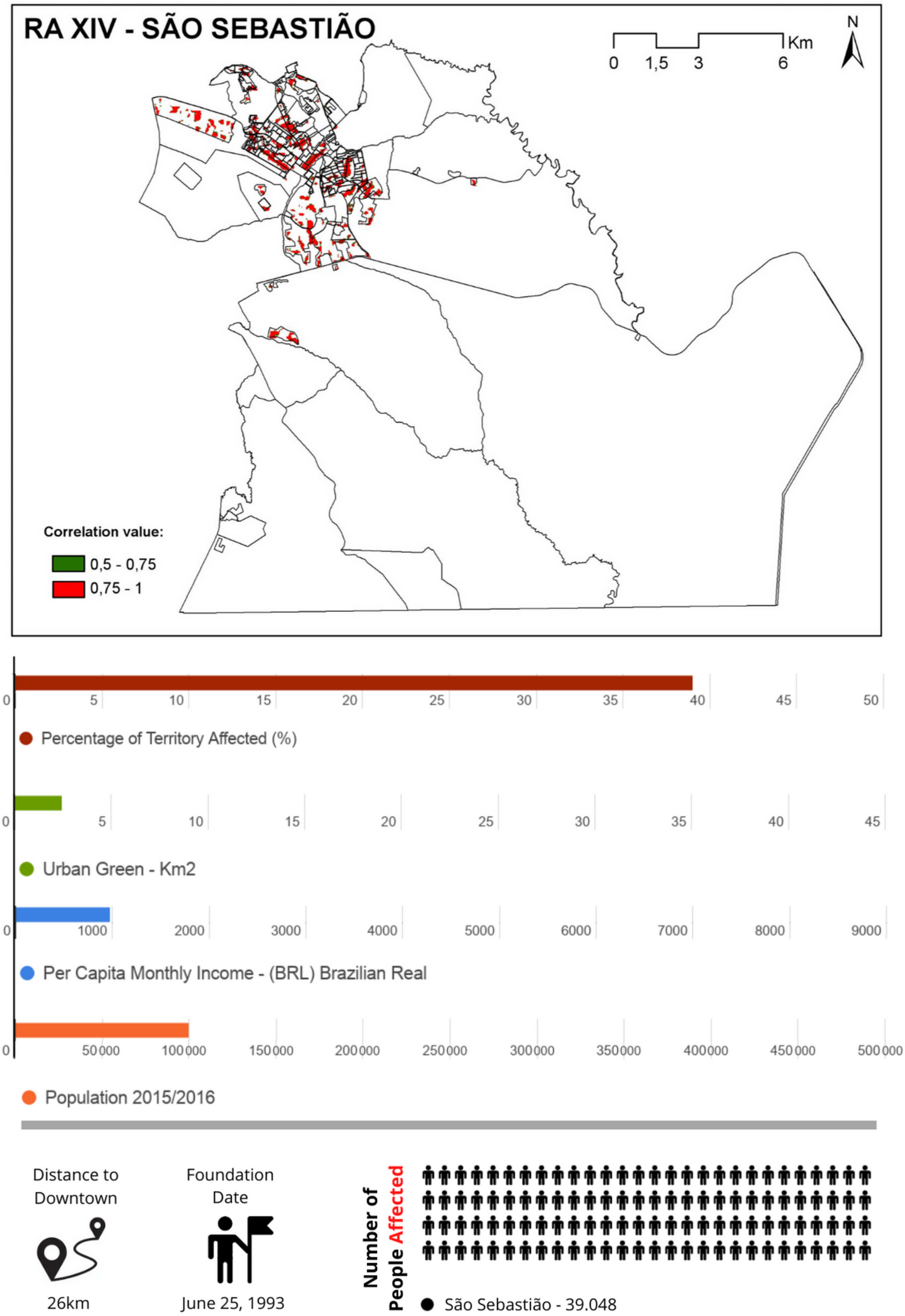


Figure 36 São Sebastião

São Sebastião has the second largest correlation pixel concentration within its boundaries. There are about one hundred thousand people living there, and it has almost

40% of its territory concentrating correlation hotspots which give us an estimate of 39.000 people being exposed to places hosting high LST and crime. Those correlations hotspots were found over urban tissues of massive concrete and absence of green such as presented on Figure 35.

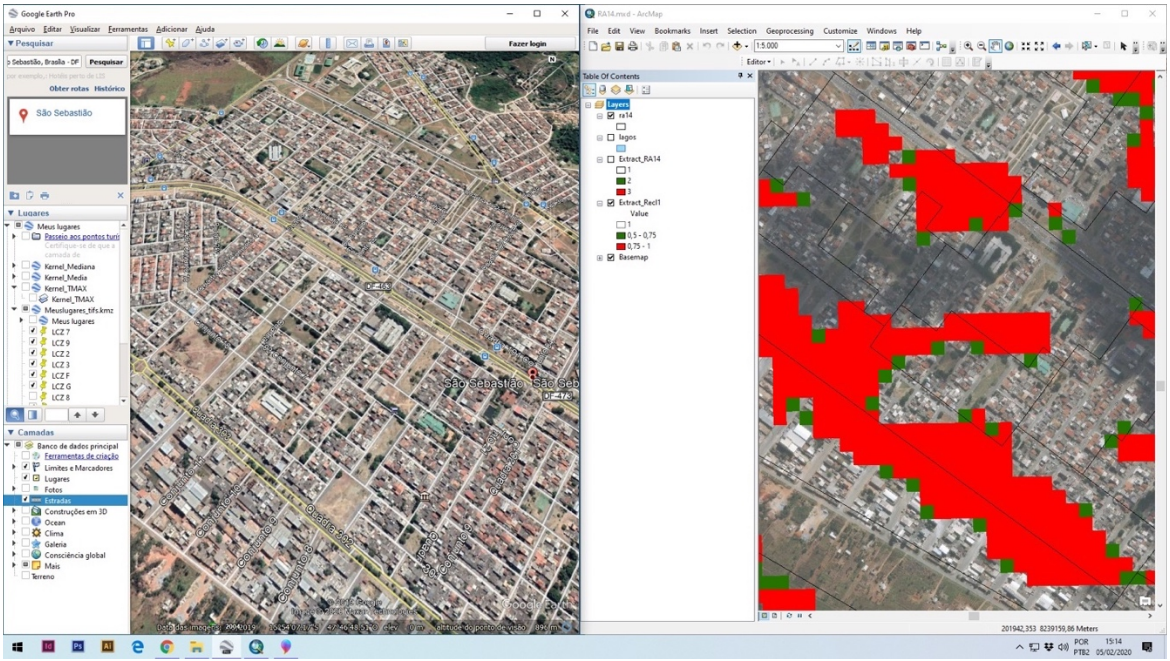


Figure 37 RA XIV São Sebastião – HD Sample

Sample 2 for São Sebastião indicates correlation pixels lying over a transition zone, in between a dense built environment consisting of a massive concrete environment and the edge of a “green island”. It is interesting to note that only one side of this green island concentrates a major correlations hotspot.

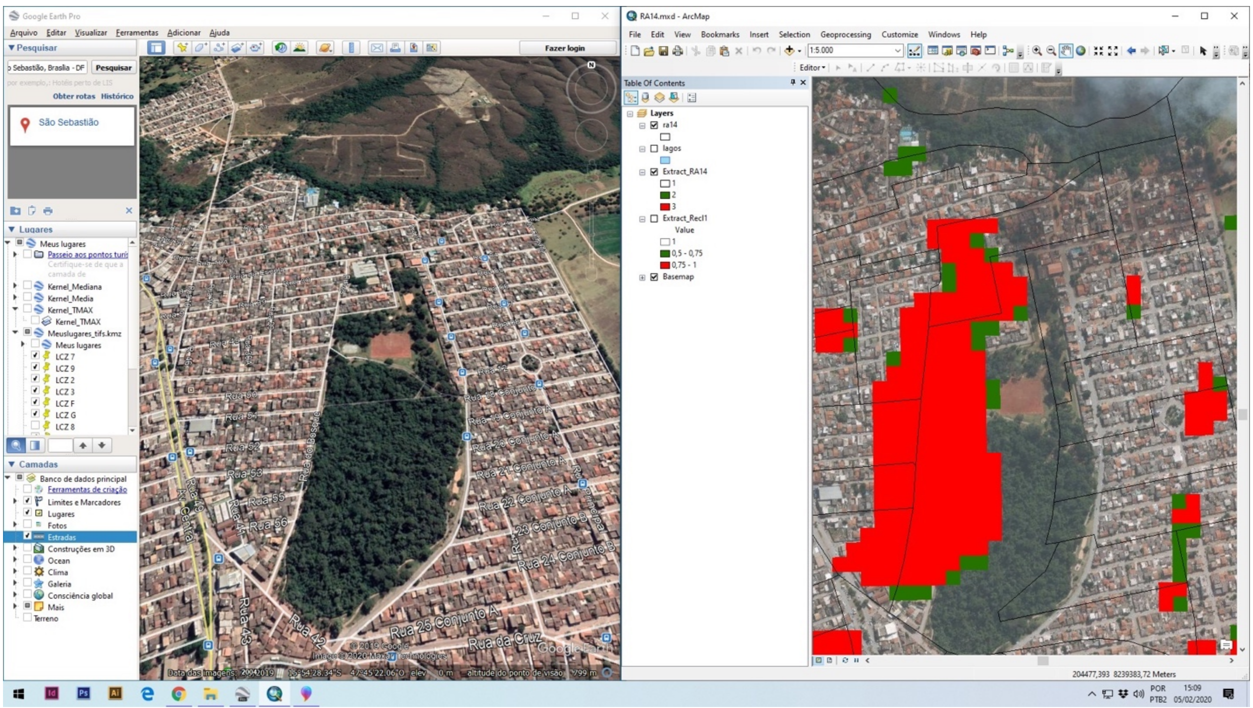


Figure 38 RA XIV São Sebastião – HD Sample

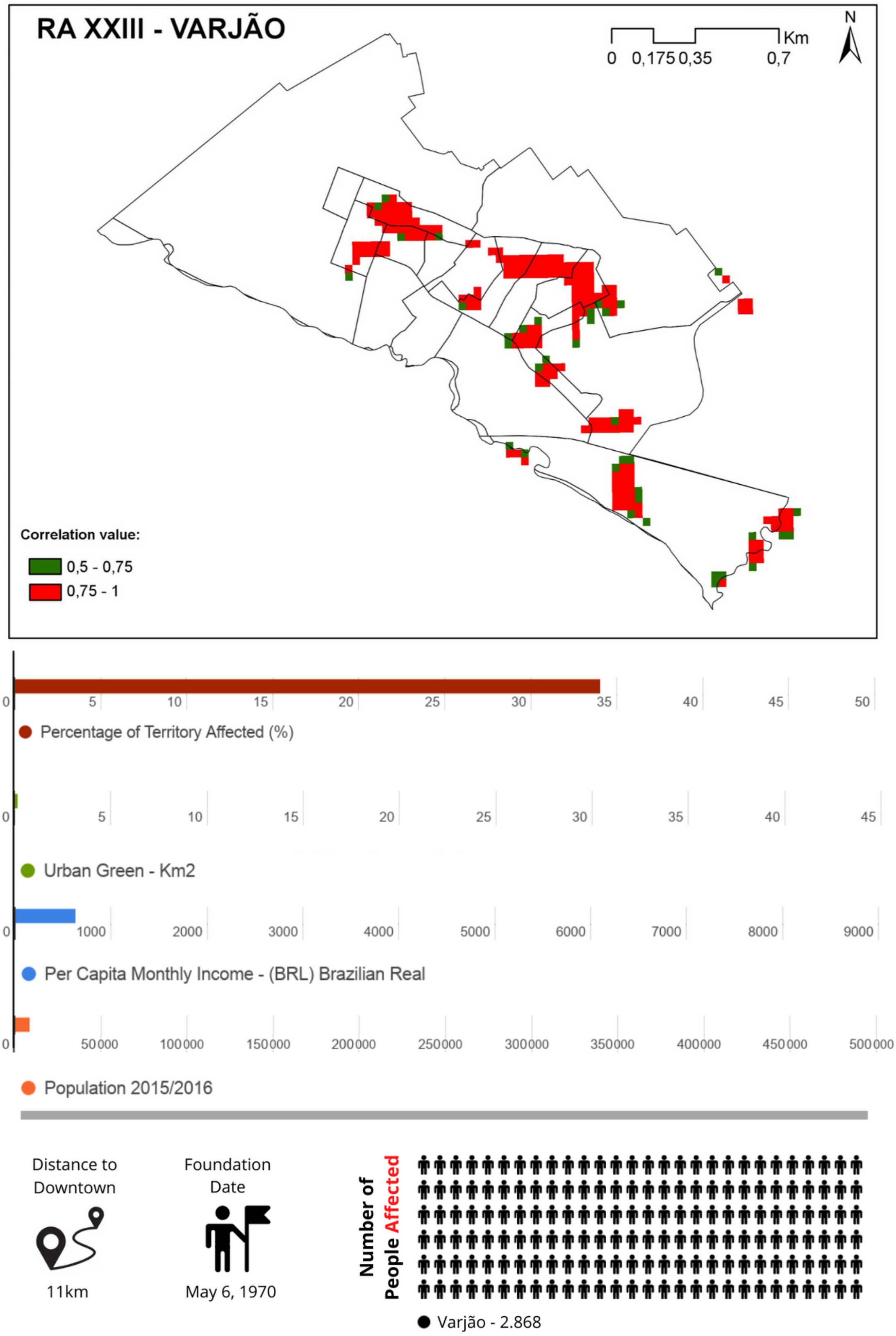


Figure 39 Varjão

Once an informal community in its early days, Varjão currently holds a status of RA. This neighborhood is composed mainly by low-income families living in an urban tissue with less quality of urban planning. With almost zero green availability to its small population, it has had a number of correlation pixels equivalent to almost 35% of its territory. Similarly, to previous samples, Varjão also found its correlations lying over its outskirt's boundaries, on the edge of built and natural environments.

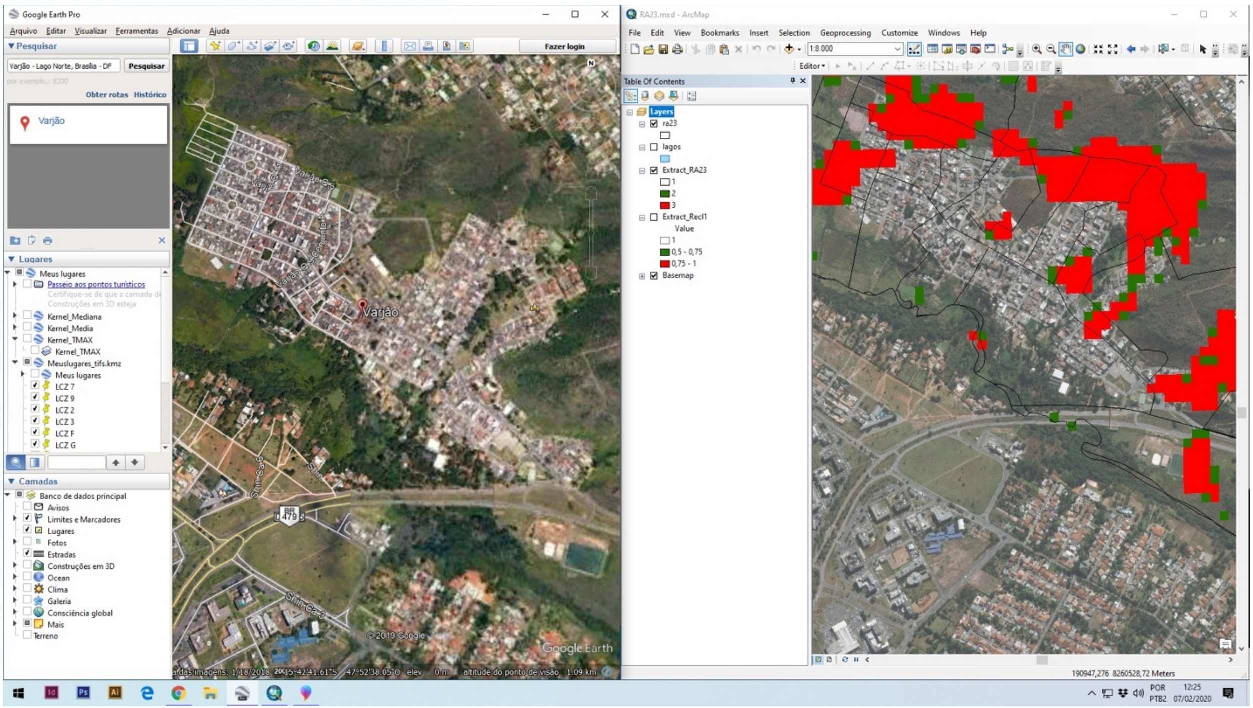


Figure 40 RA XXIII Varjão – HD Sample

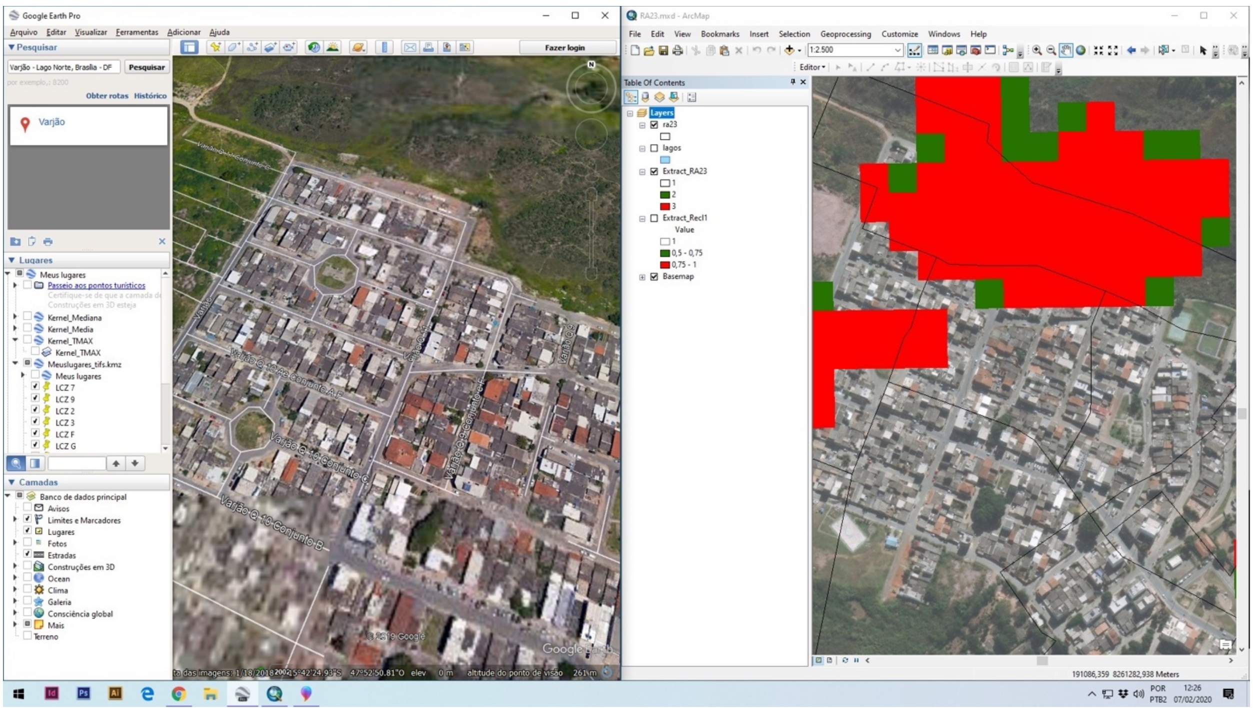


Figure 41 RA XXIII Varjão – HD Sample

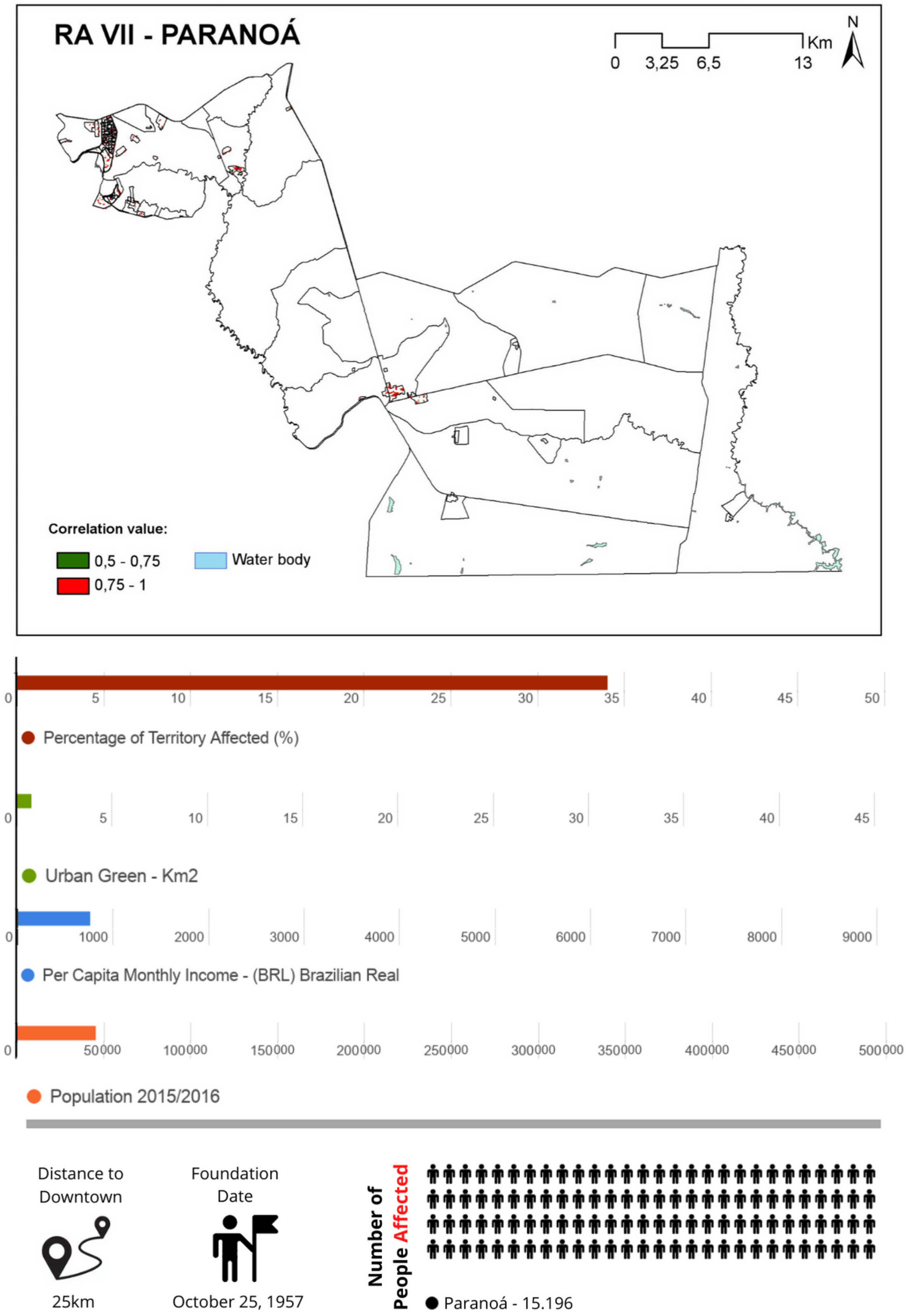


Figure 42 Paranoá

Paranoá is one of the oldest Administrative Regions of Distrito Federal. Mostly rural, its urbanized area figures as a low-income neighborhood which hosts about 50,000 people. We estimate that around 15,000 are exposed to places having correlations in Paranoá. Also, almost no green is available in its urban territory that was found to have an extension of correlation pixels of approximately 35% of its cityscape. Correlation hotspots were found not only along an area that constitutes a discontinuity between a forestry reserve and the built environment crossed by a road, but also in places having high built density, massive concrete and no trees.

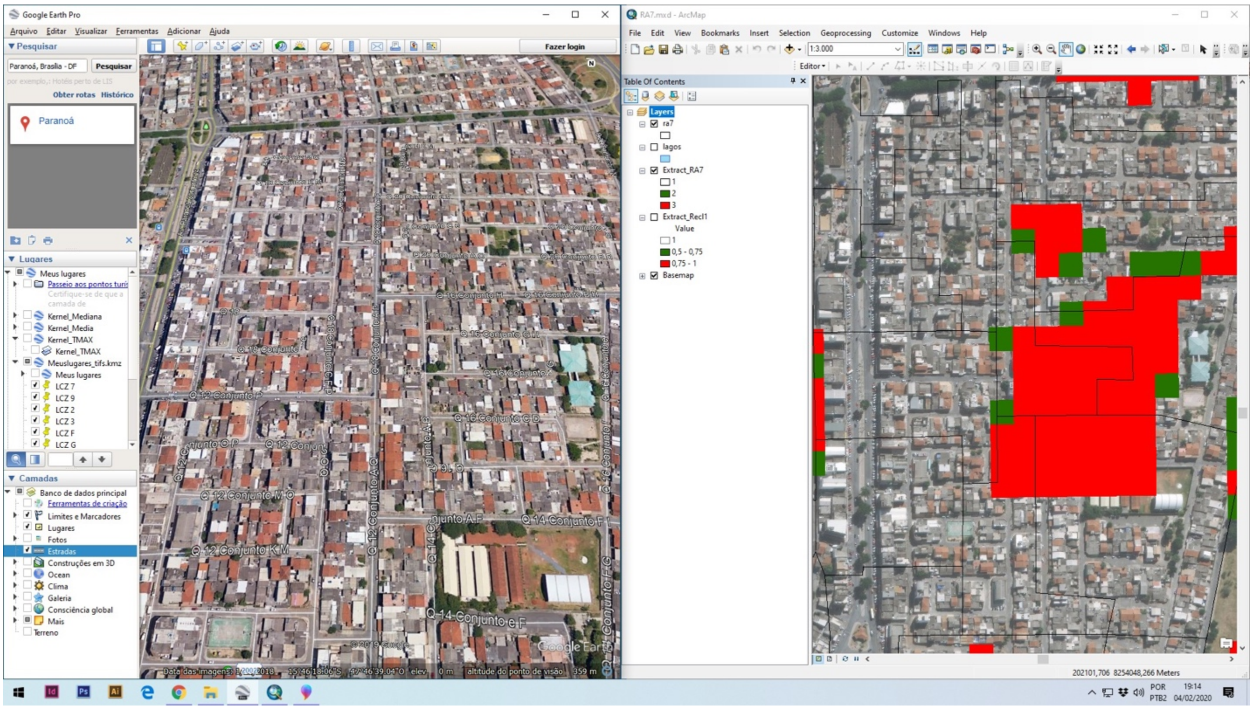


Figure 43 RA VII Paranoá – HD Sample

Sample 3 also shows correlation hotspots lying over exposed soil, and roads that pictures discontinuities in terms of urban tissue. A new popular vertical condominium having no greenery or gardening makes evident the way it was found high land surface temperature in its surroundings.

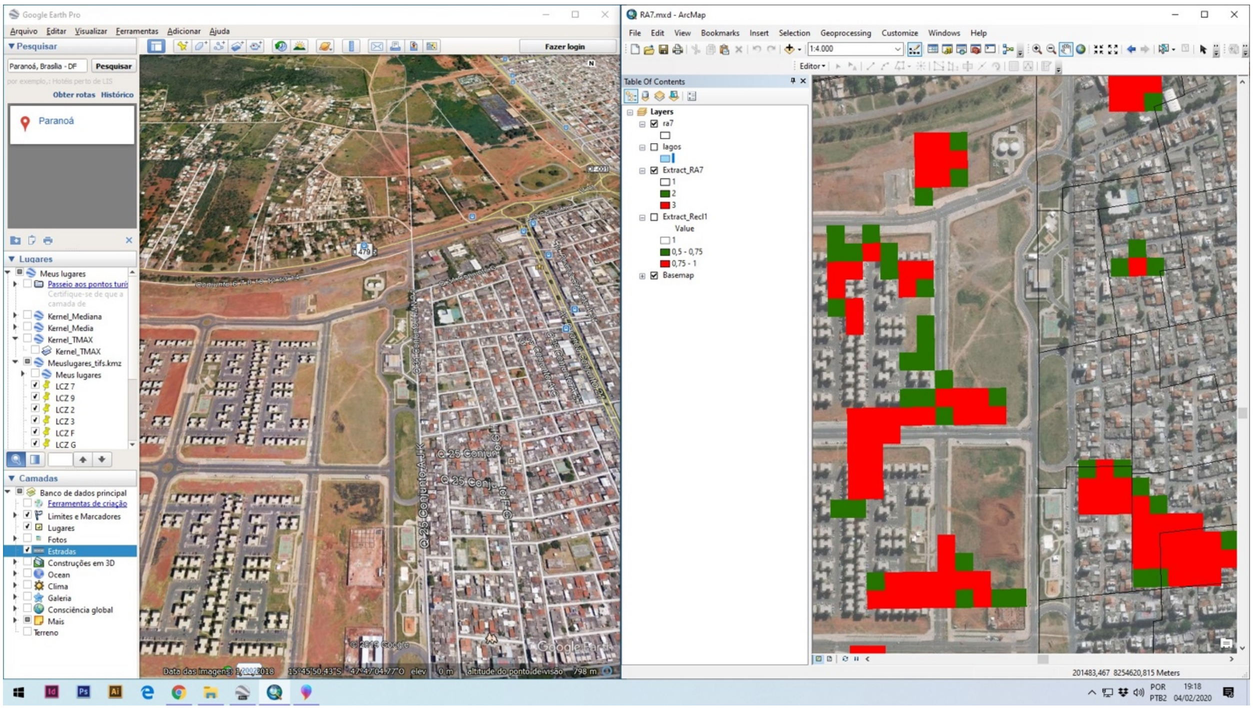


Figure 44 RA VII Paranoá – HD Sample

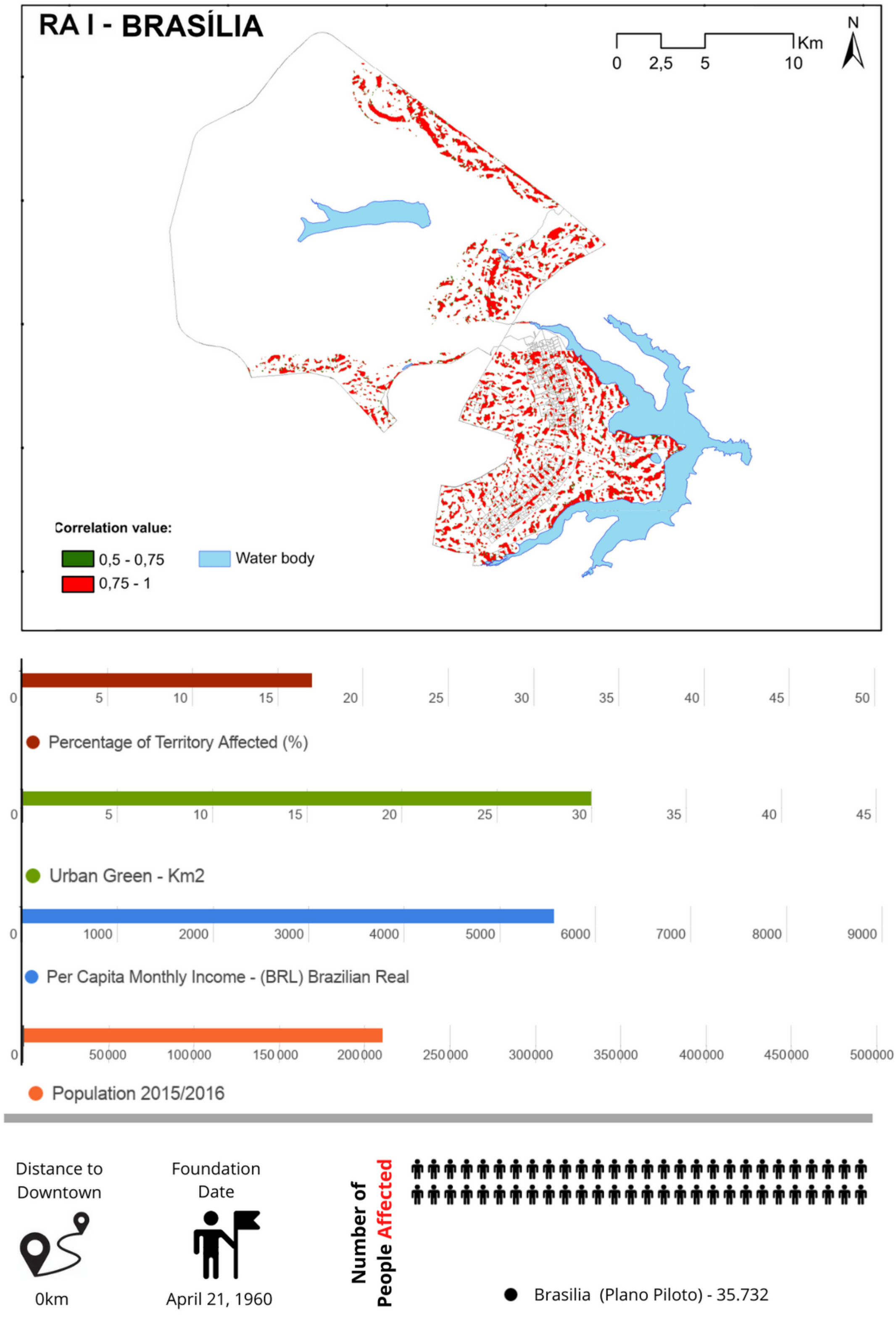


Figure 45 Brasília

The City of Brasília is the main RA of Distrito Federal. The historical project centrality is one of the richest and greenest neighborhoods hosting more than 200,000 inhabitants. Differently from other RAs that had larger hotspots of correlation concentrated, in Brasília pixels were found very spread, among the whole territory. Yet, it was possible to notice some patterns of hotspots falling over commercial areas (massive concrete and asphalt with no trees on the high street stores).

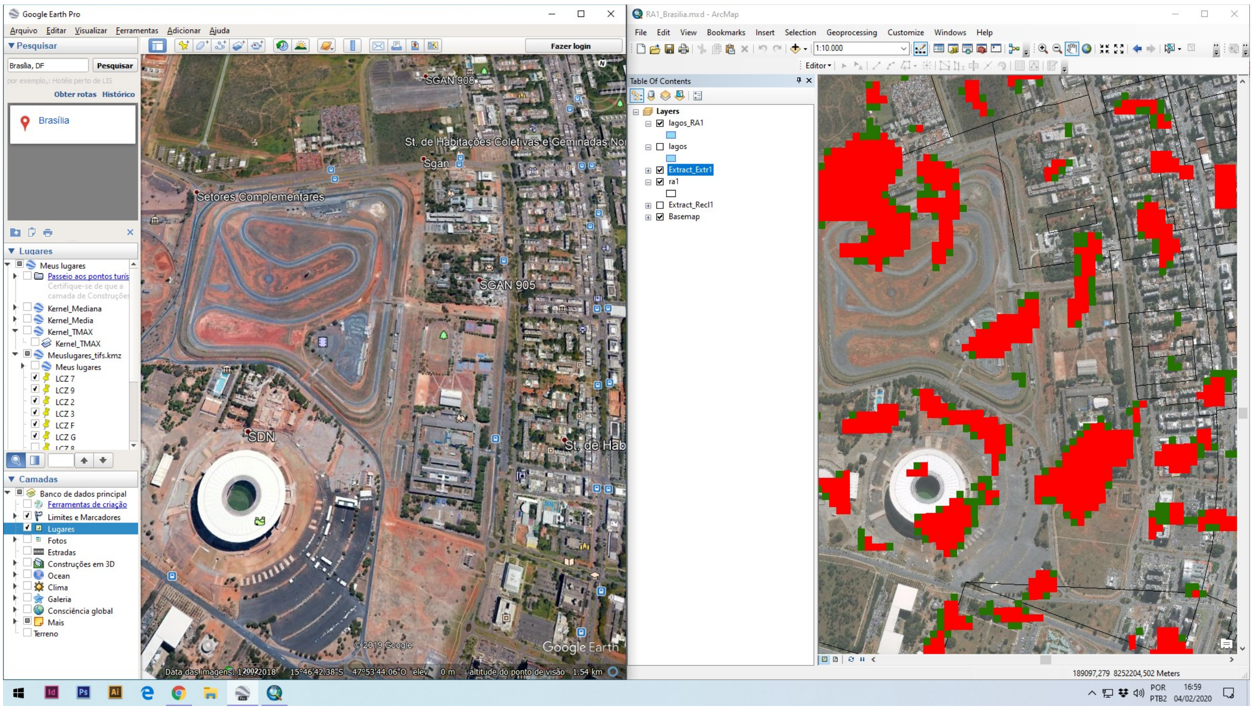


Figure 46 RA I Brasília – HD Sample

In addition to commercial areas, homogeneous correlation hotspots were found massively surrounding the Lago Paranoá *(Paranoá Lake)*, on spots of emptiness, others having exposed soil, massive concrete or asphaltic surfaces and on urban tissues' discontinuities which were crossed by roads such as the BR-001.

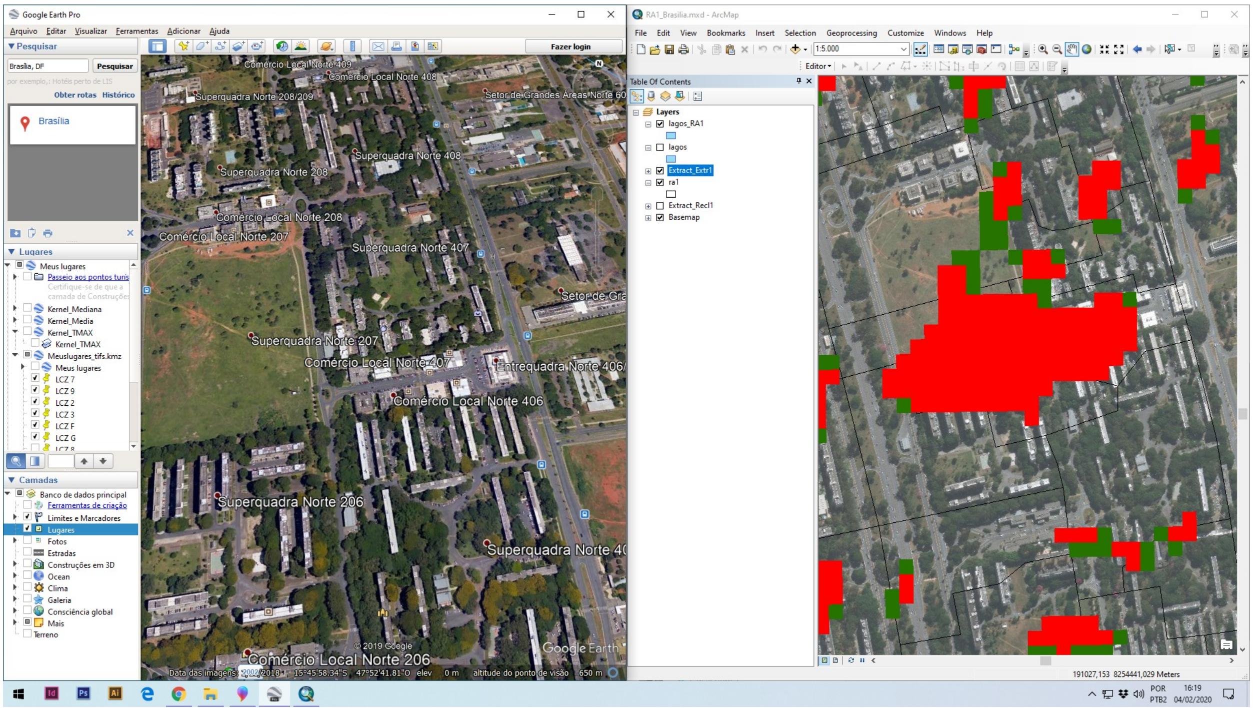


Figure 47 RA I Brasília – HD Sample

If we take a closer look at the demographic data displayed at the bottom of each correlation map, we can perceive a socio-spatial hierarchy. In other words, neighborhoods having more correlation hotspots are in majority distant from the green and projected city center *Plano Piloto*, and have extremely low green availability, low annual per capita income and other socio-spatial elements discussed by Romero (2015), Holanda (2006), Ribeiro *et al.,* (2012), and Lemos (2017) which configure socio-spatial segregations.

More specifically, Administrative Regions (RAs) having from 30 to about 50% of its territory colored by high and medium-high correlations of high land surface temperature and violent crimes are the ones having less than 1km^2 of green availability spread among its territories - measured by NDVI in Rodrigues et al. (2016). Besides very low green, these Administrative Regions have low and medium-low monthly per capita income (CODEPLAN, 2017). This finding reminds us about the work of Nogales Vasconcelos & Costa (2005) who found that 62% of homicides in Distrito Federal are concentrated in low income regions (p. 46). The measured Administrative regions having high number of correlations hotspots are *Candangolândia, São Sebastião, Varjão, Paranoá, SCIA/Estrutural and Brazlândia* Similarly, correlations hotspots were found at *Paranoá*, in the border of a road and a non-native forestry reserve (*pinheiral*). Some of these RAs have been discussed by Nogales Vasconcelos & Costa (2005) as having high homicide rates such as *Paranoá, Brazlândia*.

RAs hosting 20 to 30% of their territory extension affected by the correlations have both realities: low green availability (less than 1km^2) and medium-low green availability (up to 5km^2 of green), according to Rodrigues *et al*., (2016). In terms of income, these cities also vary from low-per capita income like Itapoã (less than 1,000 BRL) up to six times more which is the case of *Sudoeste/Octognal* (CODEPLAN, 2017). It is interesting to see the contrast of income and green for instance between *Sudoeste/Octogonal,* which is a wealthier neighborhood, and at the same time hosts a green availability similar to *Itapoã* (CODEPLAN, 2017).

Itapoã is double burdened in this case, since besides its low green availability it has also a low per capita income (less than 1,000 BRL) (CODEPLAN, 2017). Fifty percent (50%) of the total population of the Distrito Federal live in neighborhoods having 20-30% of the territory equivalent to correlation hotspots. Good examples are the region comprehending *Ceilândia, Samambaia* and *Taguatinga,* which accounts for 30% of DF's population, about 1 million people living with less and 5km^2 of green per R.A. *Ceilândia* and *Samambaia* have both less than 1,000 BRL annual per capita income, while *Taguatinga* computes 2,000 BRL of per capita monthly income (RODRIGUES et al., 2016; CODEPLAN, 2017).

Yet, within this range of 20-30% of territory covered by correlation hotspots, there are other examples of medium green availability and higher per capita income (PCI) such *as Águas Claras* (more than 3,000 BRL PCI) and *Sobradinho II* (2,000 BRL PCI), Vicente Pires (3,000 BRL PCI). *Fercal, Riacho Fundo, Guará, Núcleo Bandeirante, Gama* and *Recanto das Emas* also have 20-30% of its territory hosting the assessed correlations hotspots (CODEPLAN, 2017). It is true that bad quality morphology (low green for instance) affect mostly the poor (ROMERO , 2015), however, affluent communities such as Águas Claras apparently do not count on better quality cityscape according to the extent of correlations hotspots found in its territory.

Further still, the wealthier RAs are the ones having lower correlation hotspots (under 20%) spread over their territories. As an example, Lago Norte had the lowest number of correlation hotspots. Lago Norte has per capital income higher than 4,500 BRL (CODEPLAN, 2017) and 20km^2 of green availability (RODRIGUES et al., 2016). Park Way has more than 40km^2 available over its territory and computed also lower correlation hotspots. Santa Maria performed similarly to Park Way in terms of the amount of correlation's hotspots. However, Santa Maria has a lower green availability and low per capita income level. Such contrast complicates the analysis. As Davidson (2019) highlights, the extent of differences between communities should be reviewed from multiple perspectives. Therefore, recommendations for advancing knowledge in this sense will be given further. Table X presents a summary of findings in terms of percentage of correlations found to each RA, green and income.

RA	**% of territory covered by correlation hotspots**	**Urban green availability (Km2)**	**Monthly Income (BRL/2015)**	**Income group**
Candangolândia	**50% - 30%**	Less than 1 km2	1.460,98	Medium-low
São Sebastião		2,4 km2	966,96	Medium-low
Varjão		Less than 1 km2	627,81	Low
Paranoá		Less than 1 km2	756,88	Low
SCIA/ Estrutural		Less than 1 km2	521,80	Low

Brazlândia		1,15 km2	983,66	Medium-low
Riacho Fundo	30% - 20%	Less than 1 km2	1.624,19	Medium-low
Fercal		Less than 1 km2	625,81	Low
Sudoeste/ Octogonal		1,98 km2	6.589,90	High
Guará		5,46 km2	2.683,23	Medium-high
Núcleo Bandeirante		1,29 km2	1.842,38	Medium-high
Águas Claras		6,75 km2	3.339,91	Medium-high
Sobradinho II		6,90 km2	1.732,52	Medium-high
Samambaia		Less than 1 km2	914,75	Medium-low
Gama		3,12 km2	1.396,93	Medium-low
Recanto das Emas		Less than 1 km2	803,92	Medium-low
Itapoã		2,51 km2	702,38	Medium-low
Vicente Pires		7,72 km2	2.725,23	Medium-high
Ceilândia		3,19 km2	914,61	Medium-low
Taguatinga		3,57 km2	1.998,14	Medium-high
Lago Sul		23,32 km2	8.117,53	High
Jardim Botânico		12,64 km2	3.930,39	High

Sobradinho	**20% - 15%**	5,70 km2	1.775,79	Medium-high
Brasília (Plano Piloto)		29,96 km2	5.559,75	High
Cruzeiro		1,21 km2	2.725,23	Medium-high
Riacho Fundo II		Less than 1 km2	930,37	Medium-low
Planaltina		5,17 km2	933,80	Medium-low
Park Way		41,34 km2	5.207,54	High
Santa Maria		1,82 km2	887,63	Medium-low
Lago Norte	**Less than 15%**	20,12 km2	4.736,75	High
SIA		1,46 km2	1.763,13	Medium-high

Table 19 Summary of correlation percentage, green and income for each R.A.

Source: The author adapted from Codeplan (2017) and Rodrigues *et al.,* (2016)

CRITICAL DISCUSSION

Undoubtedly, the frequency of crime depends on a wide range of factors that encompasses demography, social conditions and psychological elements. However, according to the methods and variables chosen in this assessment, we measured a potential extent of weather and the built environment influencing the frequency of violent crime in Brasília, Distrito Federal. Such relationship between violence and the built environment is quite challenging to get empirically demonstrated, especially in developing countries where data is quite scarce. Therefore, this is a pioneer study for the Federal District which should inform transdisciplinary projects and policies dedicated for alleviating violence and leveraging environmental-cityscape stewardship.

By aggregating data in several temporal scales (from hourly to quarterly), we managed to visualize the patterns of crime frequency for the 4 assessed variables: homicide and its attempts as well as rape and its attempts. The descriptive analysis of cases in the hourly basis already indicated nighttime as concentrating major occurrences for all variables, but the higher number of rapes registered as happening early in the mornings and at lunch time picked attention. Daily aggregation also showed that rapes pike on Monday morning. McLean (2007) also found significant correlations for sexual crime and sunshine. In addition, homicides and its attempts happen mostly on the weekends and in the first and fourth quarters of the year. Scholars advocating for the Routine Activity Theory (RAT) would argue potential evidence regarding these findings. Yet, we did not control for such variables because we considered it out of scope in terms of weather and ecological implications to crime.

With regards to the assumption of higher temperatures leading higher crime rates, contrary to our own expectations, we found significant but weak correlation coefficients to temperatures versus homicide and its attempts on the Spearman test. Nevertheless, it follows the logic shown on the descriptive analysis. Temperatures are milder at night when most homicides and its attempts take place. Similarly, DeFronzo (1984) has found weaker correlations to 142 largest cities to weather variables. In Brazil, (PEREIRA, ANDRESEN & MOTA, 2016) have found weaker correlations between homicide and temperature in Recife where temperature is high during the whole year, which makes it difficult to capture variations on temperature versus homicide. Rio de Janeiro, Recife, Manaus, Porto Alegre and São Paulo presented more significant correlations in the study of Mendonça (2001). Cecatto (2005) also found few significant weather variables on her models for assessing weather and homicides in São Paulo.

The Spearman correlation test conducted for this thesis revealed no association between weather variables and cases of rape and its attempts. Such results differ from Michael & Zumpe (1983), and McLean (2007) who found associations between intimate partner violence and temperature for different places in the United States and Greater Manchester, respectively. To these authors gender violence is represented by a linear relation to temperature. However, as shown in our descriptive analysis, most cases were registered as happening early in the morning, especially on Mondays, and it increases during May, June and July, which are the colder months in Distrito Federal. Further studies should be conducted to clarify such patterns of sexual crime occurrence.

As the weather is very demarcated by dry and wet seasons – the larger amount of rain falling over Brasilia in summer - the more relevant correlation coefficients found with respect to accumulated rainfall emphasize warmth. Therefore, results out of our statistical arrangements indicate that in Brasília summer and rainy seasons positively influence homicide and its attempts. When aggregating data into quarters of months, the R^2 showed that 19.5% of homicides and 21.5% of homicide attempts had their frequency correlated to the average temperature (21.5°C) and rainfall (343.2 mm) at a significant *p* value <0,00001. Besides demonstrating seasonal patterns frequency (increasing in summers which is the rainy season in the Distrito Federal), it dialogues with the assumption of warmth playing a role on human's violent behavior defended by several scholars such as Michael e Zumpe (1983) who found significant correlations of increased assaults and rape in months having higher temperatures in sixteen different locations in the United States. Our findings also meet the assumptions of Anderson e Anderson (1984), Anderson (1987), Tennenbaum & Fink (1994), Van de Vlier, *et al.*, (1999), Rotton & Cohn (2000), Bell (2005), Fay & Maner (2014), Michel et al., (2016) of weather, in special heat positively influencing aggression and violent crimes.

Also, we should not disregard the fact that the rainy season in Brasilia coincides with summer and it occurs over the 1st and 4th quarters of the year. Cecatto (2005) controlled for temporal variables and her results point out the routine activity as playing a major role on murder rates in São Paulo as it concentrates murdering on major holidays and vacations (1st and 4th quarters of the year as well). Similarly, Anderson (2001) highlights that this difference in murdering rates between summer and other seasons "could be a spurious artifact" of differences in activities people carry out in different times of the year (ANDERSON, 2001, p. 33). Although the Routine Activity Theory (RAT) is something of pretty common-knowledge and offers no newly insights towards formulating policies for violence alleviation, further studies should separately control for temporal variables in Brasília in order to advance on disentangling these two major theories (RAT and TAM) and achieving a better understanding about the dynamic of crime in Distrito Federal.

Yet in São Paulo Cecatto's regression results in the monthly time scale found a R^2 of 66% of variations in homicide explained by weather variables in São Paulo. Although the impressive R^2 coefficient is given most likely to the sample's size, when adding dummy temporal variables such as payday into the model, weather variables were no longer significant (CECATTO, 2005). In our case, the R^2 of the Negative Binomial Regression showed that warmth beyond average temperature of 21.5°C and averages of 114 mm of rainfall inform a variation of 9% in homicides and 11.5% in homicide attempts, also regarding the same monthly time scale. Differently from Cecatto (2005) we scaled up temporal scales to trimesters, thus increasing the R^2.

Before moving towards the spatial analysis, additional reflections upon weaker correlations found on temperature influencing homicides in Distrito Federal and São Paulo pose a question: Should the significant but weak correlation results be found due to measuring air-temperature as the unique variable for temperatures? In other words – is measuring only air temperature enough to analyze thermal discomfort potentially leading to aggression? On top of it, the geographic conditions of Brasília hold monthly temperature averages like 21.5°C. Distrito Federal according to official data from Projetee[12] – an online platform from the Ministry of Environment (MMA) and National Meteorological Institute INNMET, has almost the whole year within the temperature comfort zone (INMET, 2016). According to the Climate-data Organization[13], the monthly air temperature average in São Paulo is 18°C. Moreover, air is a bad heat conductor although it warms up as solar radiation increases. However, air temperature is not sensibly felt as much as the radiant temperature increases at the pedestrian level (WERNECK, 2018). Anderson (2001) suggests a triangulation of data for finding missing pieces on the puzzle of heat and violence and, in this sense, this study brings a contribution also on the spatial analysis.

Results out of our spatial analyses helped to understand where these above-mentioned temporal patterns physically manifest in the territory of Distrito Federal, and this is an elegant and innovative experiment to this field of study, in the sense that we have adapted open-source remote sensing big data and processed it in cloud, in order to figure urban diagnosis in regard to our research assumptions. We will keep the script of

[12] Projetee MMA INMET: http://projeteee.mma.gov.br/dados-climaticos/?cidade=DF+-+Bras%C3%ADlia&id_cidade=bra_df_brasilia-kubitschek.intl.ap.833780_try.1962 accessed on May 22nd 2020 at 2:25 pm

[13] https://pt.climate-data.org/america-do-sul/brasil/sao-paulo/sao-paulo-655/ Accessed on June 7, 2020 at 11:12 pm

geostatistics “open-access”, so any city in the world having its crime records spatialized (having the geocode – LAT/LONG) can proceed with the same spatial analysis we conducted for Brasilia, and which results will be discussed from now on.

Correlation maps embedding the 9 years of consolidated crime registries are the outputs. Due to the large number of crimes occurring in the time-spam and the dimension of the pixels (900m^2), it resulted in crime clusters spread all over Distrito Federal overlapped with high land surface temperatures. Hu, Wang, *et al.*, (2018) adopted similar technique for crime hotspots based on Kernel Density and a matrix of pixels corresponding to statistical significance level. However, the authors did not overlap geocodes of crime to weather variables such as Land Surface Temperature (LST). Actually, studies correlating LST and violent crimes are scarce.

For this reason, the methods adopted open an avenue for a new field of study: interdisciplinary research to study and discuss all types of urban spaces covered by correlation hotspots. Differently, Hu, Wang, *et al.*, (2018) only assessed incidents of crime hotspots restrained to residential land-uses. Bounadi (2018) for instance, combined daily average land surface temperature and rainfall to correlate deadly social armed conflict in Afghanistan using ordinary least squares, and found that exchanging from colder to warmer days increase the likelihood of conflict, marginal seasonal heterogeneity (positive impact of higher temperature on summer and winter) and no significance was found while correlating conflicted to daily rainfall.

Bringing temperature to the center of discussion and using LST to correlate frequency of violence is a new scientific fashion, and it can be enhanced and expanded to other socioeconomic and public health issues. In our case, Pearson’s correlation resulted in geostatistical maps of medium-high and high correlation hotspots (green and red) between LST and violent crime, but it could have been LST and any other event to be measured spatially. A good example is brought by Bounadi (2018) cross-checking LST to shocks on opium production, which in turn could also drive temperature-conflict. Nevertheless, there was no comparison between types of urban tissues over the districts hosting hotspots in Afghanistan.

Zooming-in these results with the support of high-resolution imagery, enabled us to visualize that the majority of hotspots were falling into places having similar urban tissues. For instance, a large extent of hotspots was found surrounding borders of cities or on edges or more technically speaking “discontinuances” of the urban tissue. Most of the places having high and medium-high correlations indicate a morphological disruption caused by an intersection in the built environment, and “green spaces”. As Kimpton, Corcoran & Wickes (2016) highlight, the green spaces terminology refers to a miscellaneous of places and “particular types of green spaces are more prone to crime than others” (p.2). In addition, the presence or not of amenities and socioeconomic conditions of surrounding communities also weigh in.

In this sense, outskirts and urban boundaries from all the Administrative Regions are mostly composed of “green areas” (grassy and non-mowed bushes). Mostly may have the aspect of “abandoned urban emptiness” for which there is literature discussing how these spaces may translate a sense of fear (NASAR & FISHER, 1992). Actually, these outskirts are “green” just in terms of colors, and they are green during the wet season. When the dry season brings the drought to Brasília, these green spaces composed of grassy soil turn into beige color and exposed soil. According to Baptista (2003) biomass changing colors also changes how the satellite measures land surface temperature due to the Photochemical Reflectance Index (PRI).

The discussion pertaining to surface temperature, colors, thermal comfort and the reflectivity of active-climate surfaces mostly regards to the concept of mean radiant temperature (WERNECK, 2018). In fact, this is a parameter that affects the pedestrian thermal and the energy balance due to exchange of radiation among surfaces, materials, and sky’s temperature and solar radiation (WERNECK, 2018).

Higher temperatures found in green areas composed by tree-mass instead of grassy may be explained by incidence of fires over the analyzed time series. Fires are commonly used to clear up the terrain to open space for urban sprawling. Grassy emptiness categorized as discontinuities at the borders of the satellite cities have high radiation - similarly to asphalt, due to soil compactness (RIBEIRO *et al.*, 2012; BAPTISTA 2003).

Therefore, built environments having no trees or bad materials such as massive concrete, asphalt, dark impervious surfaces, urban interstices[14] and places hosting sources of CO_2 emission (urban CO_2 dome) are the ones having higher land surface temperature (BAPTISTA, 2004). Furthermore, Romero (2011) would classify these green spaces hosting correlation hotspots of crime and LST of bad bioclimatic conditions. In the built environment, the urban geometry dictates its thermal performance and the amount of solar radiation it would absorb and store (ROMERO, 2011). Further still, other kinds of urban morphology would inform land surface temperature (LST) and heat trapping such as the W/H relation (W - width and H - height), sky view factor (SVF) its density (ROMERO, 2011 p. 92)

[14] Urban interstices are tissues fragmented, without morphological continuity. NORBERG-SCHULZ, 1979 *Genius Loci : paesaggio, ambiente architettura*, Milano, p. 58

Commercial areas in Distrito Federal are usually crowded. Correlations over commercial areas match with the morphology prone to heat storage during the day discussed by ROMERO (2011) and a total emptiness during non-business hours, and it is when crime takes place. Thus, our correlation hotspots should be seen as an indicator of areas that deserve attention towards land-use change in order to enhance its sustainability and public security. Regarding the hotspots falling over residential areas, it is important to consider that the four violent crime variables are grouped, and for this reason we should keep in mind that rapes and its attempts are commonly committed in private places such as in residences. In addition, many spaces having high density of residences may be classified as claustrophobic spaces which is also described by Romero (2011) as potential heat traps (p.93), but of course there are exceptions as we noticed correlation hotspots over wealthier mansions at Lago Sul, for instance. In this sense, we must keep in mind that all crimes are grouped in one single raster and rape and its attempts are commonly registered as happening indoors (DAVIDSON, 2019).

Although we did find consistent results, the methods adopted have their limitations and we always should bear in mind that scientific papers only provide a fragmented piece of knowledge about the reality. Further studies are necessary to advance knowledge. Yet in terms of potential flaws of our methods, the way our crime geocodes were tailored has been the very first experience of Codeplan. The task was to identify latitude and longitude of each by looking at similarities. Crime addresses were crosschecked among the DF Electricity Company (CEB), Water and Sewage Company (CAESB) and Codeplan's databanks. Since crime reports were hand-written by the policemen, there were many addresses like "in front of the bakery, behind the soccer field', etc. Thus, the first policy recommendation that this study claims for is adopting tablets with GPS for the police force to register crimes on the streets. If they do so, future studies like ours would become much more accurate in geospatial terms. In addition, due to the lack of specific weather data divided for each R.A we had to adopt LandSat imagery because first of all it is free, it covers the area of study, and more importantly it has data that matches the time series we aimed to analyze (2009 – 2017). Of course, there are still limitations since data is acquired by the satellite each 16 days at the same time, so we had to process the average of temperatures to move forward with the analyses.

As discussed by Kimpton, Corcoran e Wickes (2016) and Romero (2011), some green spaces and different kinds of built environment are more prone to crime and heat than others. Thus, it was very interesting to quantify in our study the number of spaces hosting correlation hotspots by each R.A. By doing so and collating sociodemographic secondary data we could estimate a number of people exposed to correlation hotspots (crime and LST) by each Administrative Region.

With regards to the performance of a planned city versus the more spontaneous ones in terms of correlation hotspots, Brasília RA-I (*Plano Piloto*) has had a very spread correlation map, but in total, the amount of correlations pixels was one of fewest. Only a bit more than 15% of *Plano Piloto's* territory was affected by the correlation colored hotspots on the map, which is a good performance in terms of a cityscape. It is not in low concentration of correlation hotspots that the Plano Piloto performs well. According to Romero (2015) the Plano Piloto has plenty of infrastructure and public services differently from its periphery (p. 136).

Yet, the excessive spread of correlation pixels all over Brasília's map can be explained by its Monumental scale in which it fits many pixels of $900m^2$ of resolution. Also, hotspots spread might be due the Modernist style which hosts both: Massive grey areas such as the "*Praça dos Três Poderes*", and a large number of bucolic green spaces (ROMERO, 2015). Dark impervious areas trap heat and when these aforementioned greenspaces shift its vegetation color turning into beige the satellite measures higher LST (BAPTISTA, 2003). The borders of the Lago Paranoá (lake) presented a large number of hotspots, as well as in commercial areas between the *superquadras* and on the urban interstices. These findings dialogue with Kimpton, Corcoran & Wickes (2016) which states that high-amenity greenspaces are not enough to prevent violence if these amenities do not "increase guardianship and reporting behaviors" (p. 23). Another limitation of this work, is the lack of data normalization between the demographic information displayed on the correlation maps for each R.A. The initial idea was only to contrast these demographic data against our findings, and not to add additional inferential conclusions. Further studies should take our findings (in special spatial results) and advance with local analyses so it would be possible to depict if the influence of surface heat over violence still stands, regardless of population, income and green availability. In addition, in order to dig in more towards the straight relationship of weather influencing crime, it would be ideal to analyze heat waves, assessing the impact of crime occurrence a few days after consecutive extreme weather conditions, in special heat and rainfall, and this is a limitation regarding our time series analysis.

Edges and urban interstices such as when shifting from emptiness to residential areas, or from massive concrete such as the "commercials" to green areas have been already captured by Werneck (2018) when measuring the effect of active surfaces on the *Plano Piloto*, looking at the average of radiant temperature that increases in commercial squares of both North and South wings due to the low albedo and its materials features.

Correlation hotspots falling over the "commercials" denote two major problems: Poor shading and bad land-use, since during the day these spaces are very crowded and the thermal comfort at the pedestrian level is bad (WERNECK, 2018), and at night, due to a restrict commercial land-use, the “commercials” areas become vulnerable to hosting violent crimes when out of businesses hours.

Although our findings contribute to the existing literature, these are a small and fragmented piece of the reality pertaining to Distrito Federal. Therefore, advancing knowledge with future studies is required. A way to go would be comparing different landscapes hosting the same amount of correlation hotspots, which would be checking levels of compactness versus diffuseness of these places (PESCATORI, 2015). Another way to advance knowledge should be conducting ethnographic fieldwork among these communities in order to learn better about the issue we investigate on the ground, from the people who face this reality in their daily lives.

There is much debate about what really means sustainability to the territory of Brasília Romero (2011); Nogales Vasconcelos & Costa (2005); Romero (2015); Codeplan (2017). In this sense, the policy recommendations suggested further, aim to downscale the knowledge generated in academia and benefit ordinary people, in special the most vulnerable ones. In his doctoral dissertation a colleague tested the hypothesis of a direct correlation between urban green and social vulnerability. His premise did not stand true to other metropolitan regions of the country, but for Brasília and the Distrito Federal the higher amount of green in less socially vulnerable areas is prevalent (SILVA, 2018). According to Silva (2018), the urban planning of the Distrito Federal played a role in providing green to specific privileged areas, what did not happen homogeneously the whole district’s territory (SILVA, 2018, p. 353).

Therefore, places mapped with correlations such as borders and outskirts of RAs and urban discontinuities (*terrenos baldios*) must have its policing efforts enhanced. These efforts should prioritize the timetable found as having more frequency of crimes (e.g. weekends at night for homicide and its attempts). Another policy recommendation would concern the land-use. If the places hosting correlation hotspots are public, the government in collaboration with local dwellers and surrounding businesses should take actions to bring the realm to these places. If the local community adopts these places, they could take the shape of boulevards, sports places, plazas, bioclimatic gardens or even cooling places to alleviate heat and provide moisture that would contribute to public health during the months of drought in Brasília. Another option would be destining those empty places for collective projects on food-gardens. So, instead of hosting violence these spaces could produce organic food for people in need. As discussed by Kimpton, Corcoran & Wickes (2016) just adding amenities to criminogenic spaces hosting correlation hotspots would not alleviate violence without community ownership, identity and guardianship over these places.

Nevertheless, more importantly in terms of policy recommendation regards changing the path or urban development following the business-as-usual. This is something in place since the creation of Brasília and the result is the socio-spatial segregation according to Romero (2015); Holanda (2006); Ribeiro (2012); Lemos (2017); Nogales Vasconcelos & Costa (2005). Such a sprawled city-fashion creates borders and discontinuities and other places prone to hosting violence (ROMERO, 2015).

Lastly, this study contributes also to the existing literature stating that the found correlation hotspots of heat and violence is also an indicator of socio-spatial segregation. Only understanding local weather in a three-dimensional way, will make it possible to advance towards giving more precise inferences about the extent to which the weather influences violent behavior. With our methodology we were able to answer our research questions initially stating that yes, there are seasonality for the occurrence of violent crimes and, on top of it, we empirically demonstrate a unstainable side-effect of the cityscape constituting Distrito Federal by mapping hotspots of heat and violence. Furthermore, achieving the 11th Sustainable Development Goal will be something very difficult to witness by 2030, or even by 2050 if we insist in continuing with this type of urban development, based on the business-as-usual and segregation ethos.

CONCLUSIONS

Disentangling the extent to which the weather influences the frequency of violent crime requires sophisticated methods of which according to the current literature, science has not been fully achieved yet. By conducting this study in Brasília, The Brazilian Distrito Federal, we advanced knowledge on the dichotomy of weather influencing crime from 3 perspectives: temporal, spatial and urbanistic.

The temporal analysis revealed seasonal trends on frequency of violent crimes, since the smallest quantitative units such as registers per hour to larger samples such as aggregating occurrences in trimesters. Descriptive statistics have shown that nights and weekends have higher frequency of homicides and its attempts on the hour and daily time scales. When looking at months we perceived increases in homicide and its attempts in the 1st and 4th quarters of the year and decreasing in May and June. Counts indicate rapes and its attempts increasing by the middle of the year (winter time in Brazil).

Weak but significant correlation coefficients were obtained between homicide and its attempt to accumulated rainfall and mean average temperature on monthly and trimester aggregations. The negative binomial regression demonstrated that warmth beyond average temperature of 21.5°C and averages of 114 mm of rainfall informed a variation of 9% in homicides and 11.5% in homicide attempts, also regarding the same monthly time scale, scaling up temporal scales to trimesters increasing the R^2 accordingly. Rape and its attempts have presented no correlation at all to weather variables. Although results show that Distrito Federal faces a higher frequency of these violent crimes when temperatures are higher and raining (summers), its territory experiences most of its hours and months within the thermal comfort range, which makes it difficult ensuring the exact effect exerted by heat on the frequency of violent crimes. In addition, beyond heat, the social routine may also play a role which requires further studies.

By overlapping land surface temperature and geocodes of crime, the spatial analysis has allowed us to quantify the amount of correlation hotspots found for each of the 31 Administrative Regions. Besides noticing a similar hierarchy between the massive amounts of hotspots and the degree of socio-spatial segregation previously discussed by other scholars, we figured similar morphologies of criminogenic urban tissues. Our correlation maps put into evidence that borders of cities, densely built neighborhoods, urban interstices, massive impervious grey areas and different types of greenspaces are commonly prone for hosting violent crimes in Brasília.

Finally, the projected *Plano Piloto* performed better than other types of urban tissues inlaid in Distrito Federal hosting a lower number of correlations. Above all, tackling urban heat for violence alleviation also implicates on tackling the chronic social and spatial segregation, changing restricted land-uses and enhancing ownership and guardianship of criminogenic greenspaces mapped hosting correlation hotspots. We conclude stating that for a more sustainable, just and safer future for Brasília and the whole Distrito Federal, it should be avoided the segregated, sprawled and polynucleated kinds of urban development, since these are the spaces we identified as being the most vulnerable ones to host violent crime

BIBLIOGRAPHIC REFERENCES

ABDULLAH, A. et al. Validating Crime Prevention through Environmental Design Using Structural Equation Model. **Procedia Social and Behavioral Sciences**, n. 36, p. 591-601, 2012.

AMORIM, M. C. D. C. T. **Ilhas de Calor Urbanas:** Métodos e Técnicas de Análise. XIII Simpósio Brasileiro de Climatologia Geográfica. [S.l.]: Revista Brasilieira de Climatologia. 2019. p. 22-46.

ANDERSON, A.; ANDERSON, D. C. Ambient temperature and violent crime: Tests of the linear and curvilinear hypotheses. **Journal of Personality and Social Psychology**, v. 46, n. 1, p. 91-97, 1984.

ANDERSON, C. Temperature and Aggression: Effects on Quarterly, Yearly, and City Rates of Violent and Nonviolent Crime. **Journal of Personality and Social Psychology**, v. 52, n. 6, p. 1161-1173, 1987.

ANDERSON, C. Temperature and Aggression: Ubiquitous Effects of Heat on Occurrence of Human Violence. **Psychological Bulletin**, p. 74-96, 1989.

ANDERSON, C. A. Heat and Violence. **Current Directions in Psychological Science**, 2001.

ANDERSON, C. A.; ANDERSON, K. B. Temperature and aggression: paradox, controversy, and a (fairly) clear picture. In: GEEN, R.; DONNERSTEIN, E. **Human aggression:** theories, research, and implications for social policy. San Diego, CA: Academic Press, 1998. p. 240-298.

BÉU, E. **Os filhos dos candangos:** Brasília sob o Olhar da Periferia. [S.l.]: Editora UnB, 2013.

BANDO, D. H.; VOLPE, F. M. Seasonal variation of suicide in the city of São Paulo, Brazil, 1996–2010.. **Crisis: The Journal of Crisis Intervention and Suicide Prevention**, v. 35, n. 1, p. 5-9, 2014.

BAPTISTA, G. M. M. Validação da modelagem de seqüestro de carbono para ambientes tropicais de cerrado, por meio de dados aviris e hyperion. **Anais XI SBSR**, Belo Horizonte, p. 1037-1044, 2003.

BAPTISTA, M. M. Mapeamento do Seqüestro de Carbono e de Domos Urbanos de CO2 em Ambientes Tropicais, por meio de Sensoriamento Remoto Hiperespectral. **Geografia**, Rio Claro, v. 29, p. 189-202, 2004.

BAPTISTA, M. M. Introdução ao processamento de imagens de sensoriamento remoto. **CNPq**, p. 221-238, 2012.

BARON, R. A. Aggression as a function of ambient temperature and prior anger arousal. **Journal of Personality and Social Psychology**, v. 21, p. 183-189, 1972.

BARON, R. A.; BELL, P. A. Aggression and heat: The influence of ambient temperature, negative affect, and a cooling drink on physical aggression. **Journal of Personality and Social Psychology**, v. 33, p. 245-255, 1976.

BARON, R. A.; RANSBERGER, V. M. Ambient temperature and the occurrence of collective violence: The "long, hot summer" revisited. **Journal of Personality and Social Psychology** , v. 36, n. 4, 1978. ISSN 351-360.

BELL, P. In Defense of the Negative Affect Escape Model of Heat and Aggression. **Psychological Bulletin**, v. 111, n. 2, p. 342-346, 1992.

BELL, P. Reanalysis and perspective in the heat-aggression debate. **Journal of Personality and Social Psychology**, v. 89, n. 1, p. 71-73, 2005.

BELL, P. A.; BARON, R. A. Aggression and Heat: The mediating role of negative affect. **Journal of Applied Social Psychology**, v. 6, n. 1, p. 18-30, 1976.

BELL, P.; BARON, R. Aggression and Heat: The Mediating Role of Negative Affect. **Journal of Applied Social Psychology**, v. 6, n. 1, p. 18-30, 1976.

BOUNADI, M. E. **Weather and Conflicts in Afghanistan**. [S.l.]: EBA Working Paper, 2018.

BRIGHENTI, A. M. **Urban Interstices:** The Aesthetics and the Politics of the In-between. [S.l.]: Ashgate Publishing Limited, 2013.

BRITTO, M. C.; FERREIRA, C. D. C. M. Análise dos homicídios ocorridos em Juiz de Fora entre os anos de 1980 e 2012 e sua relação com as condições climáticas. **Revista Brasileira de Climatologia**, v. 13, n. 9, p. 214-235, 2013.

BURKE, M. et al. Higher temperatures increase suicide rates in the United States and Mexico. **Nature Climate Change**, v. 8, p. 723-729, 2018.

BUSHMAN, B.; ANDERSON, C.; WANG, M. Is the curve relating temperature to aggression linear or curvilinear? A response to Bell (2005) and to Cohn and Rotton (2005). **Journal of Personality and Social Psychology**, v. 89, n. 1, p. 74-77, 2005.

BUSHMAN, B.; DEWALL, N. Hot under the collar in a lukewarm environment: Words associated with hot temperature increase aggressive thoughts and hostile perceptions. **Journal of Experimental Social Psychology**, v. 45, n. 4, p. 1045-1047, 2009.

CALIXTER, A. L. et al. Mário Covas Rodoanel Project - Northern Section, Brazil. **Inter-American Development Bank - Felipe Herrera Library**, 2015.

CARLSMITH, J. M.; ANDERSON, C. A. Ambient temperature and the occurrence of collective violence: A new analysis. **Journal of Personality and Social Psychology**, v. 37, n. 3, p. 337-344, 1979.

CARPANEDA, L. V. **Contribuições para o Desenho de Espaços Seguros:** Um estudo de caso nas superquadras do Plano Piloto de Brasília. Brasília: Dissertação (mestrado). Pós-Graduação da Faculdade de Arquitetura e Urbanismo de Brasília, 2008.

CASTELLS, M. **City, class and power**. London: Macmillan Press, 1978.

CEBALLOS, G. D. **"E a historia se fez cidade. ":** a construção historica e historiografica de Brasilia. Campinas: IFCH - Dissertação (mestrado) - Universidade Estadual de Campinas, Instituto de Filosofia e Ciencias Humanas, 2005.

CECCATO, V. Homicide in São Paulo, Brazil: Assessing spatial-temporal and weather variations. **Journal of Environmental Psychology**, v. 25, n. 3, p. 307-321, 2005.

CHAVAN, P.; KULKARNI, R. V. Role of non-parametric test in management and social science research. **Quest International Multidisciplinary Research Journal** , v. VI, n. IX, 2017.

CHEATWOOD , D. Is there a season for homicide? **Criminology**, v. 26, n. 2, p. 287-306, 1988.

CODEPLAN. **Texto para Discussão - Densidades Urbanas nas Regiões Administrativas do Distrito Federal**. Companhia de Planejamento do Distrito Federal. Brasília. 2017.

COHN, E. Weather and crime. **British Journal of Criminology**, v. 30, n. 1, p. 51-64, 1990.

COHN, E. The prediction of police calls for service: The influence of weather and temporal variables on rape and domestic violence. **Journal of Environmental Psychology**, v. 13, n. 1, p. 71-83, 1993.

COTTON, J. L. Ambient temperature and violent crime , v. 16, n. 9, p. 786-801, 1986.

DAVIDSON, R. N. **Crime and Environment**. [S.l.]: Routledge, 2019.

DAVIS, D. E. **Urban resilience in Situations of Chronic Violence**. Center for International Studies, Massachusetts Institute of Technology - MIT. Cambridge, MA. 2012.

DE LIMA REIS JÚNIOR, R. **CIDADE, TRABALHO E MEMÓRIA:** OS TRABALHADORES DA CONSTRUÇÃO DE BRASÍLIA (1956-1960). [S.l.]: Programa de Pós-Graduação em Ciências Sociais da Pontifícia Universidade Católica de Minas Gerais, 2008.

DEFRONZO, J. Climate and crime: Tests of an FBI Assumption. **Environment and Behavior**, v. 16, n. 2, p. 185-210, 1984.

DEFRONZO, J. W. Climate and crime: Tests of an FBI Assumption. **Environment and Behavior**, v. 16, n. 2, p. 185-210, 1984.

DELGADO, L.; FERREIRA, J. **O Brasil Republicano:** Tempo da Experiência Democrática - da democratização de 1945 ao golpe civil-militar de 1964. Rio de Janeiro: Civilização Brasileira , 2003.

DOHERTY, G. **Paradoxes of green:** landscapes of a city-state. Oakland: University of California Press, 2017.

DRÁPAL , J.; PINA-SÁNCHEZ, J. Does the weather influence sentencing? Empirical evidence from Czech data. **International Journal of Law, Crime and Justice**, v. 56, p. 1-12, 2019.

DURKHEIM , É. **Suicide, a study in sociology**. [S.l.]: Free Press, 1951.

E SILVA, F. **O conforto térmico de cavidades urbanas:** contexto climático do Distrito Federal. Brasília: Universidade de Brasília, 2013.

FAY, A.; MANER, J. When does heat promote hostility? Person by situation interactions shape the psychological effects of haptic sensations. **Journal of Experimental Social Psychology**, v. 50, n. 1, p. 210-216, 2014.

FEARON, J.; LAITIN, D. Ethnicity, Insurgency, and Civil War. **American Political Science Review**, v. 97, n. 1, p. 75-90, 2003.

FERREIRA, I. C. B. O processo de urbanização e a produção do espaço metropolitano de Brasília. In: PAVIANI, A. **Brasília, ideologia e realidade**. Brasília: Editora UnB, 2010. p. 392 p. .

FERREIRA, I. C. B.; STEINBERGER, M. O modelo de gestão de Brasília e as políticas urbanas nacionais. **Cadernos Metrópole**, v. 14, p. 67-83, 2005.

FIELD, S. The effect of temperature on crime. **The British Journal of Criminology**, v. 32, n. 3, p. 340-351, 1992.

FISHMAN, R.; CARRILLO , P.; RUSS, J. Long-term impacts of exposure to high temperatures on human capital and economic productivity. **Journal of Environmental Economics and Management** , v. 93, p. 221-238, 2019.

GOMES , W.; AMORIM, M.; DEBREUIL, V. Modelagem da Ilha de Calor Urbana Aplicada ao Ambiente Litorâneo - Ubatuba/Brasil. **Revista do Departamento de Geografia da Universidade de São Paulo**, São Paulo, v. 34, p. 82-95, 2017.

GOMES, A. L. A. **Brasília:** de espaço a lugar, de sertão a capital (1956 – 1960). Brasília: Programa de Pós-Graduação em História, Departamento de História, Universidade de Brasília, 2008.

GORELICK, N. et al. Google Earth Engine: Planetary-scale geospatial analysis for everyone. **Remote Sensing of Environment** , v. 202, p. 18-27, 2017.

GRIFFIT, W.; VEITCH, R. Hot and crowded: Influence of population density and temperature on interpersonal affective behavior. **Journal of Personality and Social Psychology** , v. 17, n. 1, p. 92-98, 1971.

GRIFFITT, W. Environmental effects on interpersonal affective behavior: Ambient effective temperature and attraction.. **Journal of Personality and Social Psychology**, v. 15, n. 3, p. 240-244, 1970.

HARRIES , K.; STADLER, S.; & ZDORKOWSKI, R. Seasonality and assault: explorations in inter-neighborhood variation, Dallas 1980. **Annals of the Association of American Geographers** , v. 74, n. 4, p. 590-604, 1984.

HOBSBAWN, E. J. **Revolutionaries - Contemporary Essays**. London: Quarter Books , 1977.

HOLANDA , F. D. Brasília: utopia ou segregação à brasileira? **Le Monde Diplomatique**, São Paulo, 2016.

HOLANDA, F. A morfologia interna da capital. In: PAVIANI, A. **Brasília, ideologia e realidade**. 2a. ed. Brasília: Editora UnB, 2010. p. 392 p,.

HOLANDA, F. D. et al. A configuração da Área Metropolitana de Brasília. In: RIBEIRO, R.; TENÓRIO, G.; HOLANDA , F. D. **Brasília:** transformações na ordem urbana. Rio de Janeiro: Letra Capital, 2015. p. 64-97.

HOLANDA, F. et al. Eccentric Brasília. **Urban Design International**, v. 7, n. 1, p. 19-28, 2002.

HOLSTON, J. **The Modernisty City:** An Antropological Critique of Brasília". [S.l.]: University of Chicago, 1989.

HSIANG , S.; MENG, K.; CANE, M. Civil conflicts are associated with the global climate. **Nature**, v. 476, n. 7361, p. 438-441, 2011.

HU, X. et al. Contrasting impacts of heat stress on violent and nonviolent robbery in Beijing, China. **Natural Hazards**, v. 87, n. 2, p. 961-972, 2017.

HU, X. et al. Impact of climate variability and change on crime rates in Tangshan, China. **Science of the Total Environment**, v. 609, p. 1041-1048, 2017.

HU, Y. et al. A spatio-temporal kernel density estimation framework for predictive crime hotspot mapping and evaluation. **Applied Geography**, v. 99, p. 89-97, 2018.

IBGE. Estimativas da população dos municípios para 2019. **Agencia de Notícias IBGE**, 2019. Disponivel em: <https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/25278-ibge-divulga-as-estimativas-da-populacao-dos-municipios-para-2019>. Acesso em: 26 Maio 2020.

IKEGAYA, H.; SUGANAMI, H. Correlation between Climate and Crime in Eastern Tokyo. **Canadian Journal of Criminology and Criminal Justice**, v. 50, n. 2, p. 81-87, 2008.

JACOBS, J. **The Death and Life of Great American Cities**. New Your: Random House, 1961.

KELLER, M. et al. A warm heart and a clear head: The contingent effects of weather on mood and cognition. **Psychological Science**, v. 16, n. 9, p. 724-731, 2005.

KELLING , G. L.; WILSON, J. Q. Broken Windows: The policy and neighborhood safety. **The Atlantic**, 1982.

KIMPTON, A.; CORCORAN, J.; WICKES, R. Greenspace and Crime: An Analysis of Greenspace Types, Neighboring Composition, and the Temporal Dimensions of Crime. **Journal of Research in Crime and Delinquency**, Brisbane, p. 1-35, 2016.

LEBEAU, J. L. The oscillation of police calls to domestic disputes with time and the temperature humidity index. **Crime Justice**, v. 27, p. 147-161, 1994.

LEE, B. X. Causes and cures VIII: Environmental violence. **Aggression and Violent Behavior**, v. 30, p. 105-109, 2016.

LEMOS, O. De Soweto à Ceilândia: siglas de segregação racial. **Paranoá cadernos de arquitetura e urbanismo**, Brasília , v. 18, 2017.

LOMBARDO, M. A. **Ilha de Calor nas Metrópoles:** O exemplo de São Paulo. São Paulo. [S.l.]: [s.n.], 1985.

MARES, D. Climate change and levels of violence in socially disadvantaged neighborhood groups. **Journal of Urban Health**, v. 90, n. 4, p. 768-783, 2013.

MARES, D.; MOFFET, K. Climate change and interpersonal violence: a “global” estimate and regional inequities. **Climatic Change**, v. 135, n. 2, p. 297-310, 2016.

MCCARTHY, R. J. Close replication attempts of the heat priming-hostile perception effect. **Journal of Experimental Social Psychology**, v. 54, p. 165-169, 2014.

MCLEAN, I. Climatic effects on incidence of sexual assault. **Journal of Forensic and Legal Medicine** , v. 14, p. 16-19, 2007.

MENDONÇA, X. C. D. **Clima e criminalidade:** ensaio analítico da correlação entre a temperatura do ar e a incidência de criminalidade urbana. [S.l.]: [s.n.], 2001.

MICHAEL, R. P.; ZUMPE, D. Annual rhythms in human violence and sexual aggression in the United States and the role of temperature. **Biodemography and Social Biology**, v. 30, n. 3, p. 263-278, 1983.

MICHAEL, R.; ZUMPE, D. Sexual violence in the United States and the role of season. **American Journal of Psychiatry**, v. 140, n. 7, p. 883-886, 1983.

MICHEL, S. J. et al. Investigating the relationship between weather and violence in Baltimore, Maryland, USA. **Injury**, v. 47, p. 272-276, 2016.

MIRÓ, F. Routine Activity Theory. **The Encyclopedia of Theoretical Criminology**, n. 1, 2014.

MMA, M. O. E. **National Adaptation Plan to Climate Change**. Brazilian Ministry of Environment. Brasília. 2016.

MONTESQUIEU, B. C. D. S. The spirit of laws, 1750.

MOURA, L. B. A.; OLIVEIRA, C. D.; VASCONCELOS , A. M. N. Violências e juventudes em um território da Área Metropolitana de Brasília, Brasil: Uma abordagem socioespacial. **Ciência & Saúde Coletiva**, v. 20, p. 3395-3405, 2015.

NASAR, J. L.; FISHER, B. 'Hot Spots' of fear and crime: A multi-method investigation. **Journal of Environmental Psychology**, v. 13, n. 3, p. 187-206, 1992.

NOGALES VASCONCELOS, A. ; COSTA, A. Demografia da violência no Distrito Federal: evolução e características. In: PAVIANI, A.; FERREIRA, I. C. B.; BARRETO, F. F. P. **Brasília:** Dimensões da violência urbana. 1. ed. Brasília : Universidade de Brasília , 2005. p. 35-58.

OKE, T. R. **Boundary layer climates**. London: Methuen , v. 32, 1978.

OKE, T. R. **Siting and Exposure of Meteorological Instruments at Urban Sites**. 27th NATO/CCMS International Technical Meeting on Air Pollution and its application. Banff: Kluwer. 2004. p. 25-29.

OKE, T. R. et al. **Urban Climates**. [S.l.]: Cambridge University Press, 2017.

PAVIANI, A. **Geografia urbana do Distrito Federal:** evolução e tendências. 1. ed. Brasília: Revista espaço e geografia , v. 10, 2007.

PEREIRA, D. V. S.; ANDRESEN, M. A.; MOTA, C. M. M. A temporal and spatial analysis of homicides. **Journal of Environmental Psychology**, v. 46, p. 116-124, 2016.

PERRY, J.; SIMPSON, M. Violent crimes in a city:Environmental Determinants. **Environment and Behavior**, v. 19, n. 1, p. 77-90, 1987.

PIRES, É. G.; FERREIRA JR, L. G. **Mapeamento da temperatura de superfície a partir de imagens termais dos satélites Landsat 7 e Landsat 8**. Anais XVII Simpósio Brasileiro de Sensoriamento Remoto - SBSR. João Pessoa - PB: Sociedade Brasileira de Sensoriamento Remoto. 2015.

PRIMO, T. F. D. **Forma urbana e a relação com A sensação de medo:** o estudo de caso em Brasília. Brasília: Dissertação (mestrado). Pós-Graduação da Faculdade de Arquitetura e Urbanismo de Brasília, 2020.

RANSON, M. Crime, weather and climate change. **Journal of Environmental Economics and Management**, v. 67, n. 3, p. 274-302, 2014.

RIBEIRO, R. J.; HOLANDA , F.; COELHO, J. M. Índices de qualidade configuracional urbana. O caso do Distrito Federal, Brasil. **Revista EURE - Revista de estudios urbanos regionales**, v. 38, n. 114, 2012.

RODRIGUES, L. S.; GONÇALVES, R. A.; TEZA, C. T. V. **A relação entre NDVI e Renda Domiciliar Média - Estudo de caso nas regiões administrativas do Distrito Federal**. XIV Encontro Nacional de Estudantes de Engenharia Ambiental. [S.l.]: Blucher Engineering Proceedings. 2016.

ROMERO , M. A. B. A violência e as condições degradantes do meio urbano. In: PAVIANI, A.; FERREIRA, I. C. B.; BARRETO, F. P. **Brasília:** Dimensões da violência urbana. Brasília: Editora UnB - Universidade de Brasília, 2015. p. 135-166.

ROMERO, M. A. B. **Arquitetura do Lugar:** Uma visão bioclimática da sustentabilidade em Brasília. Brasíia: Nova Técnica Editorial, 2011.

ROMERO, M. A. B. **A arquitetura bioclimática do espaço público**. Brasíllia : Editora UnB - Universidade de Brasília , 2015.

ROSENTHAL, J. K.; KINNEY, P. L.; METZGER, K. B. Intra-urban vulnerability to heat-related mortality in New York City, 1997–2006. **Health Place**, p. 45-60, 2014.

ROTTON, J.; COHN, E. Assault as function of time and temperature: A moderator-variable time-series analysis. **Journal of personality and psychology**, v. 72, p. 1322-1334, 1997.

ROTTON, J.; COHN, E. Weather, disorderly conduct, and assaults: From social contact to social avoidance. **Environment and Behavior**, v. 32, n. 5, p. 651-673, 2000.

ROTTON, J.; COHN, E. Outdoor temperature, climate control, and criminal assault: The spatial and temporal ecology of violence. **Environment and Behavior**, v. 36, n. 2, p. 276-306, 2004.

ROTTON, J.; COHN, E. G. Errors of commission and omission: Comment on Anderson and Anderson's (1998) "temperature and aggression". **Psychological Reports**, v. 85, n. 2, p. 611-620, 1999.

ROTTON, J.; FREY, J. Air Pollution, Weather, and Violent Crimes. Concomitant Time-Series Analysis of Archival Data. **Journal of Personality and Social Psychology**, v. 49, n. 5, p. 1207-1220, 1985.

SALEHYAN, I. From climate change to conflict? No consensus yet. **Journal of Peace Research**, v. 45, n. 3, p. 315-326, 2008.

SALLES, A. D. V. S. **Diretrizes para o Espaço Urbano Público Inibidor de Delitos:** Estudo de Caso. Brasília: Dissertação (mestrado). Pós-Graduação da Faculdade de Arquitetura e Urbanismo de Brasília, 2007.

SANZ-BARBERO, B. et al. Heat wave and the risk of intimate partner violence. **Science of the total environment** , v. 644, p. 413-419, 2018.

SCHAEFFER, M. F. C. Segregação socioespacial no Distrito Federal. **Revista Kátaliysis**, v. 6, n. 2, p. 237-248, 2003.

SEMA. **Mudanças Climáticas no DF e RIDE. Detecção e projeções das mudanças climáticas para o Distrito Federal e Região Integrada de Desenvolvimento do DF e entorno**. Secretaria do Meio Ambiente, Governo do Distrito Federal. Brasília. 2016.

SHEN, B.; HU, X.; WU, H. Impacts of climate variations on crime rates in Beijing, China. **Science of the total environment**, v. 725, 2020.

SILVA, G. P. D. Cenários dos espaços verdes urbanos no Brasil. **Tese de doutorado em desenvolvimento sustentável** , Brasília, p. 386, 2018.

SLETTEBAK, R. Don't blame the weather! climate-related natural disasters and civil conflict. **Journal of Peace Research**, v. 49, n. 1, p. 163-176, 2012.

SOUSA, N. H. B. **Construtores de Brasília:** Estudo de Operários e sua participação política. Petrópolis: Vozes, 1983.

STEVENS, H. R. et al. Hot and bothered? Associations between temperature and crime in Australia. **International Journal of Biometeorology**, v. 63, p. 747-762, 2019.

TENNENBAUM, A.; FINK, E. Temporal regularities in homicide: Cycles, seasons, and autoregression. **Journal of Quantitative Criminology**, v. 10, n. 4, p. 317-342, 1994.

THEISEN, O. Climate clashes? weather variability, land pressure, and organized violence in Kenya, 1989-2004. **Journal of Peace Research**, v. 49, n. 1, p. 81-96, 2012.

VAN DE VLIER, E. et al. Temperature, Cultural Masculinity, and Domestic Political Violence. A Cross-National Study. **Journal of Cross-Cultural Psychology**, v. 30, n. 3, p. 291-314, 1999.

VAN LANGE, P. A. M.; RINDERU, M. I.; BUSHMAN, B. J. Aggression and violence around the world: A model of CLimate, Aggression, and Self-control in Humans (CLASH). **Behavioral and Brain Sciences**, v. 40, 2017.

VIANA, E. O. **O campo térmico urbano: ilhas de calor em Brasília - DF**. Faculdade de Arquitetura e Urbanismo- UnB. [S.l.]. 2018.

VRIJ, A.; VAN DER STEEN, J.; KOOPELAAR, L. Aggression of police officers as a function of temperature: An experiment with the fire arms training system. **Journal of Community & Applied Social Psychology**, v. 4, n. 5, p. 365-370, 1994.

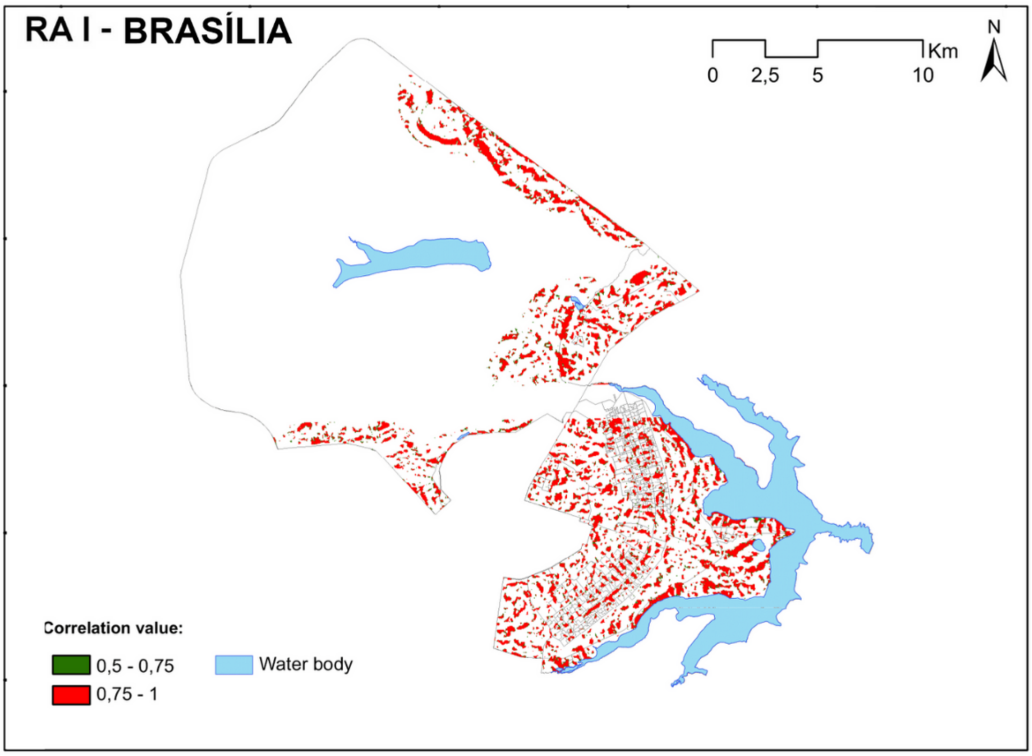
WERNECK, R. **Estratégias de mitigação das ilhas de calor urbanas:** estudo de caso em áreas comerciais em Brasília – DF. Brasília: PPGFAU, UnB, 2018.

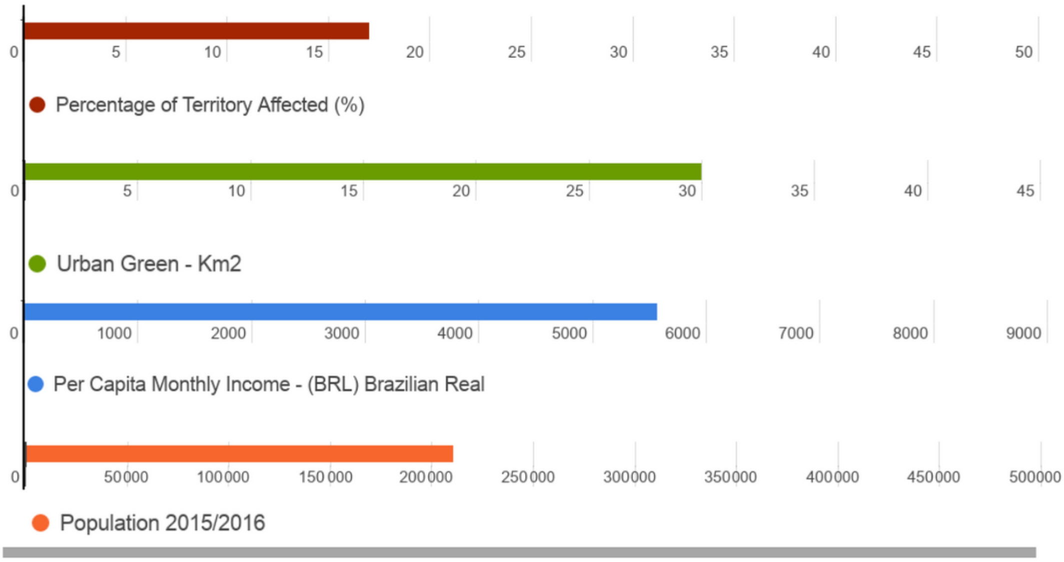
YU, C.-H. et al. Relationships between typhoons, climate and crime rates in Taiwan. **Natural Hazards**, v. 89, p. 871-897, August 2017.

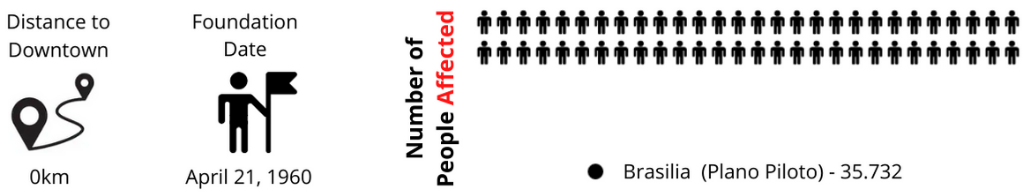
APPENDIXES

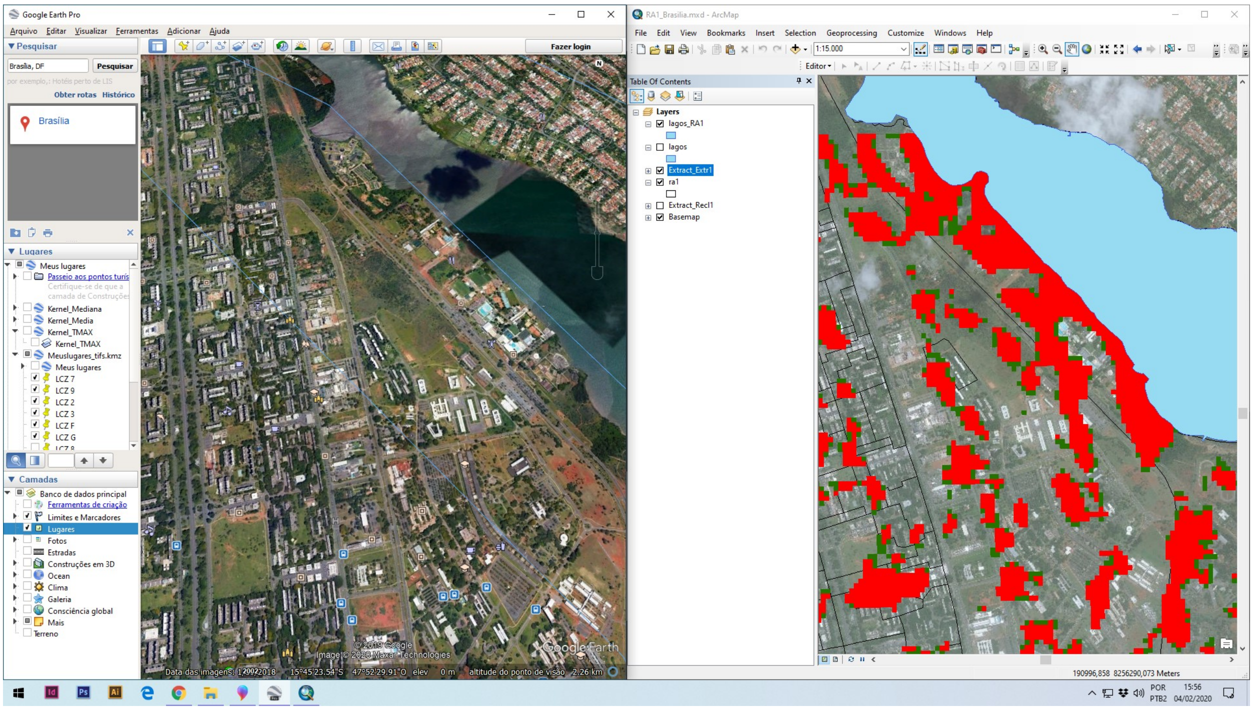
The following appendixes bring the hotspots correlation maps and its infographics, and HD imagery samples of urban tissues having correlation hotspots.

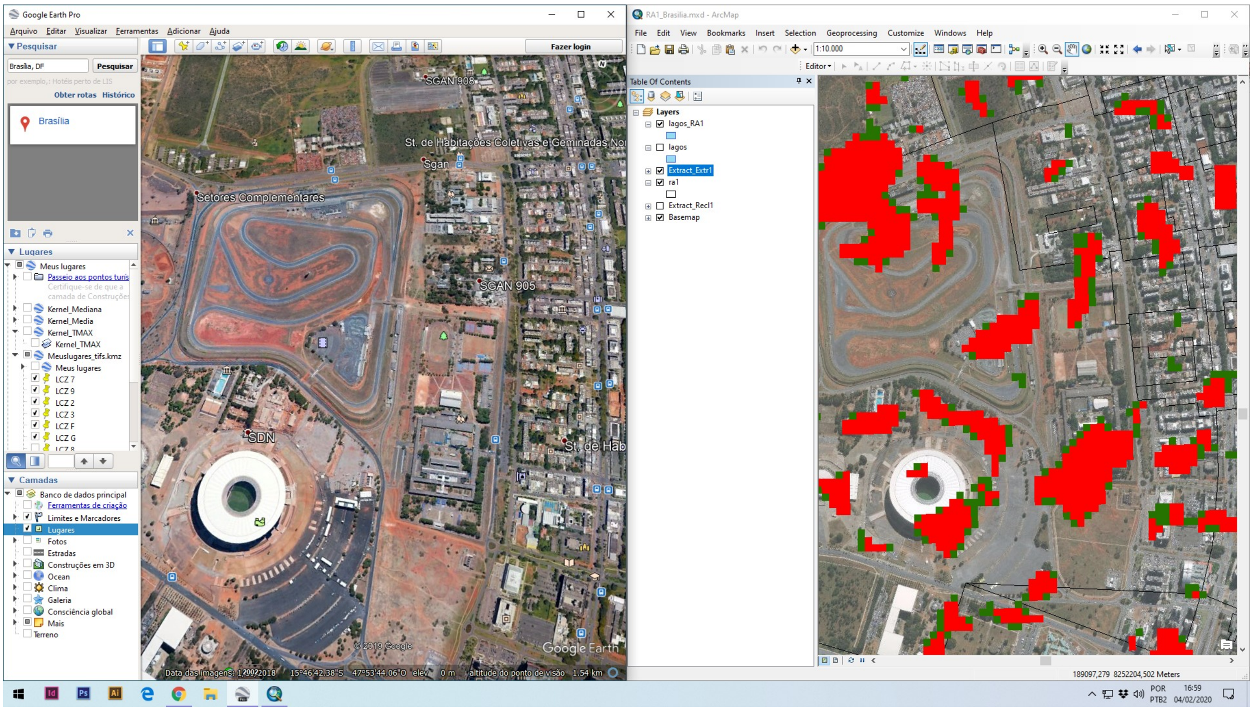
Appendix 1 RA I Brasília



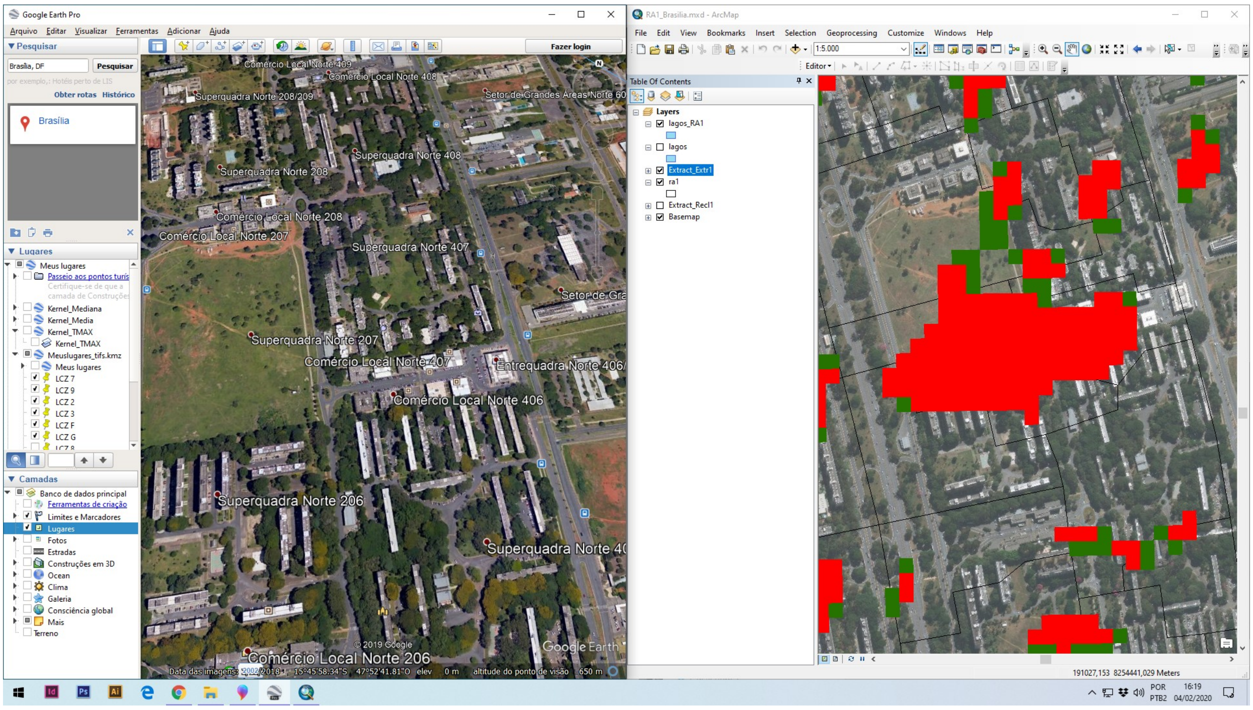




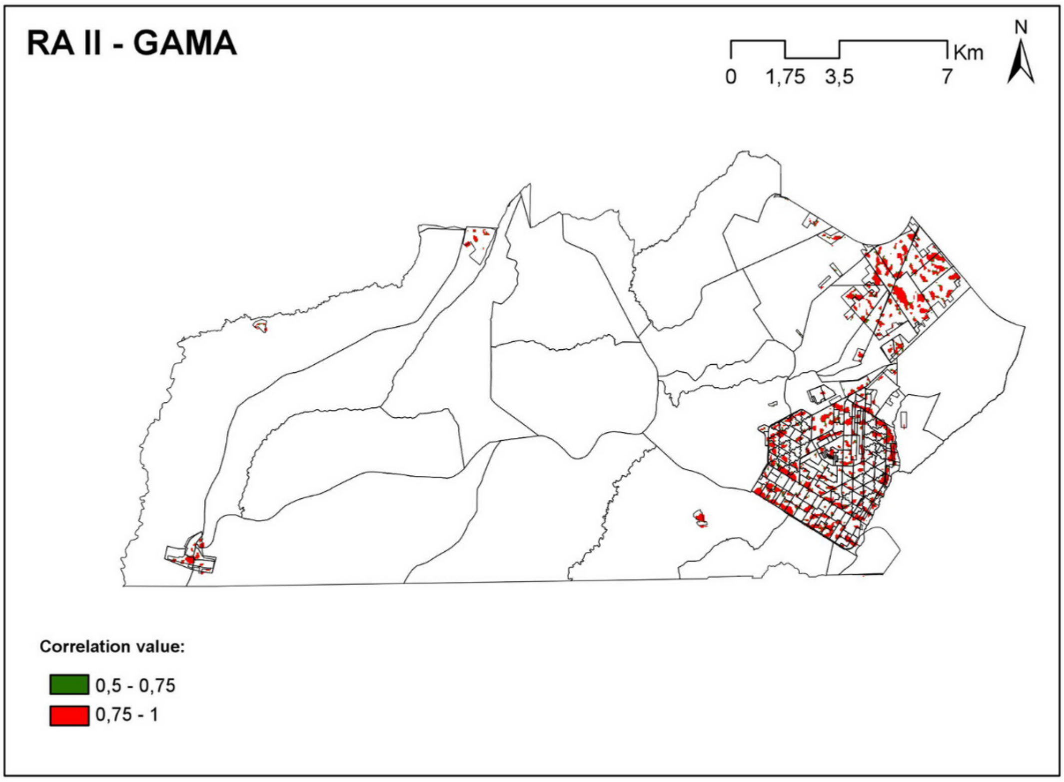


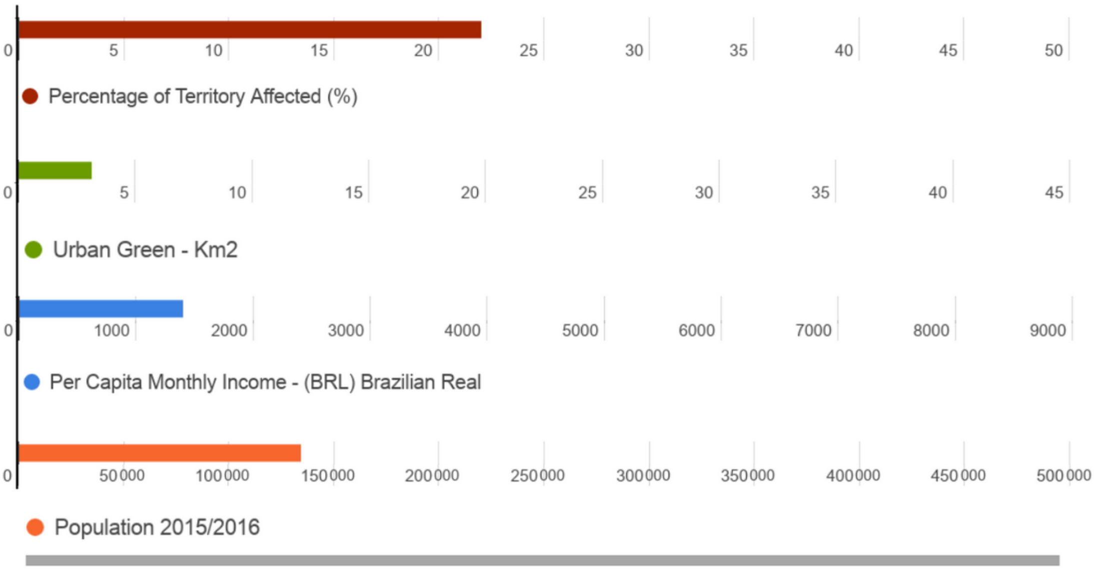


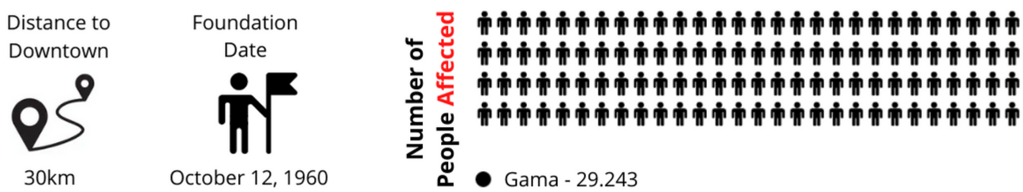
RA I Brasília – Sample 3



Appendix 2 RA II - Gama

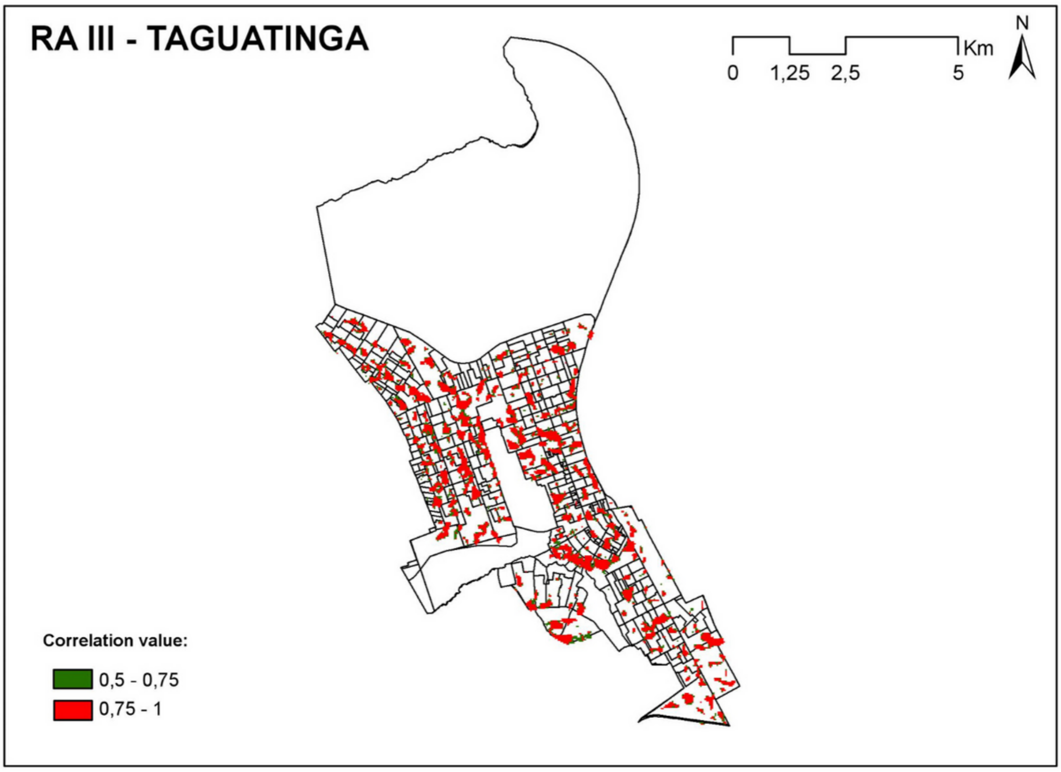


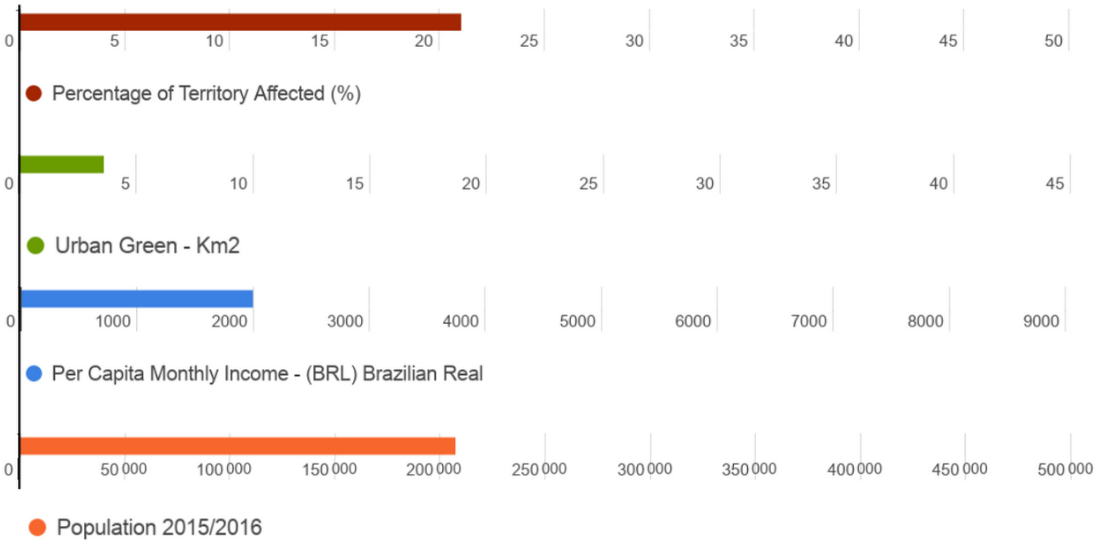


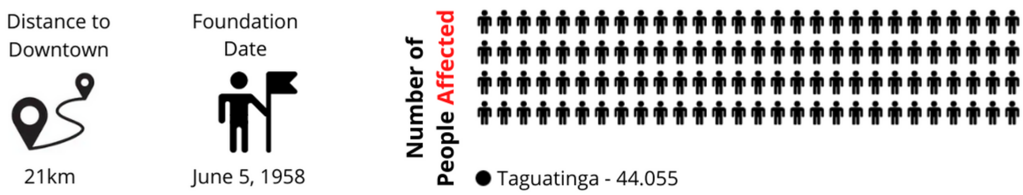


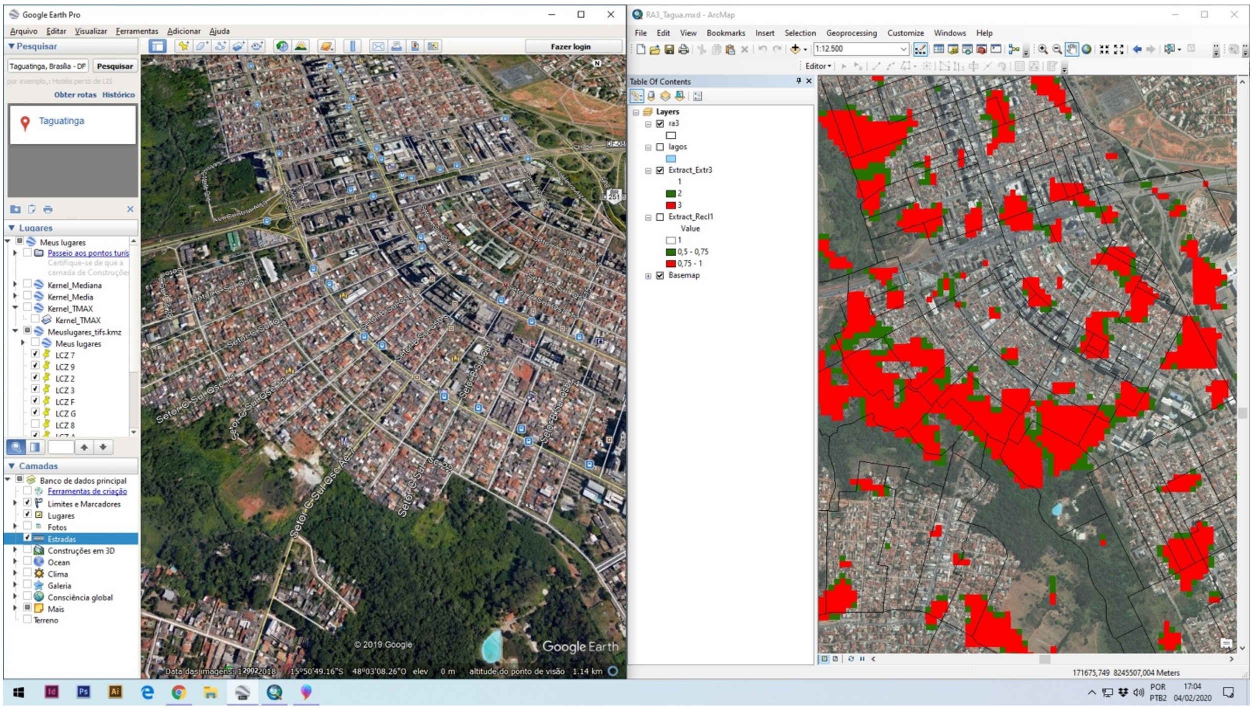
RA II Gama - Due to the covid-19 pandemics, Gama HD Imagery is missing.

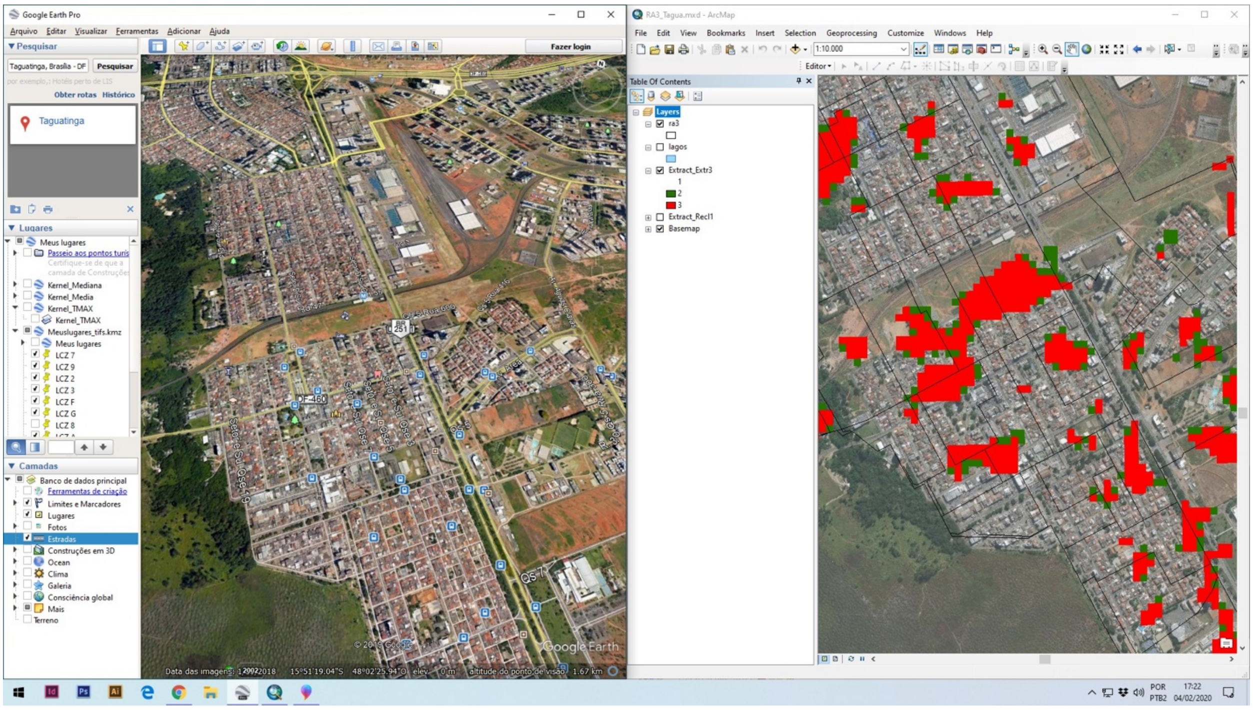
Appendix 3 RA III - Taguatinga

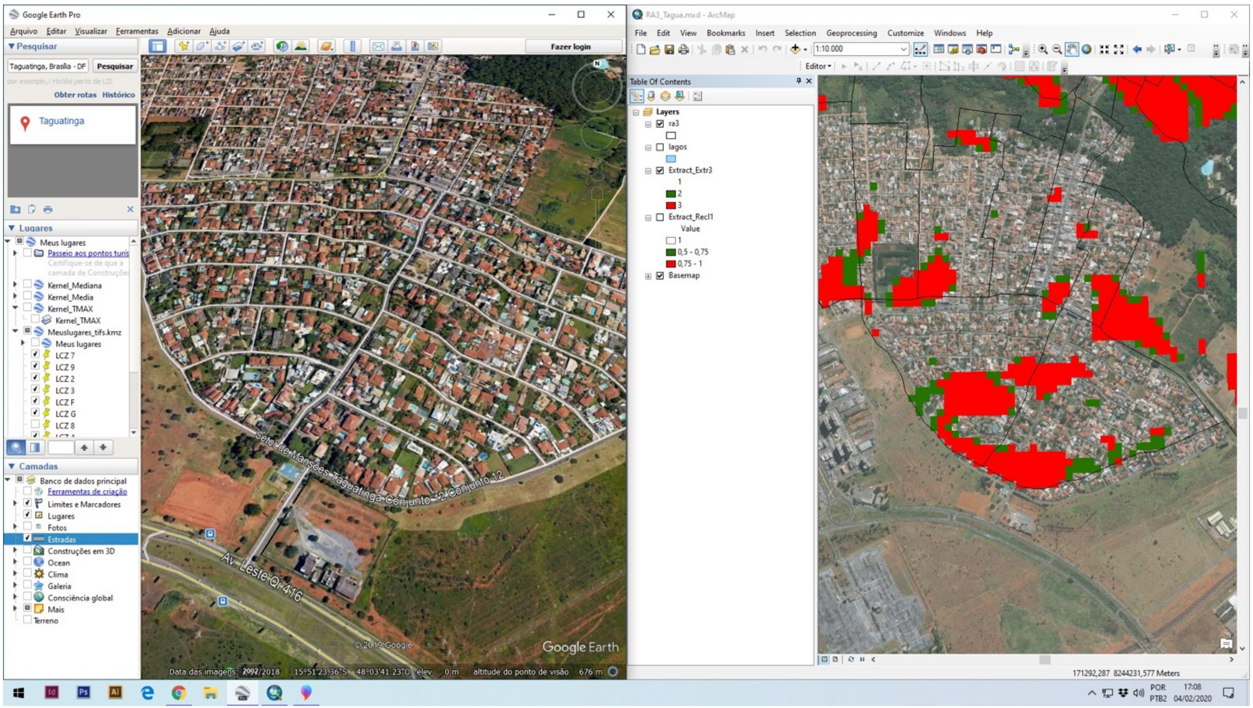




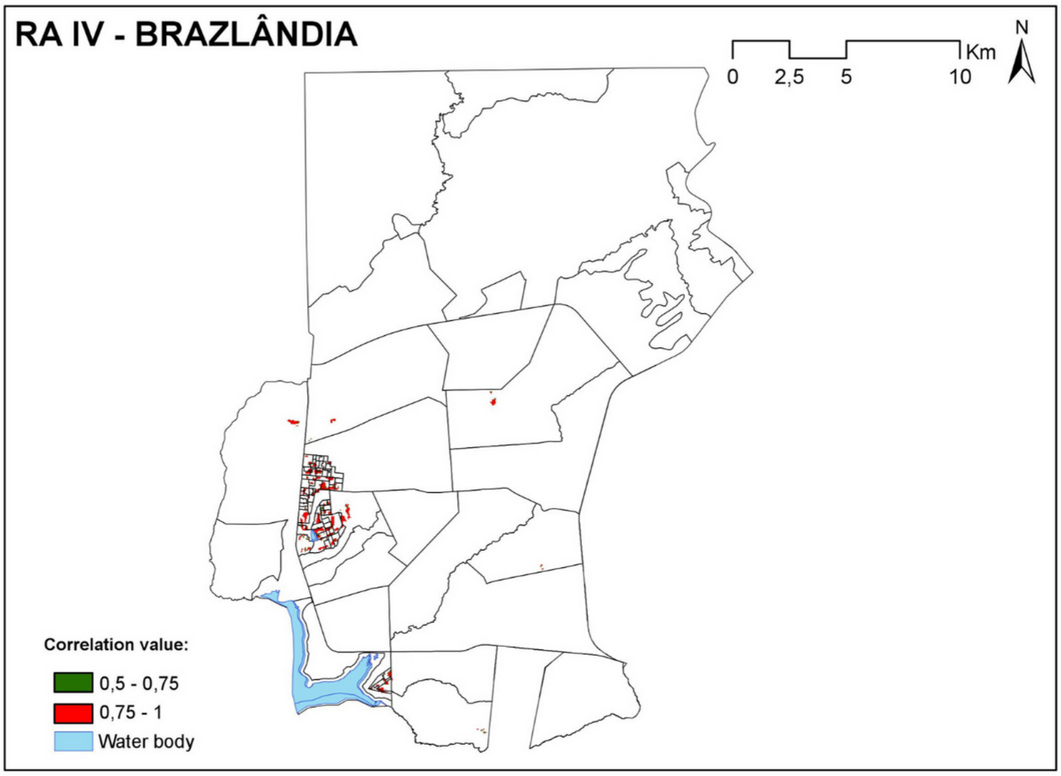


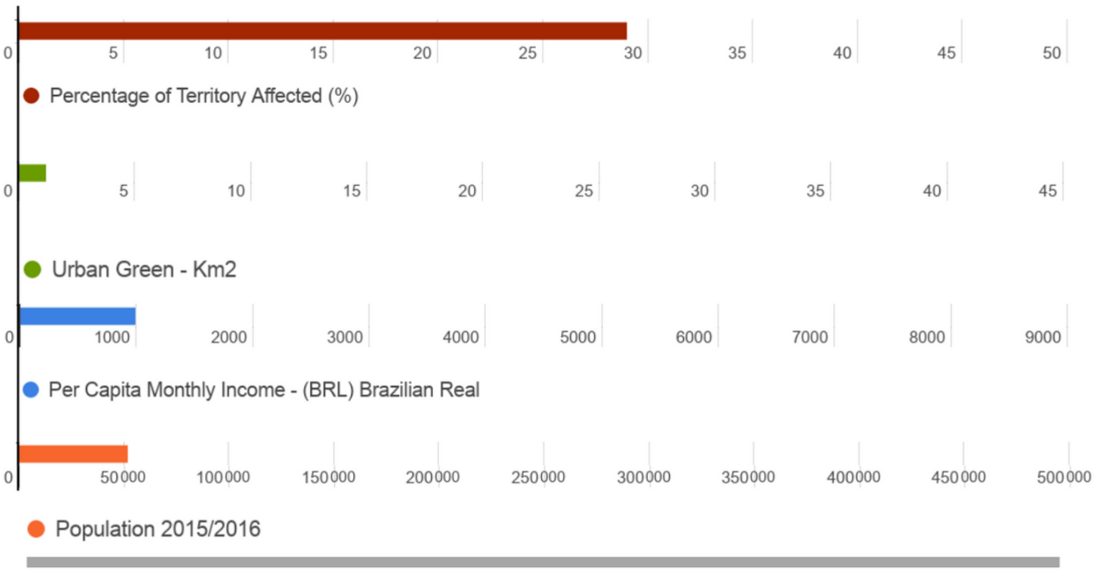

Google Earth Pro
Taguatinga
RA3_Tagua.mxd - ArcMap
Table Of Contents
Layers
ra3
lagos
Extract_Extr3
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
© 2019 Google
Google Earth
171675,749 8245507,004 Meters

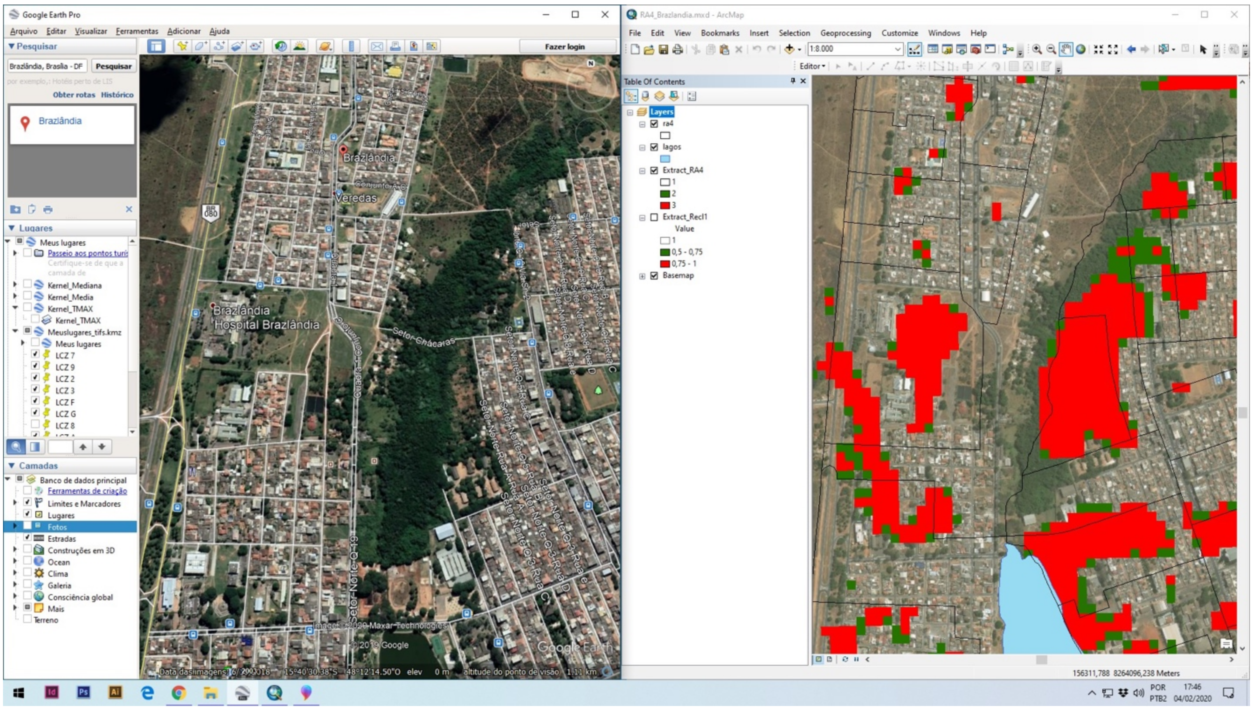

Google Earth Pro
Taguatinga
RA3_Tagua.mxd - ArcMap
Table Of Contents
Layers
ra3
lagos
Extract_Extr3
Extract_Recl1
Basemap
Google Earth

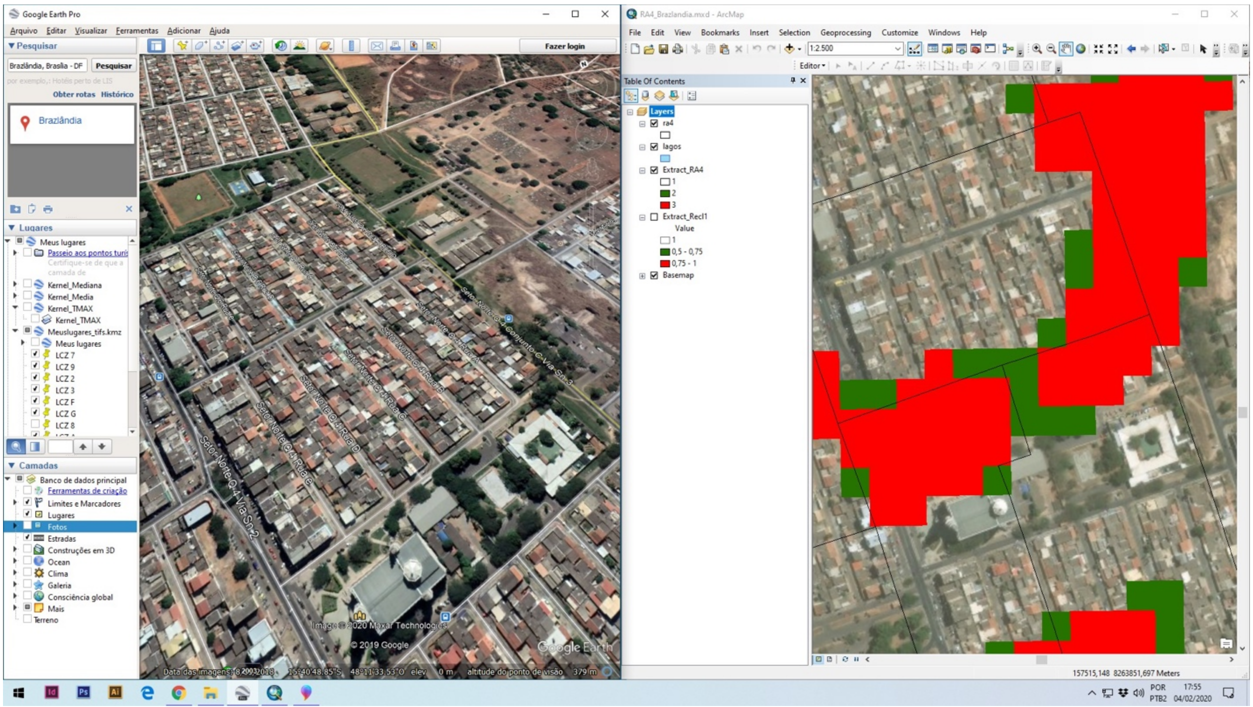

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Taguatinga, Brasília - DF
Pesquisar
Obter rotas Histórico
Taguatinga
Lugares
Meus lugares
Passeio aos pontos turís
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Ferramentas de criação
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
Av. Leste Q 416
Google Earth
RA3_Tagua.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:10.000
Table Of Contents
Layers
ra3
lagos
Extract_Extr3
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
171292,287 8244231,577 Meters
POR
PTB2
17:08
04/02/2020

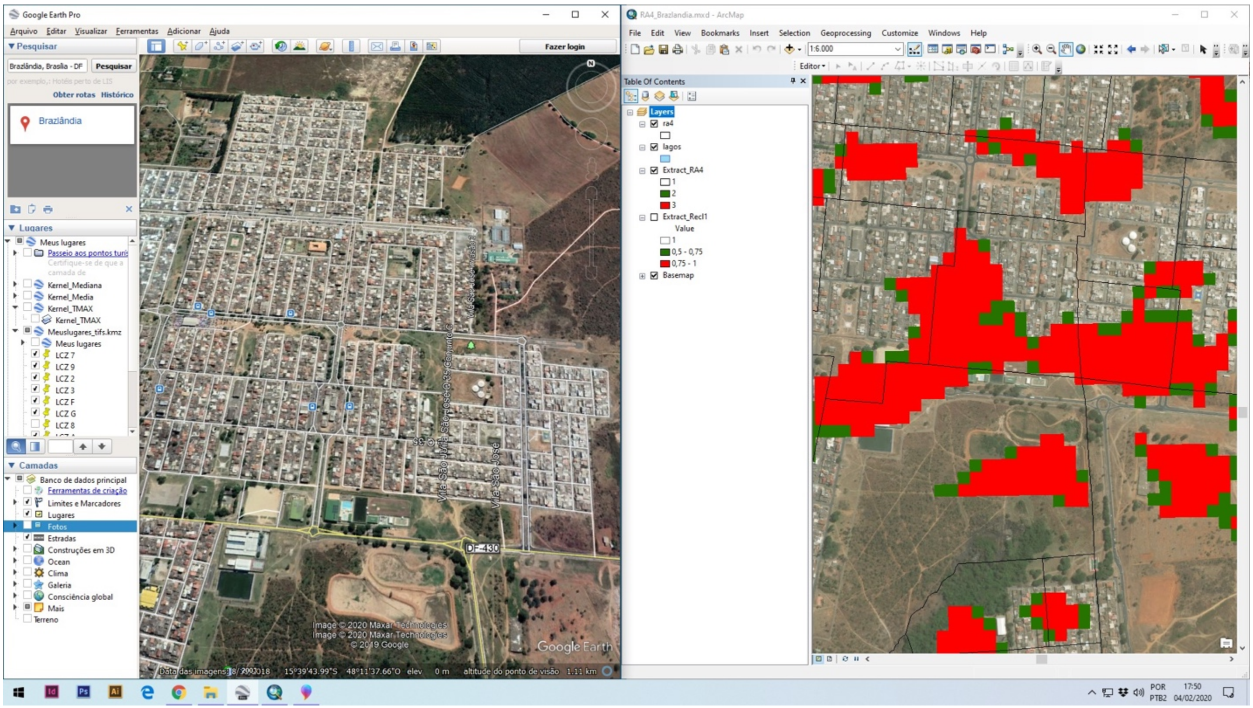
Appendix 4 RA IV - Brazlândia



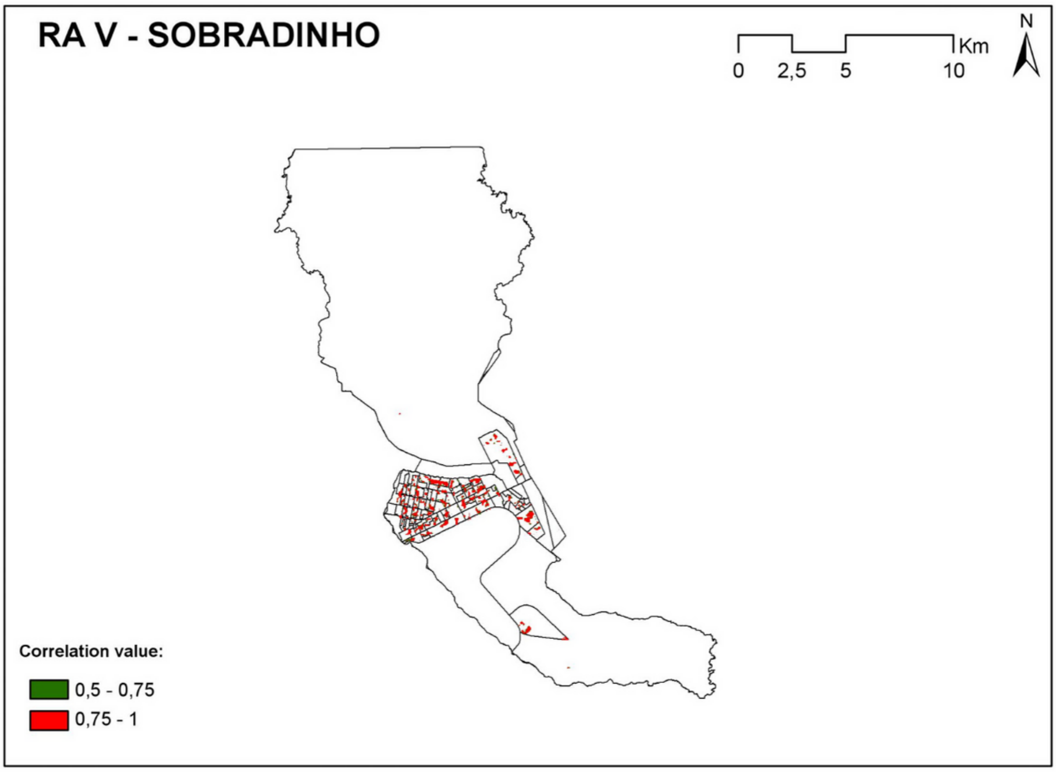


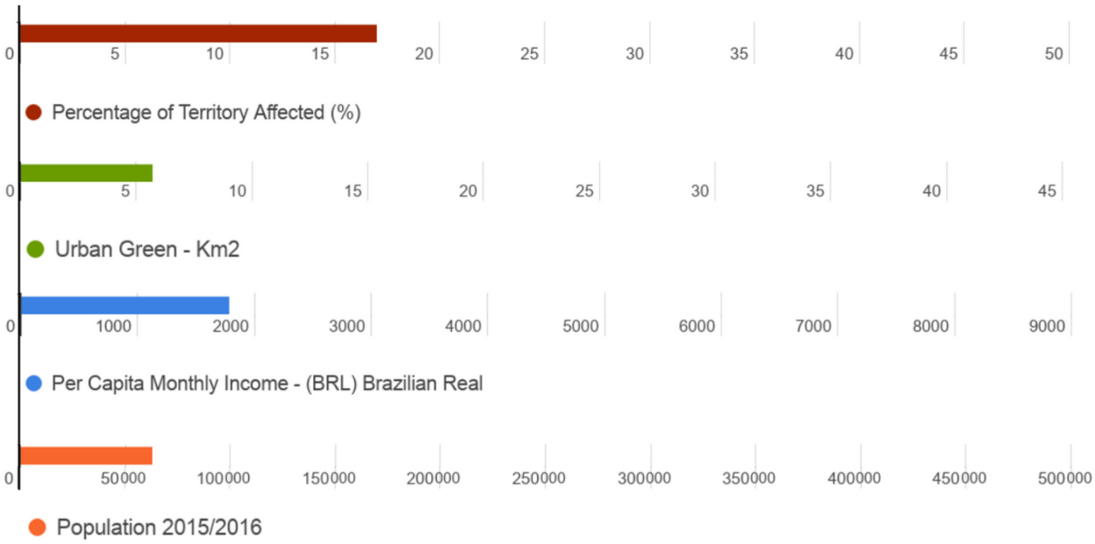

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Brazlândia
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Brazlândia
Veredas
Hospital Brazlândia
Setor Chácaras
RA4_Brazlandia.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra4
lagos
Extract_RA4
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
156311,788 8264096,238 Meters

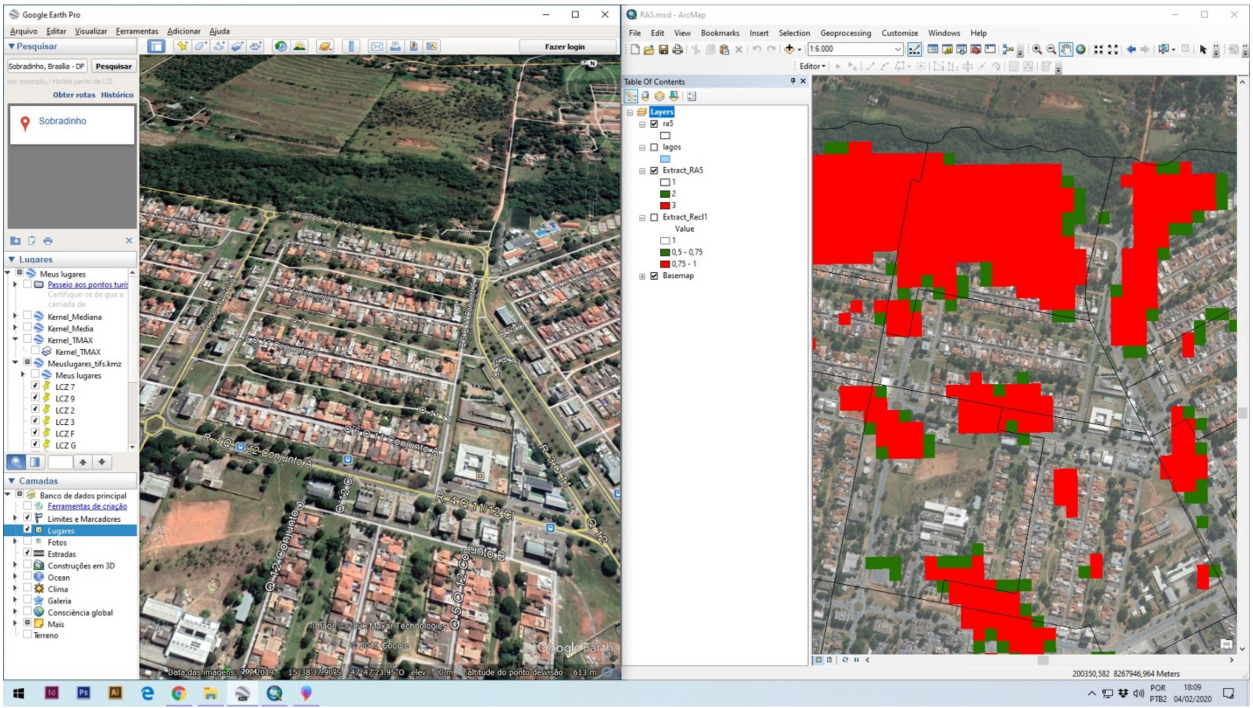

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Brazlândia
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
© 2019 Google
RA4_Brazlandia.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra4
lagos
Extract_RA4
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
157515,148 8263851,697 Meters

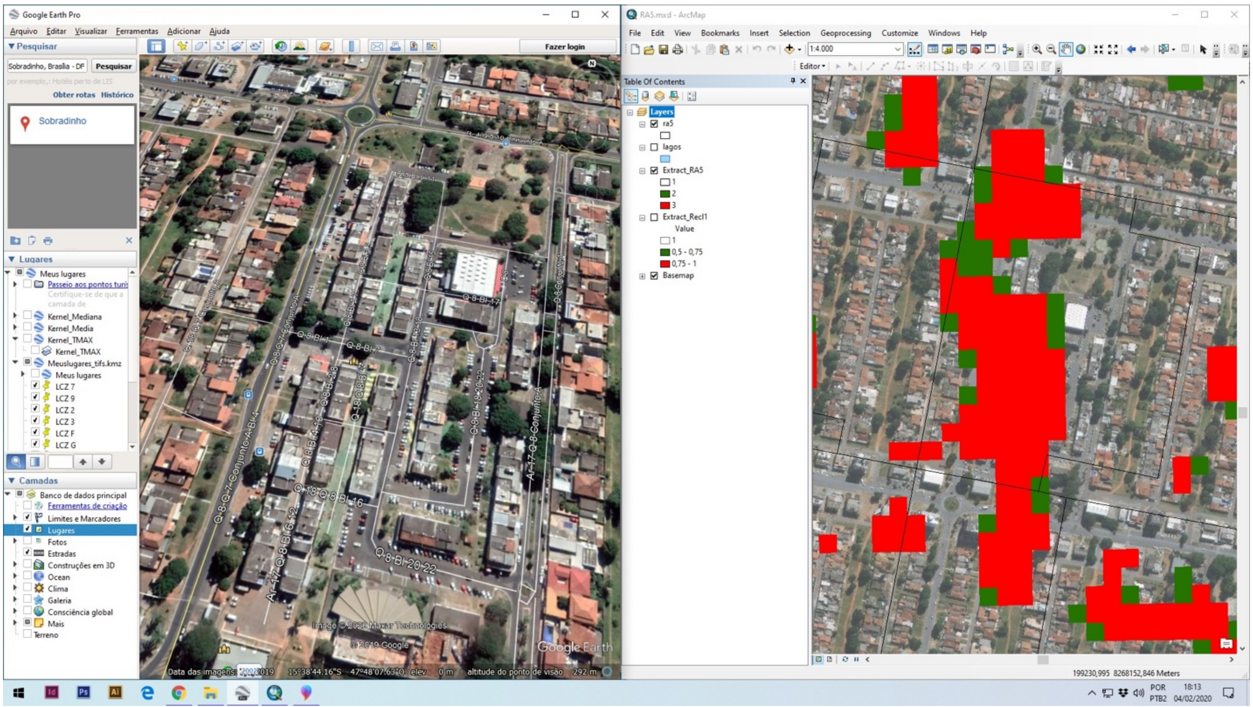

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Brazlândia, Brasília - DF
Pesquisar
Obter rotas Histórico
Brazlândia
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Ferramentas de criação
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
DF-430
Google Earth
RA4_Brazlandia.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:6.000
Editor
Table Of Contents
Layers
ra4
lagos
Extract_RA4
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
POR
PTB2
17:50
04/02/2020

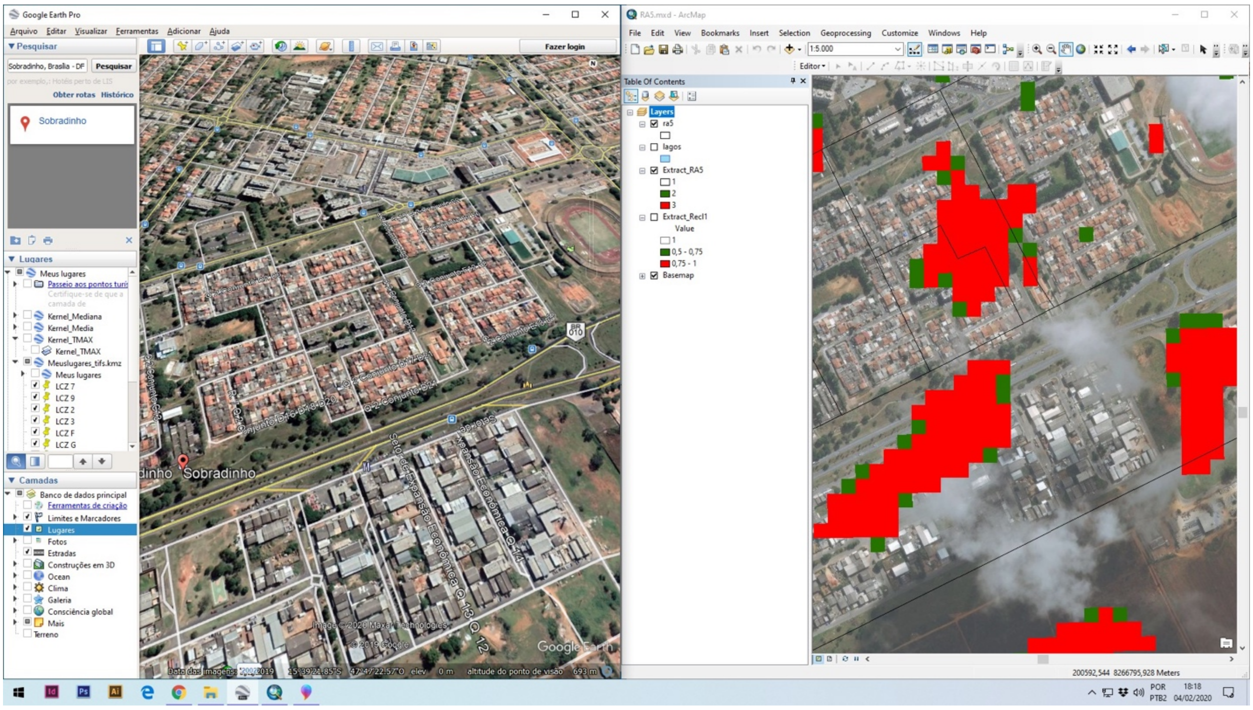
Appendix 5 RA V - Sobradinho



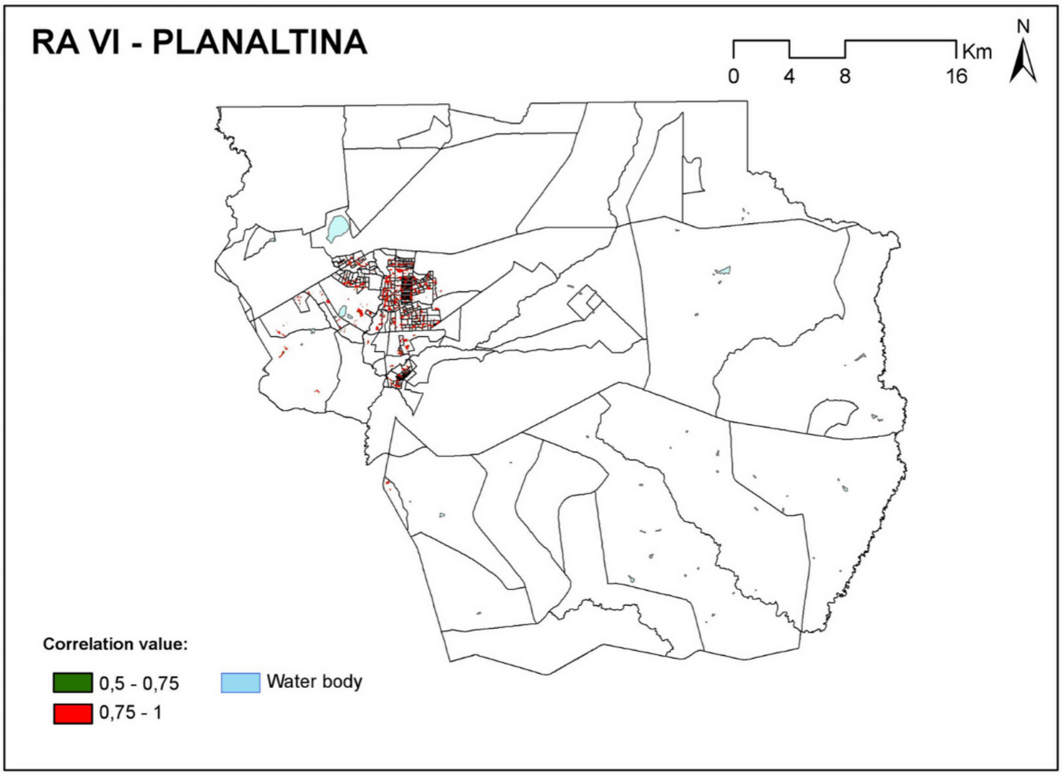


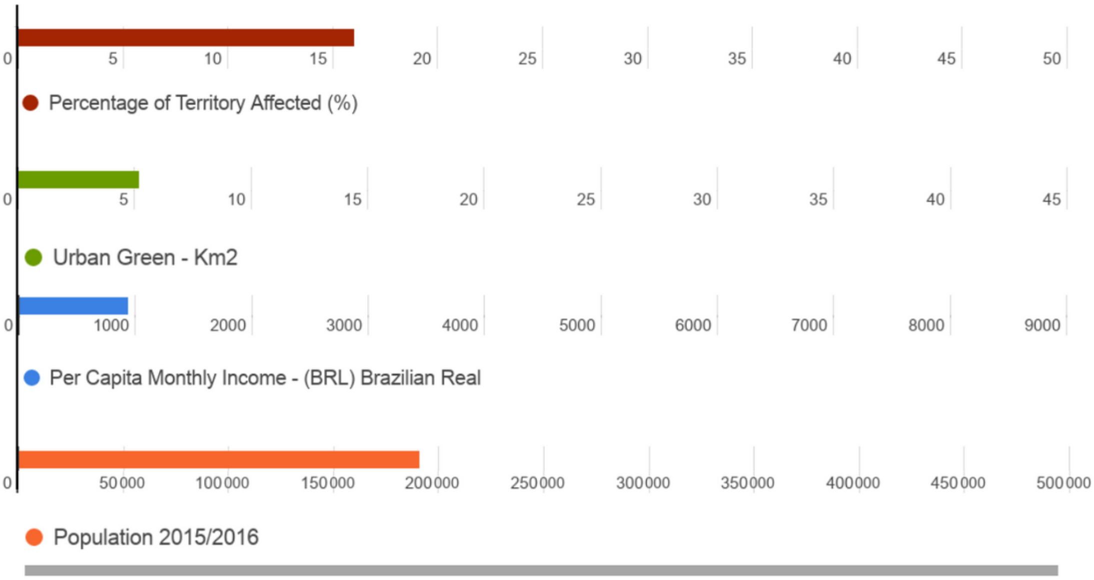

Google Earth Pro
RA5.mxd - ArcMap
Sobradinho
Table Of Contents
Layers
ra5
lagos
Extract_RA5
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Lugares
Camadas
Google Earth

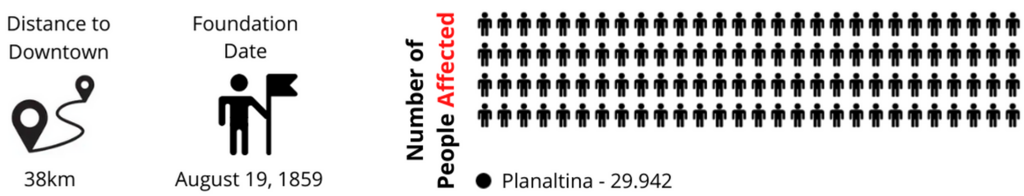

Google Earth Pro
RA5.mxd - ArcMap
Sobradinho
Table Of Contents
Layers
ra5
lagos
Extract_RA5
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Lugares
Camadas
Google Earth

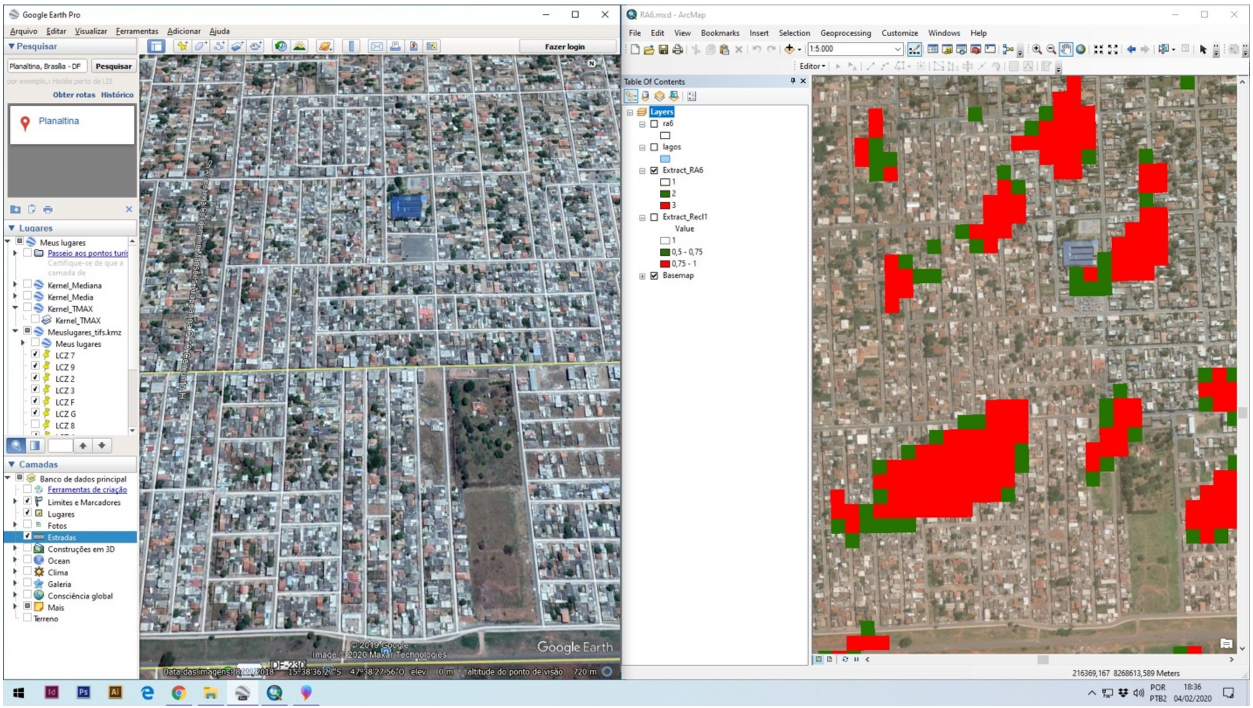

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Sobradinho, Brasília - DF
Pesquisar
Obter rotas Histórico
Sobradinho
Fazer login
Lugares
Meus lugares
Passeio aos pontos turís
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Ferramentas de criação
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Sobradinho
Google Earth
RA5.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:5.000
Editor
Table Of Contents
Layers
ra5
lagos
Extract_RA5
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
200592,544 8266795,928 Meters
POR PTB2
18:18
04/02/2020

Appendix 6 RA VI - Planaltina

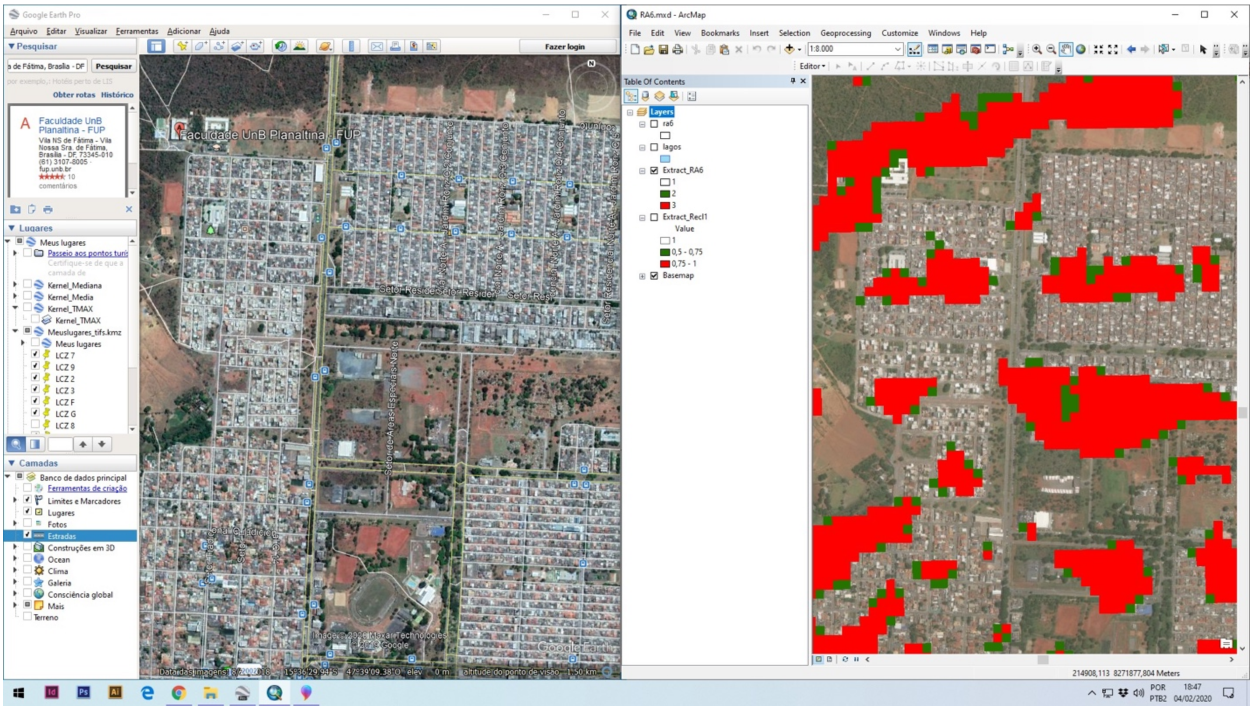


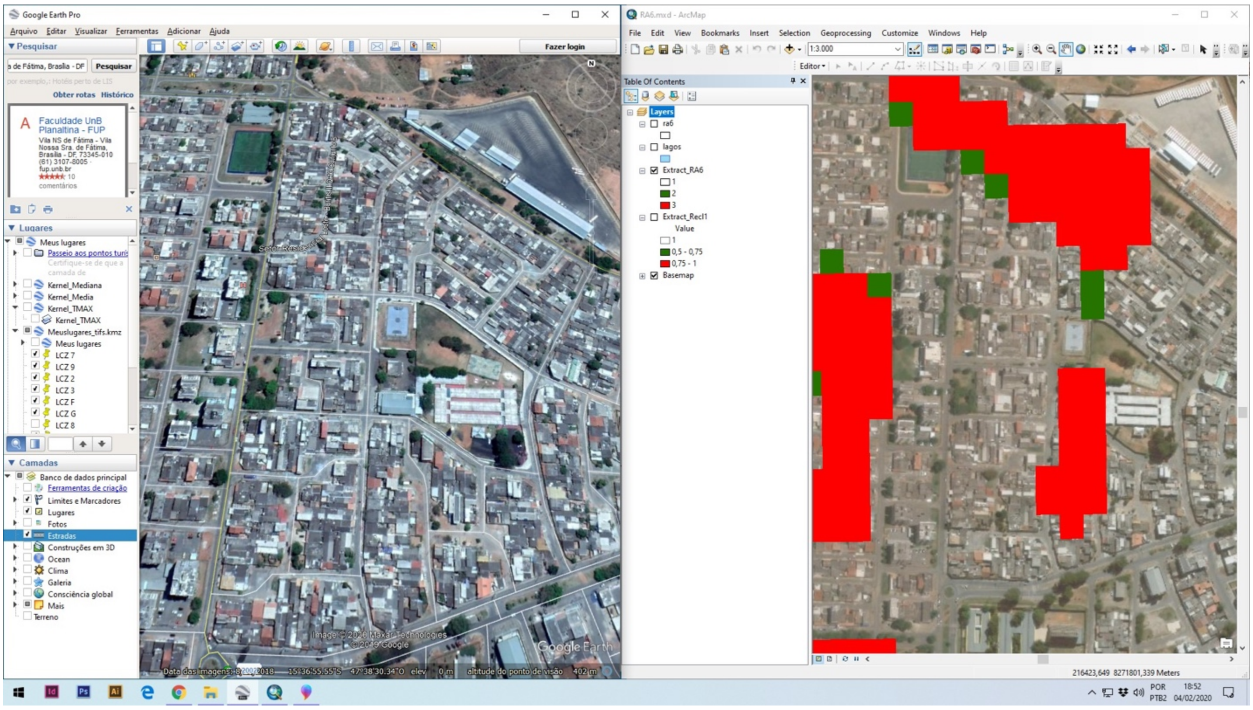




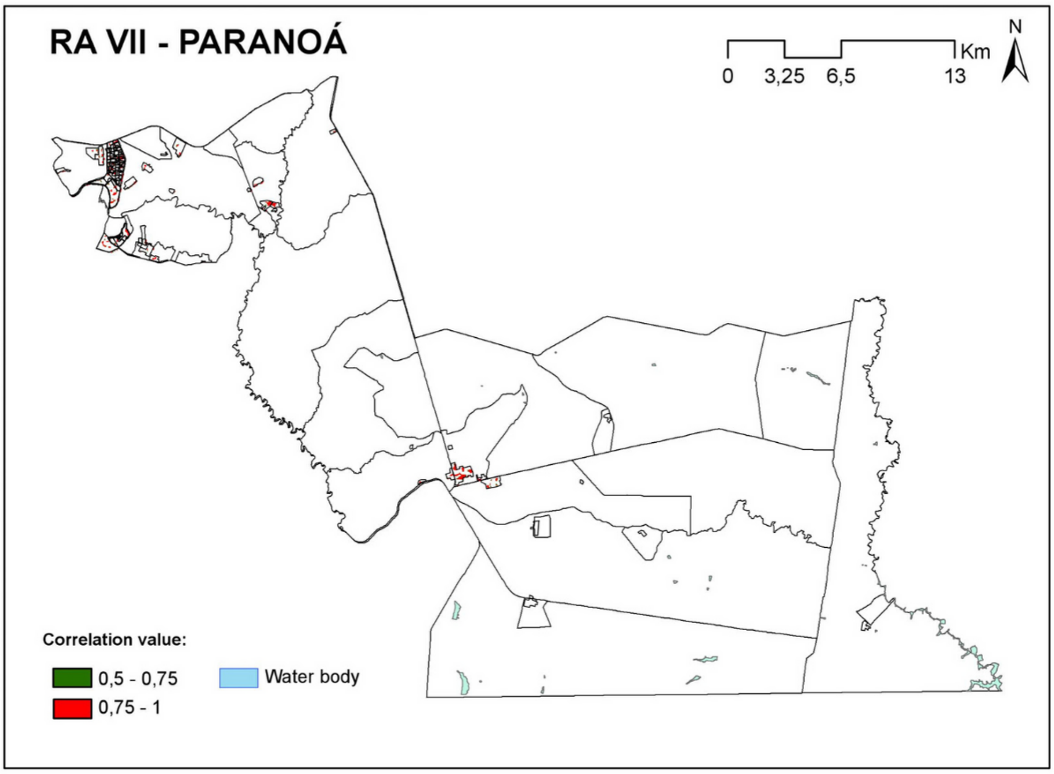


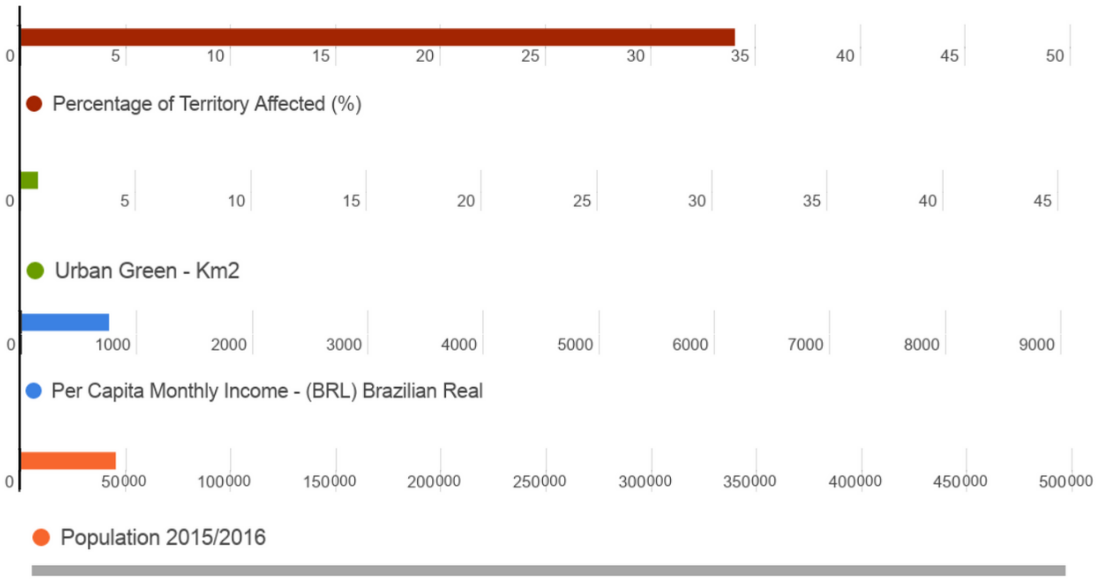
RA VI Planaltina – (Includes the UnB - FUB campus)

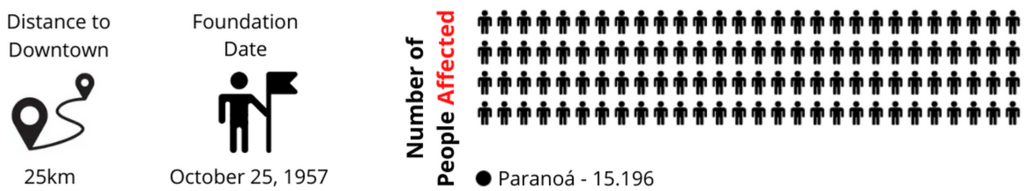


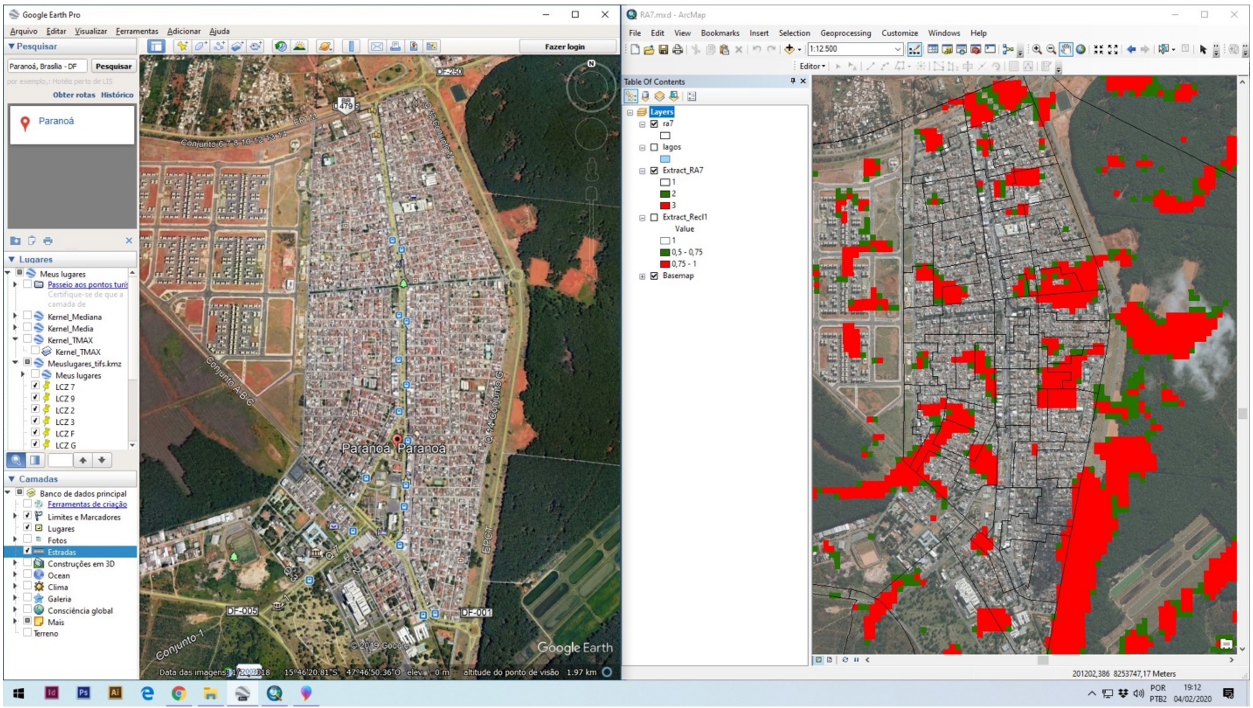


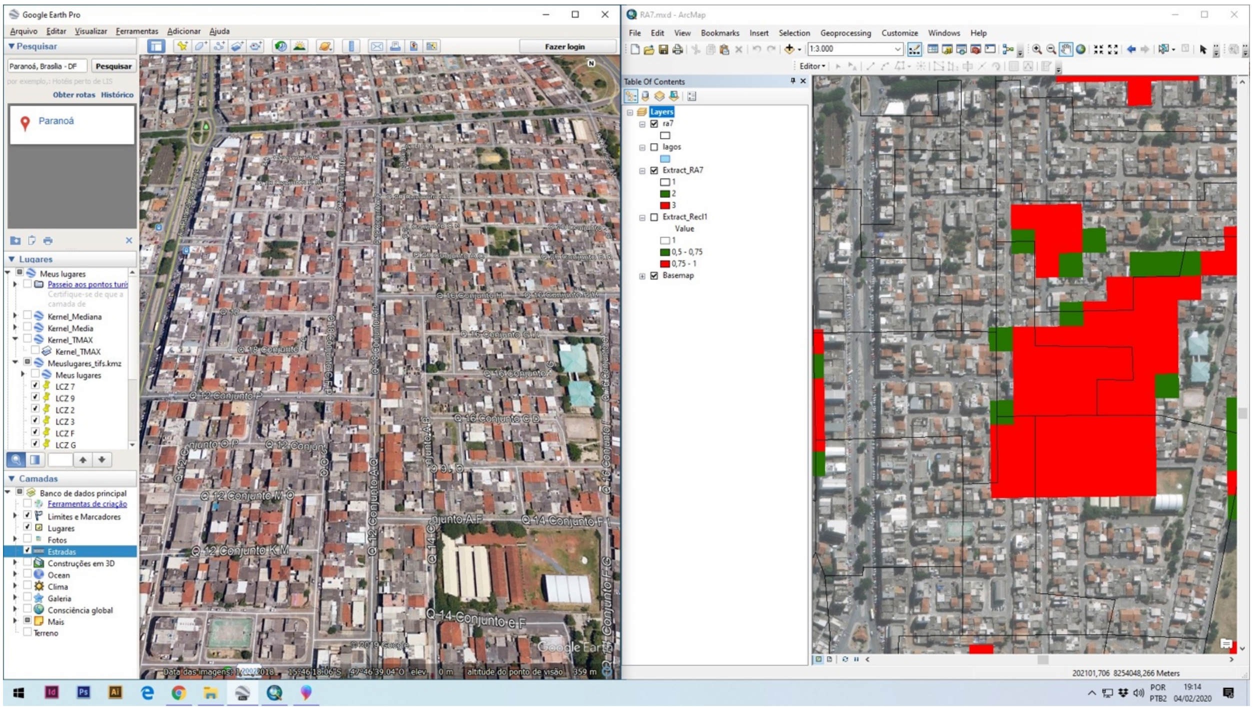
Appendix 7 RA VII - Paranoá

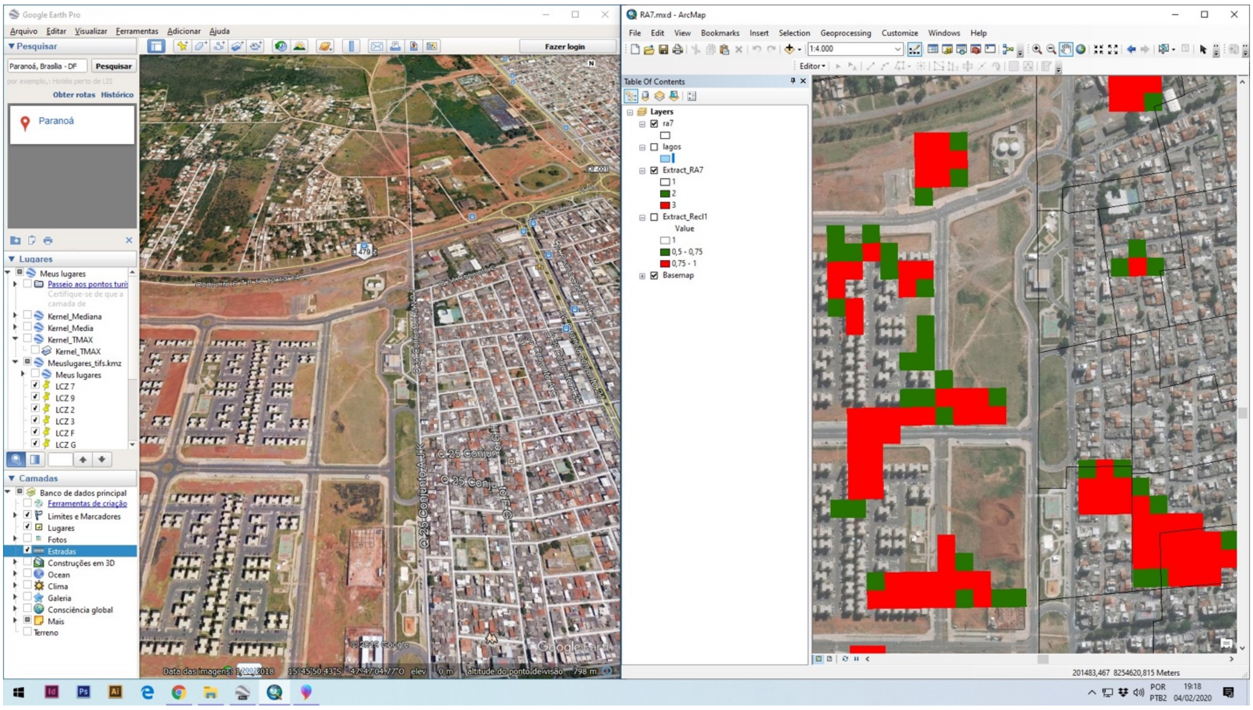




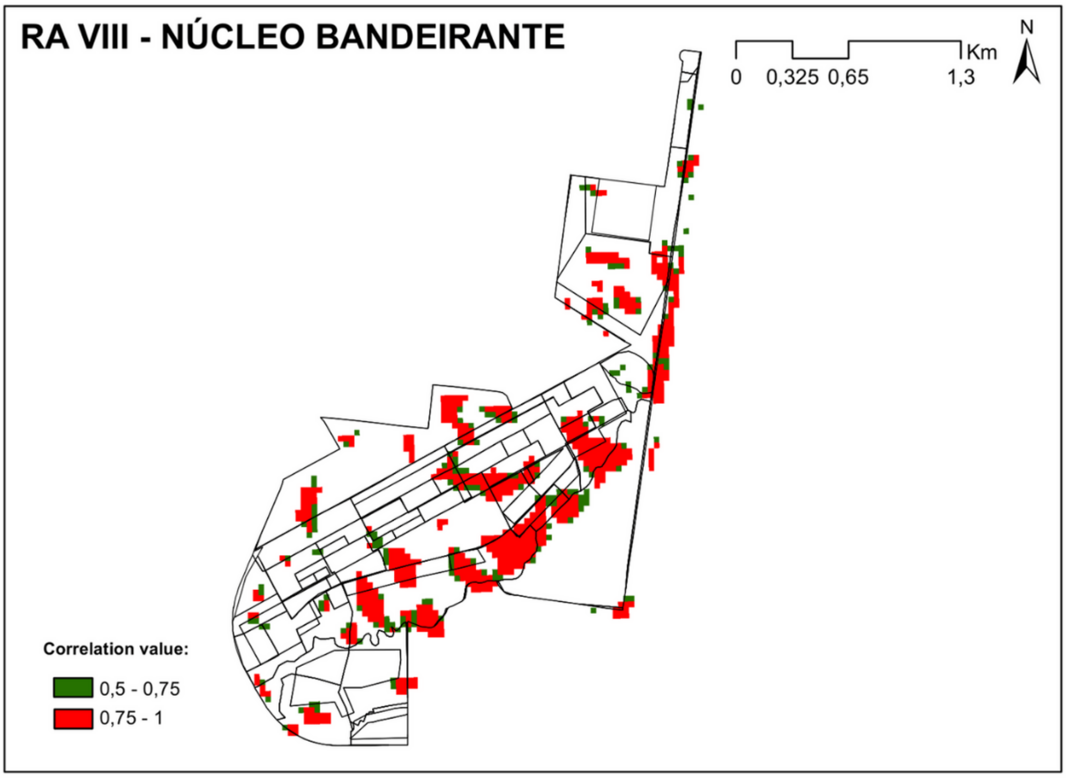


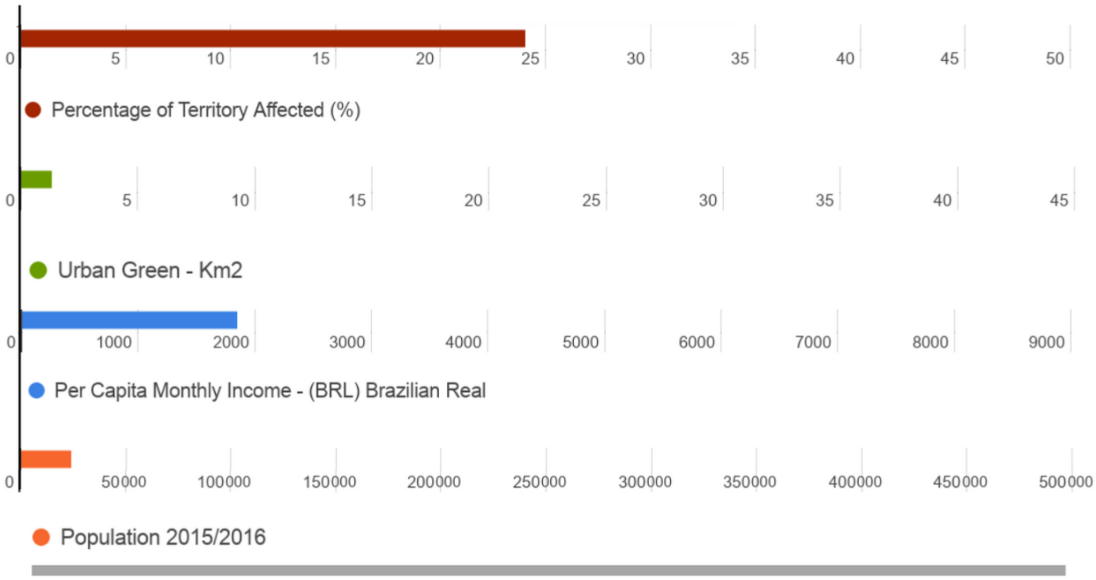

Google Earth Pro
RA7.mxd - ArcMap
Paranoá
Table Of Contents
Layers
ra7
lagos
Extract_RA7
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
Google Earth

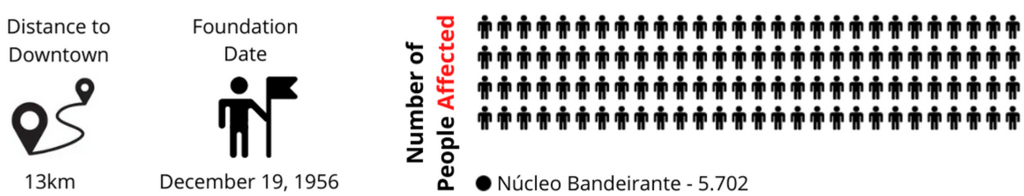

Google Earth Pro
RA7.mxd - ArcMap
Paranoá
Table Of Contents
Layers
ra7
lagos
Extract_RA7
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

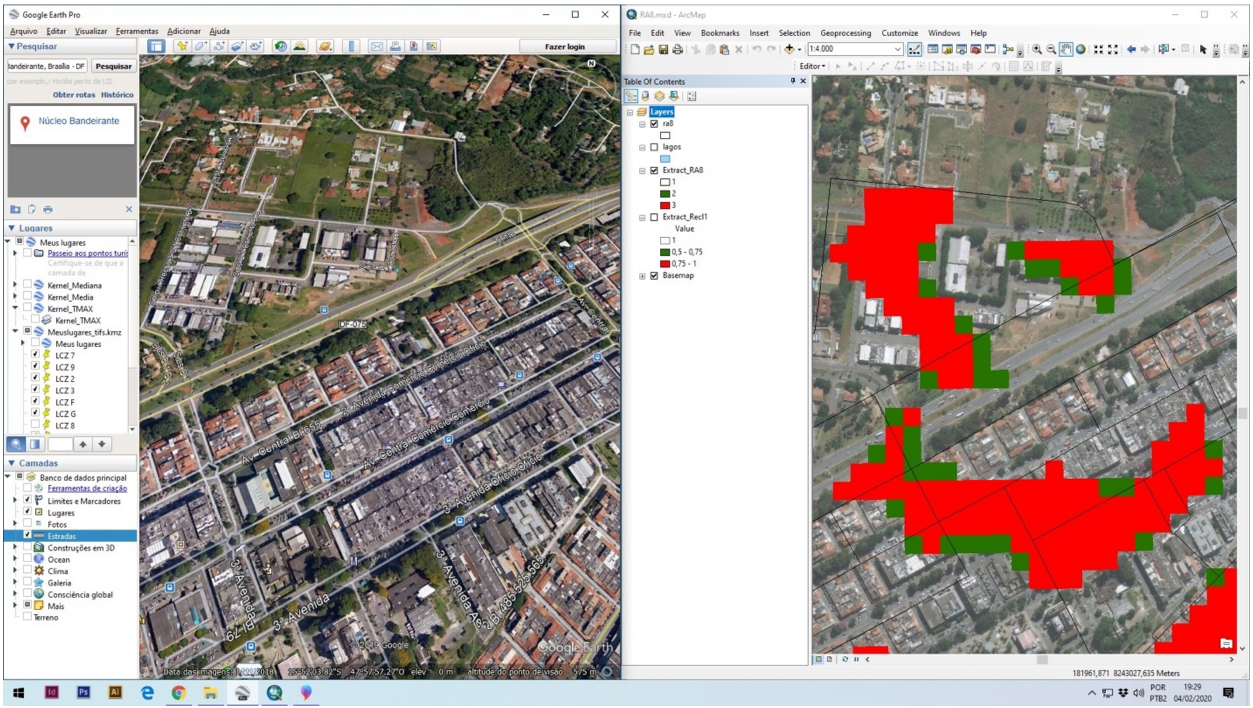


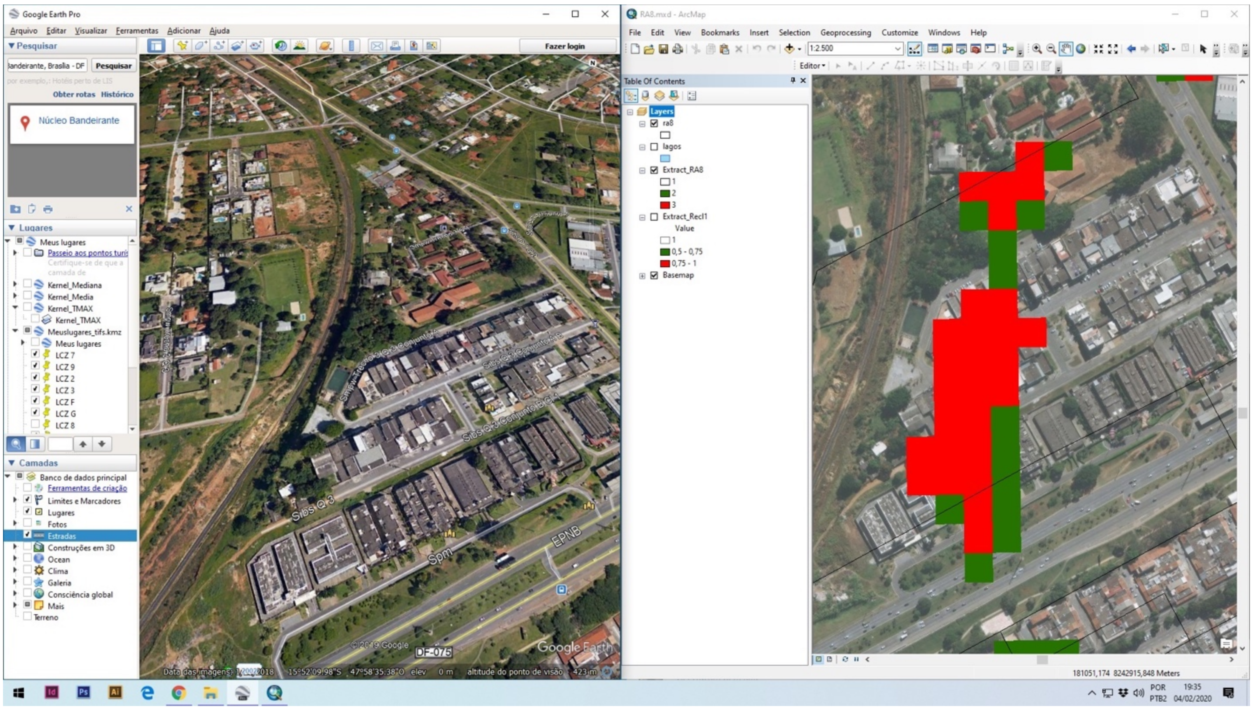
Appendix 8 RA VIII - Núcleo Bandeirante

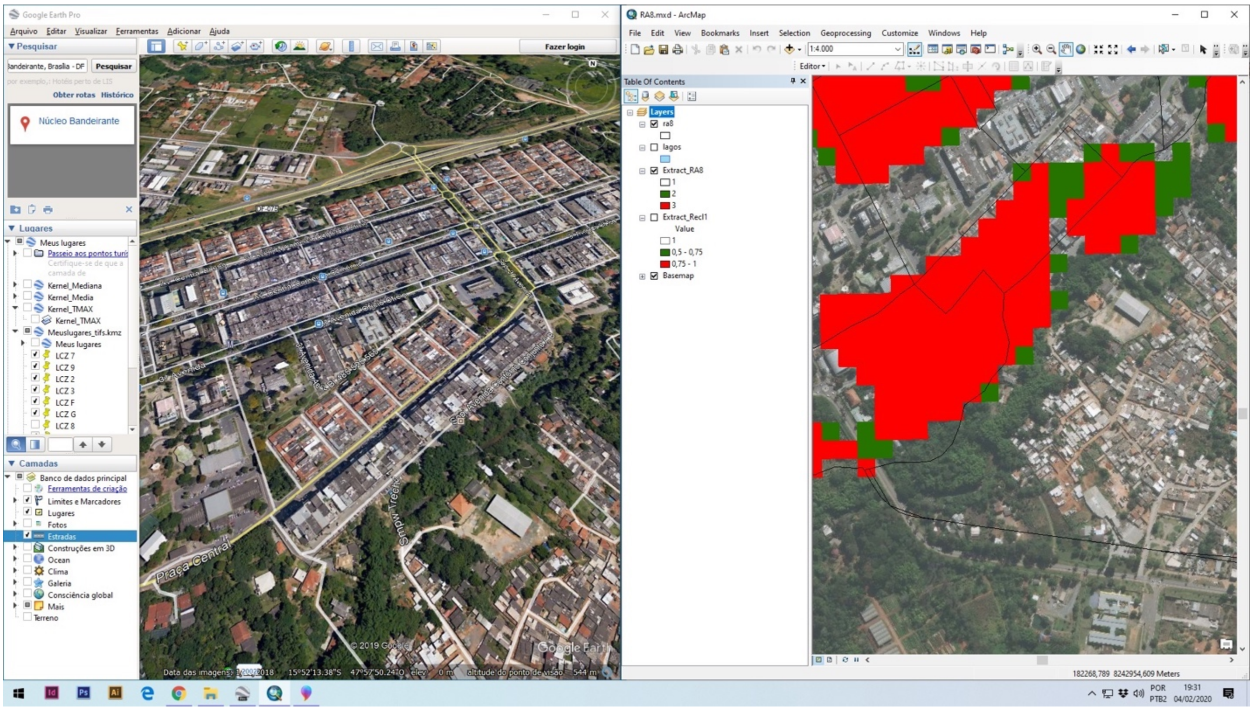




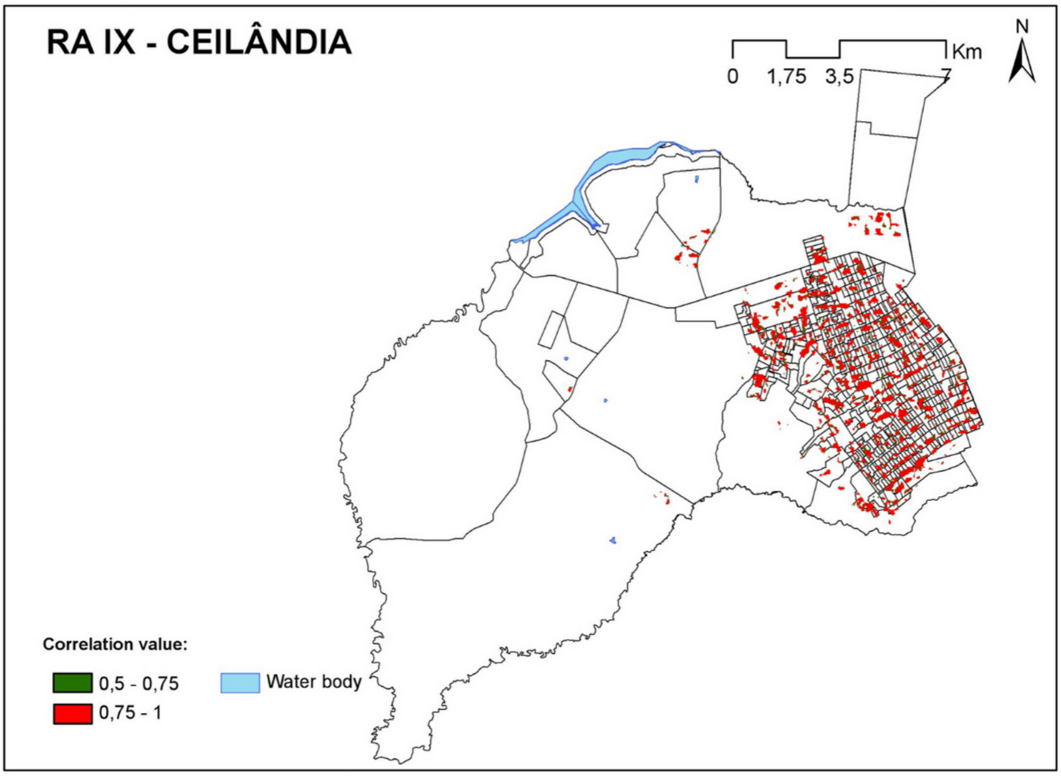


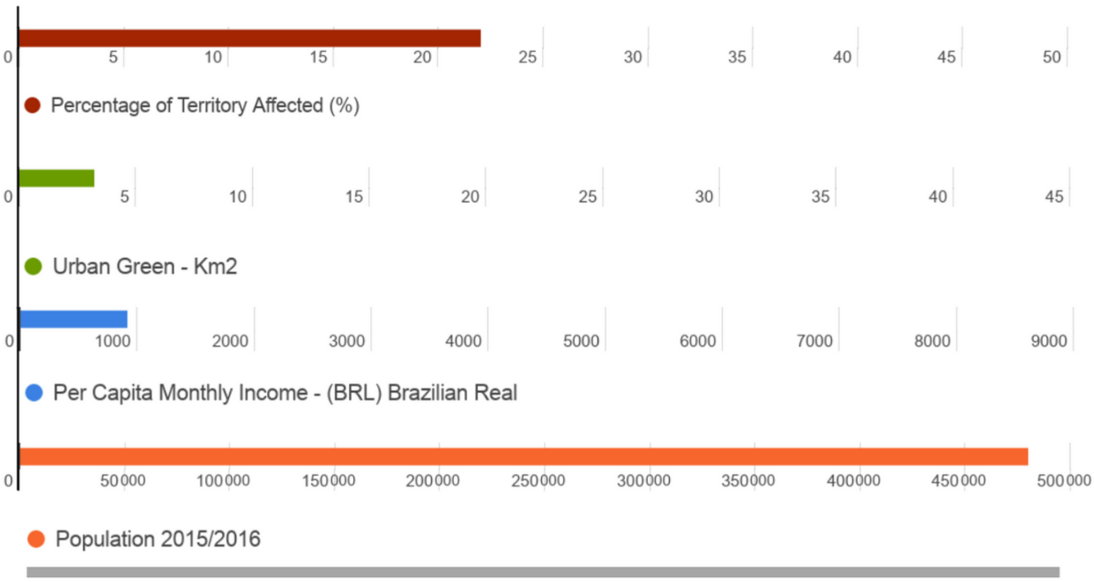

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Núcleo Bandeirante
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
RA8.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra8
lagos
Extract_RA8
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
181961,871 8243027,635 Meters

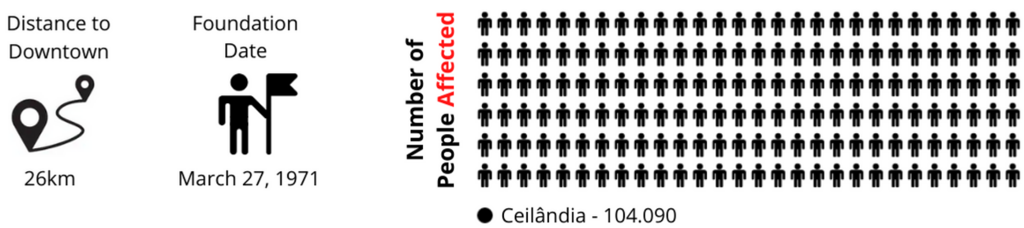

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Núcleo Bandeirante
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
RA8.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra8
lagos
Extract_RA8
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
181051,174 8242915,848 Meters

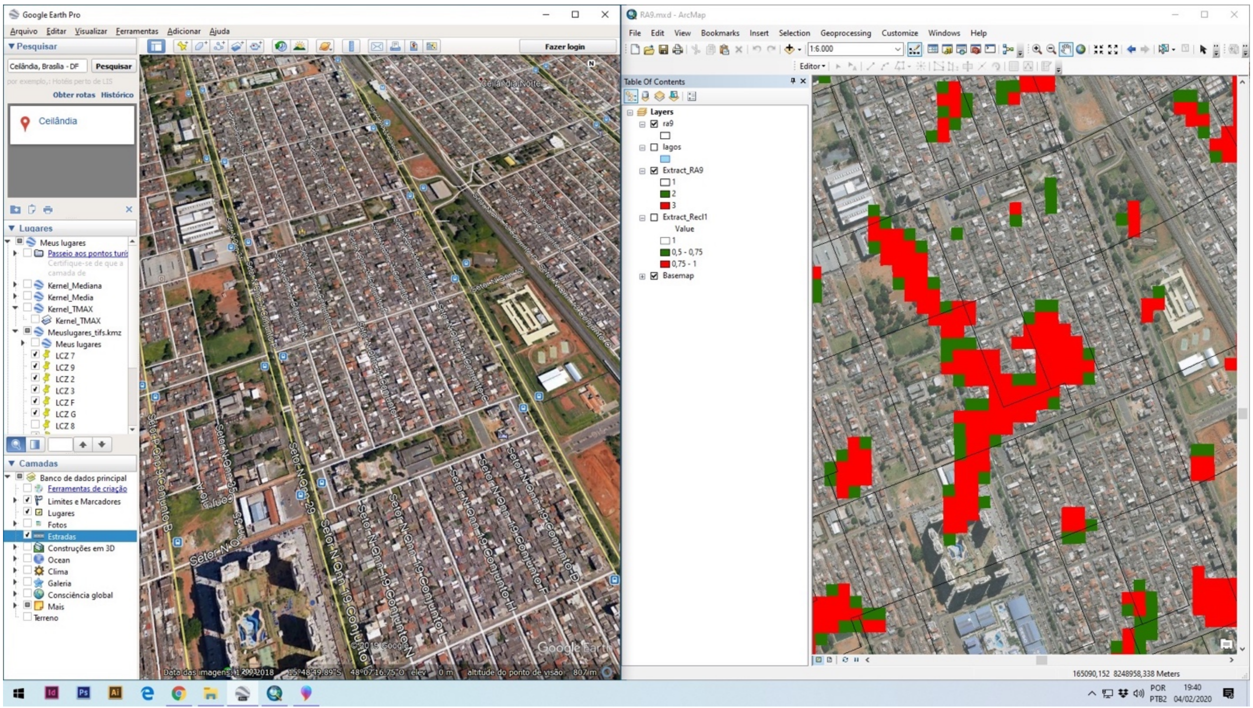

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Pesquisar
Obter rotas Histórico
Núcleo Bandeirante
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Ferramentas de criação
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
Praça Central
© 2019 Google
Google Earth
RA8.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4.000
Editor
Table Of Contents
Layers
ra8
lagos
Extract_RA8
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
182268,789 8242954,609 Meters
POR
PTB2
19:31
04/02/2020

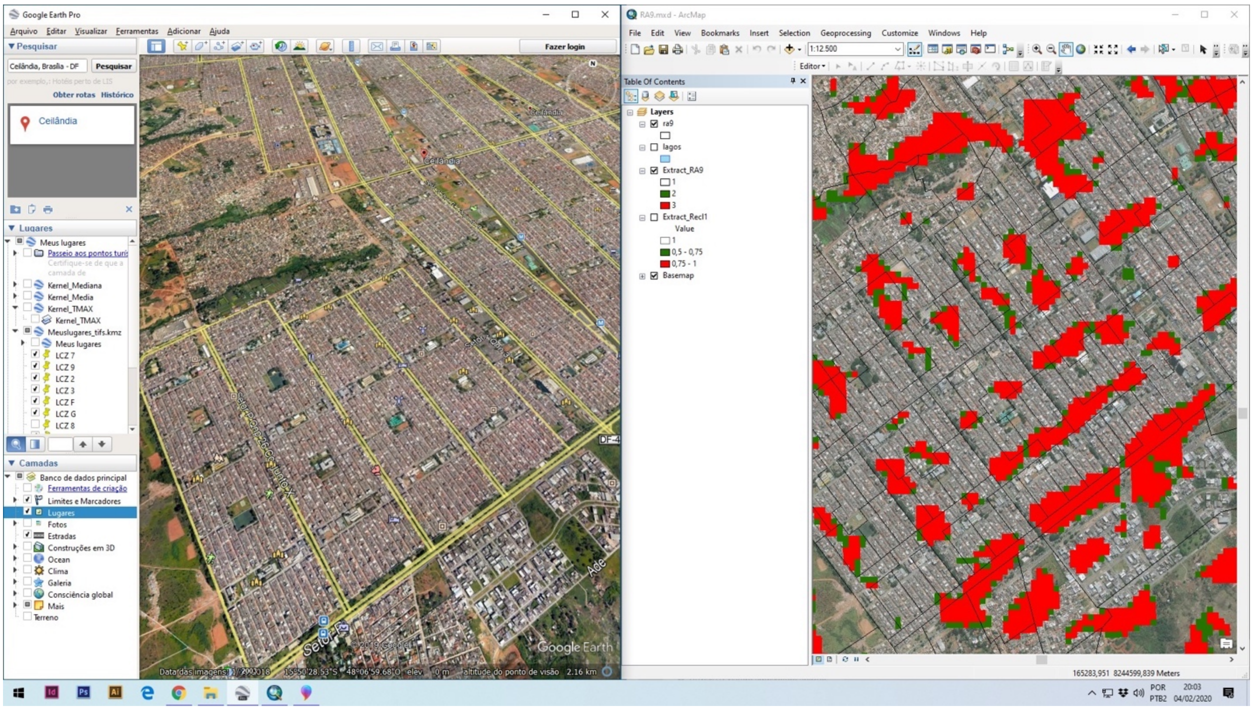
Appendix 9 RA IX - Ceilândia

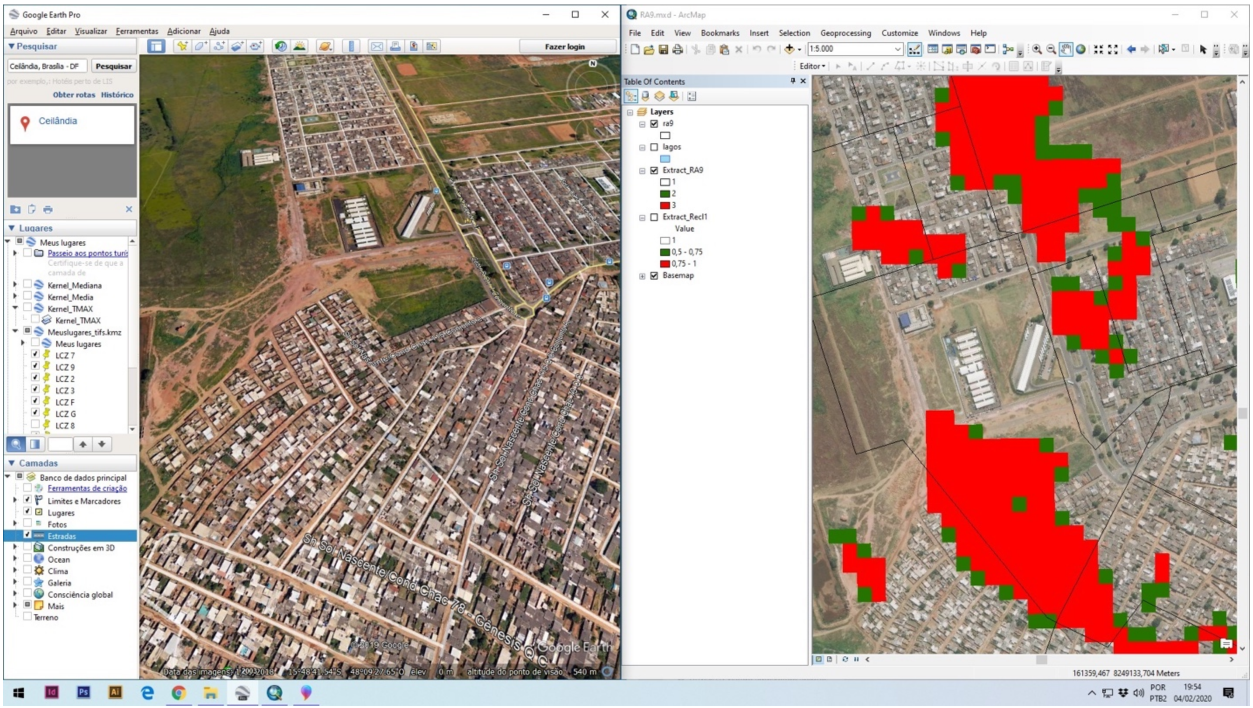




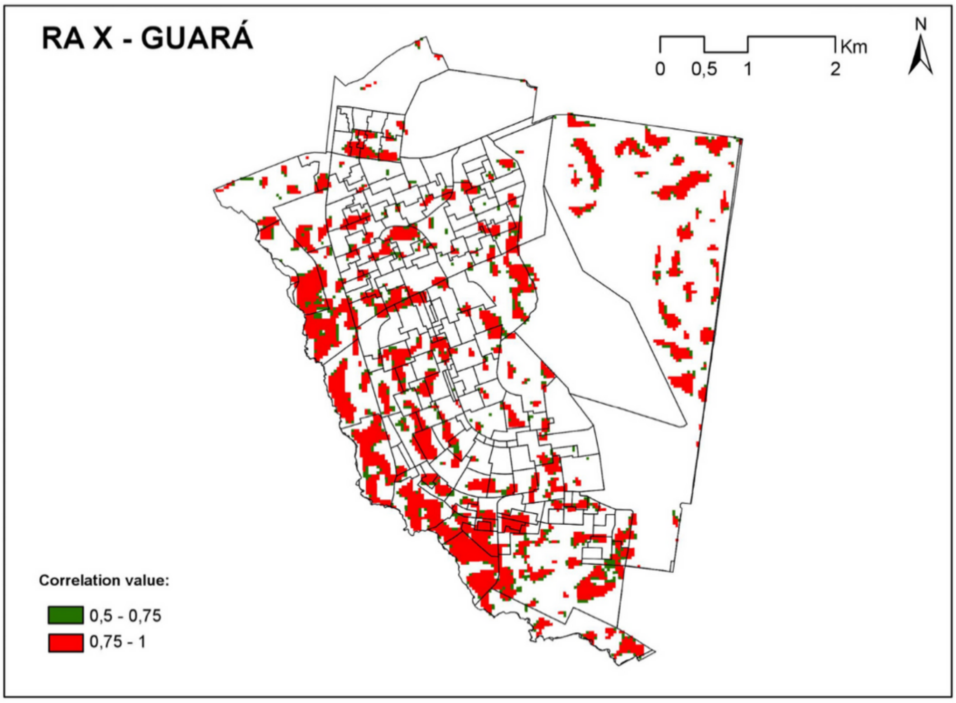


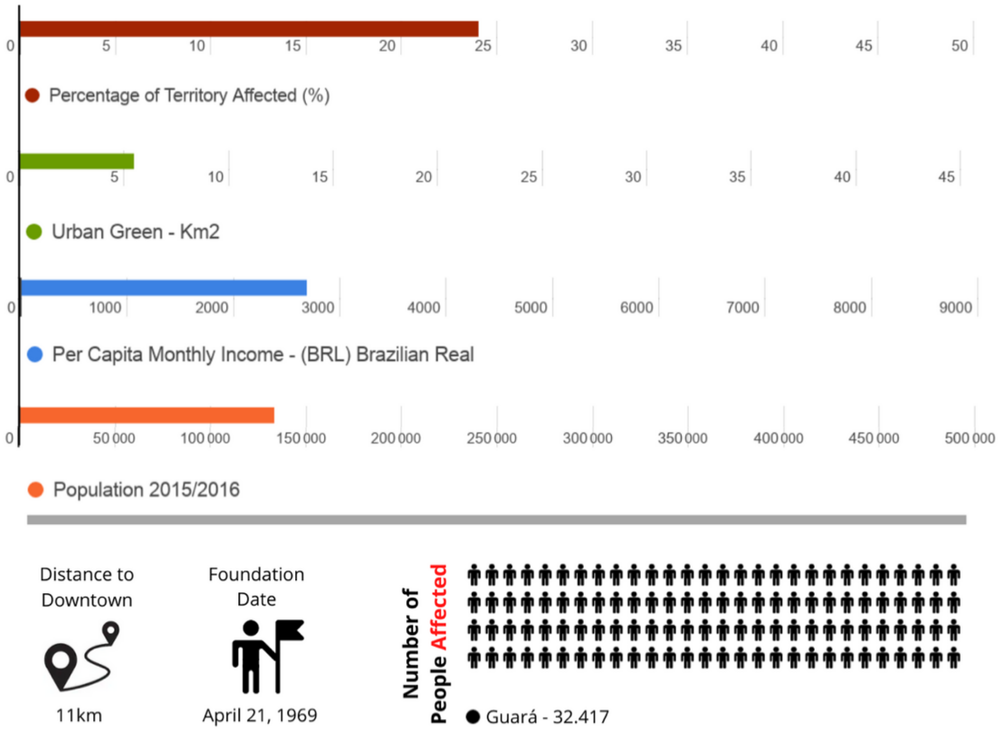

Google Earth Pro
Ceilândia
RA9.mxd - ArcMap
Table Of Contents
Layers
ra9
lagos
Extract_RA9
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

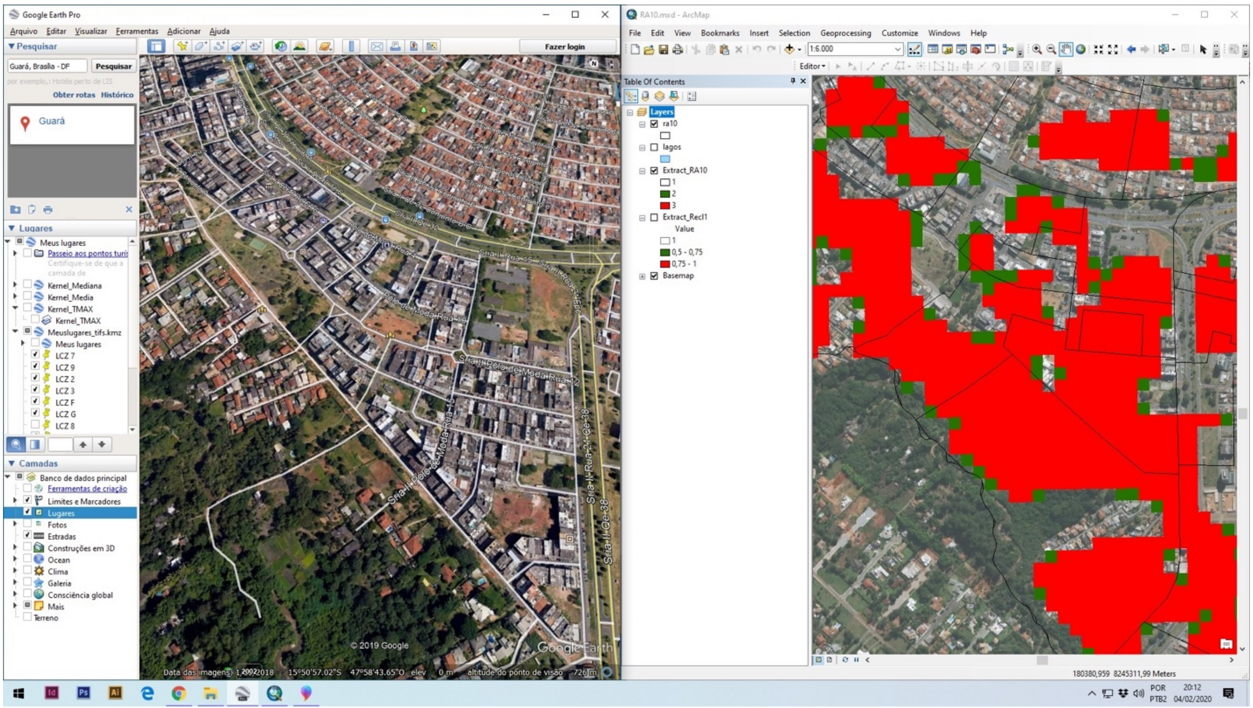

Google Earth Pro
Ceilândia
RA9.mxd - ArcMap
Table Of Contents
Layers
ra9
lagos
Extract_RA9
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

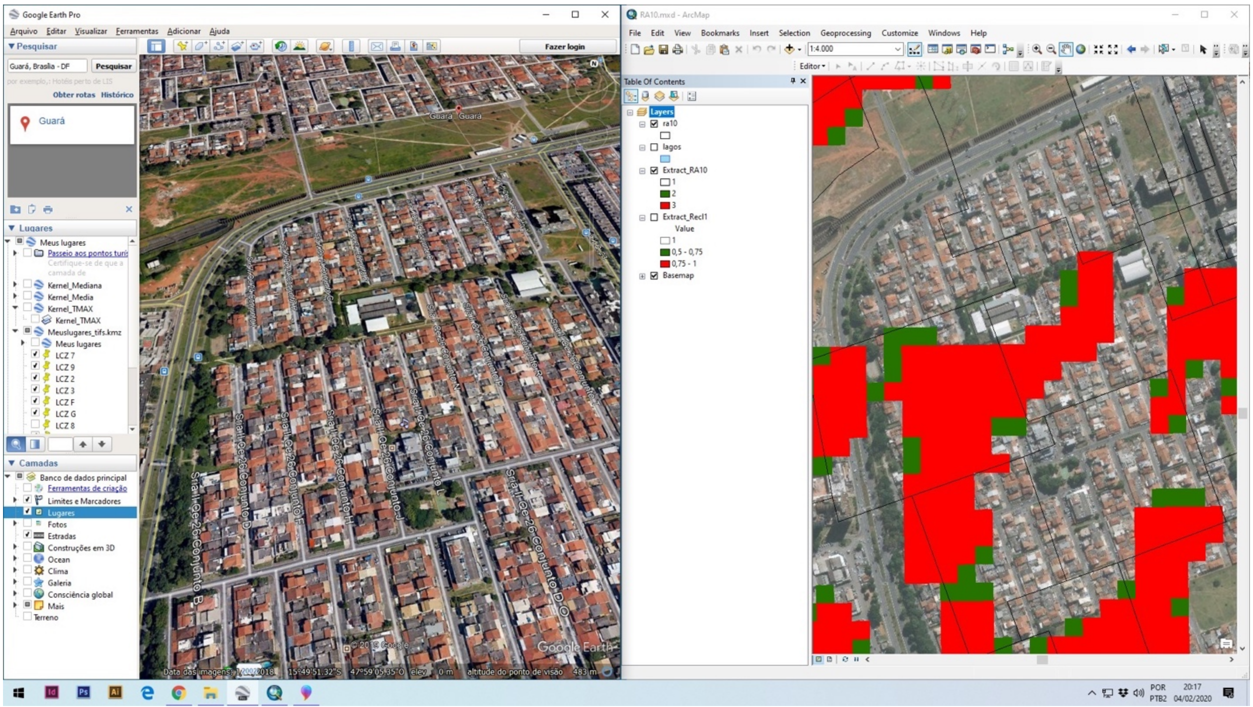

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Ceilândia, Brasília - DF
Pesquisar
Obter rotas Histórico
Ceilândia
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Ferramentas de criação
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
RA9.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:5.000
Table Of Contents
Layers
ra9
lagos
Extract_RA9
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
161359,467 8249133,704 Meters

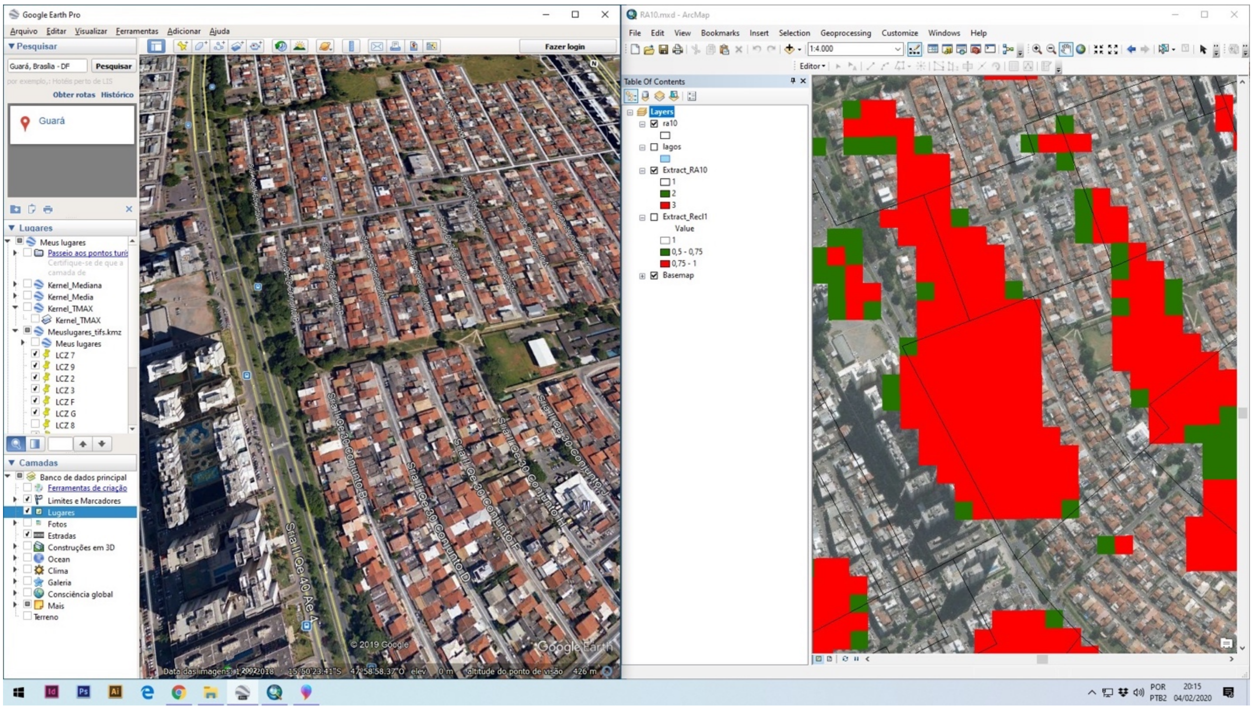
Appendix 10 RA X - Guará


RA X - GUARÁ
N
0 0,5 1 2
Km
Correlation value:
0,5 - 0,75
0,75 - 1

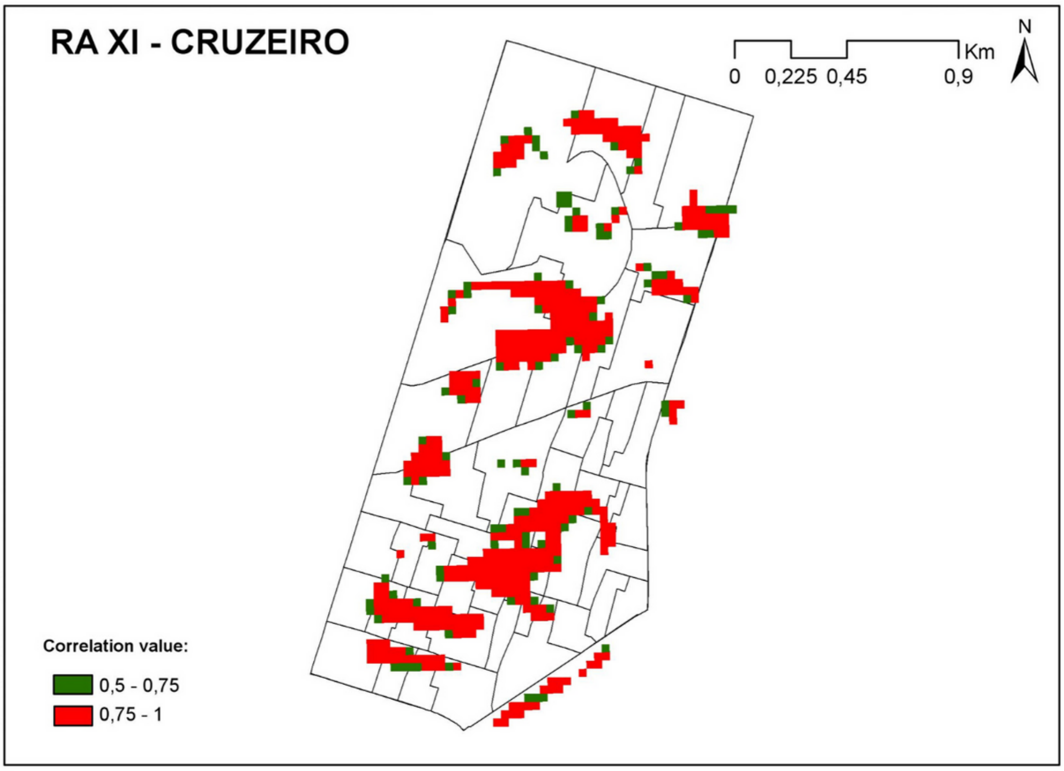

0 5 10 15 20 25 30 35 40 45 50
Percentage of Territory Affected (%)
0 5 10 15 20 25 30 35 40 45
Urban Green - Km2
0 1000 2000 3000 4000 5000 6000 7000 8000 9000
Per Capita Monthly Income - (BRL) Brazilian Real
0 50 000 100 000 150 000 200 000 250 000 300 000 350 000 400 000 450 000 500 000
Population 2015/2016
Distance to Downtown
11km
Foundation Date
April 21, 1969
Number of People Affected
Guará - 32.417

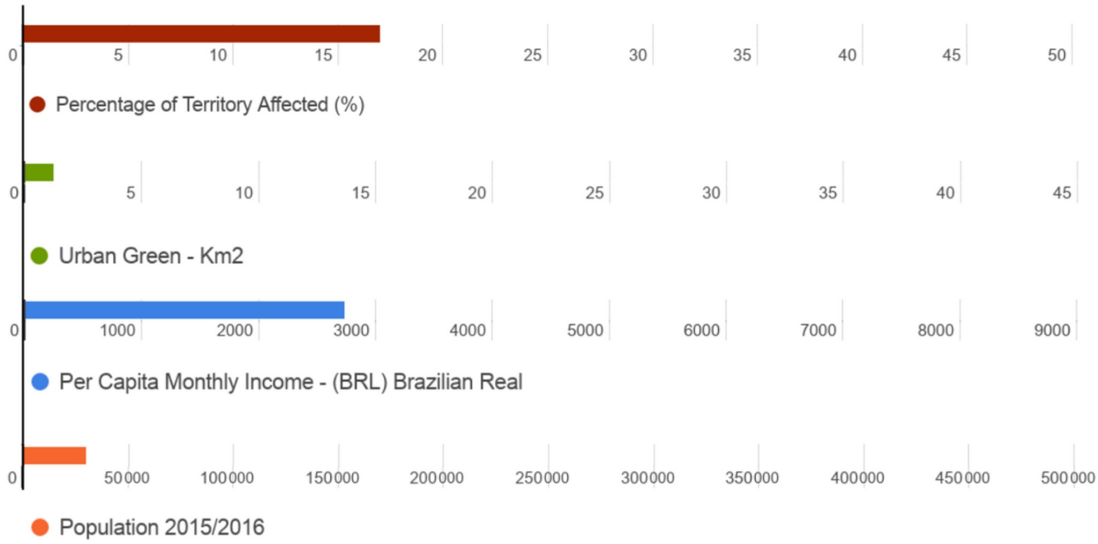

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Guará, Brasília - DF
Pesquisar
Obter rotas Histórico
Guará
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
© 2019 Google
Google Earth
RA10.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:6.000
Table Of Contents
Layers
ra10
lagos
Extract_RA10
1
2
3
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
180380,959 8245311,99 Meters

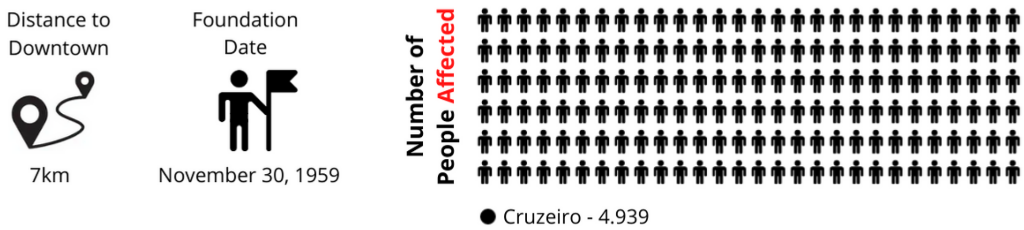

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Guará, Brasília - DF
Pesquisar
Obter rotas Histórico
Guará
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Google Earth
RA10.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4.000
Table Of Contents
Layers
ra10
lagos
Extract_RA10
1
2
3
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

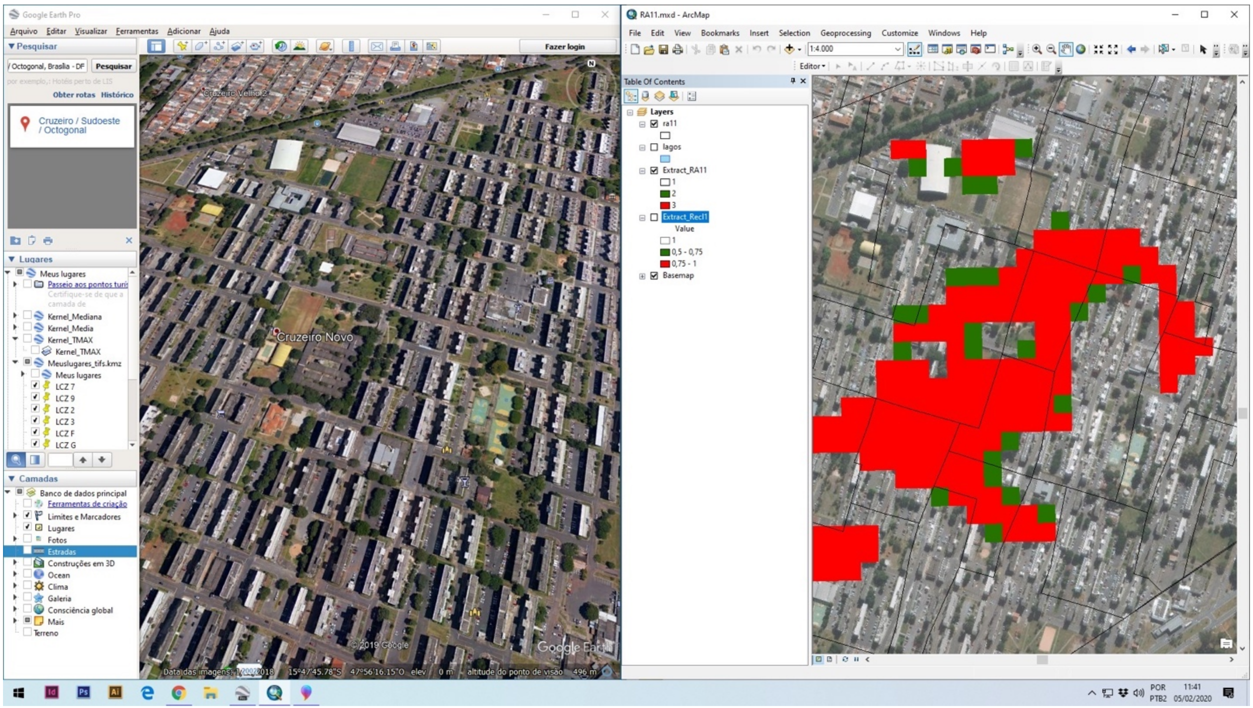


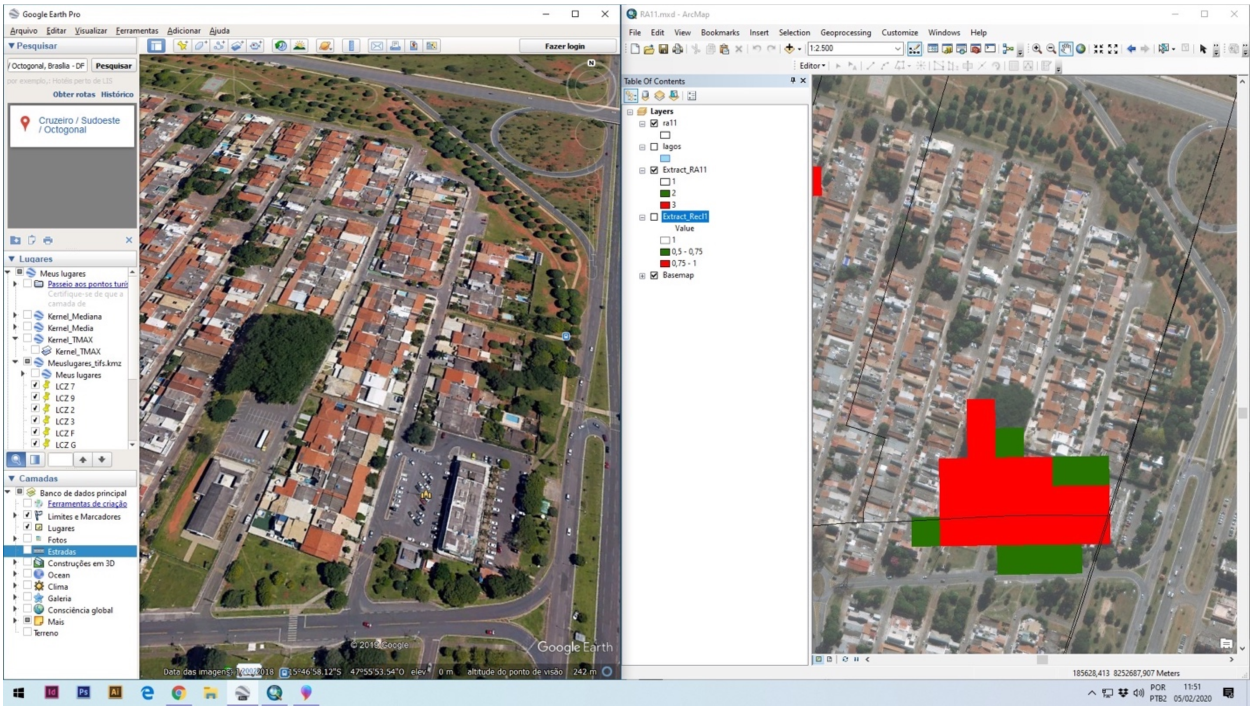
Appendix 11 RA XI - Cruzeiro

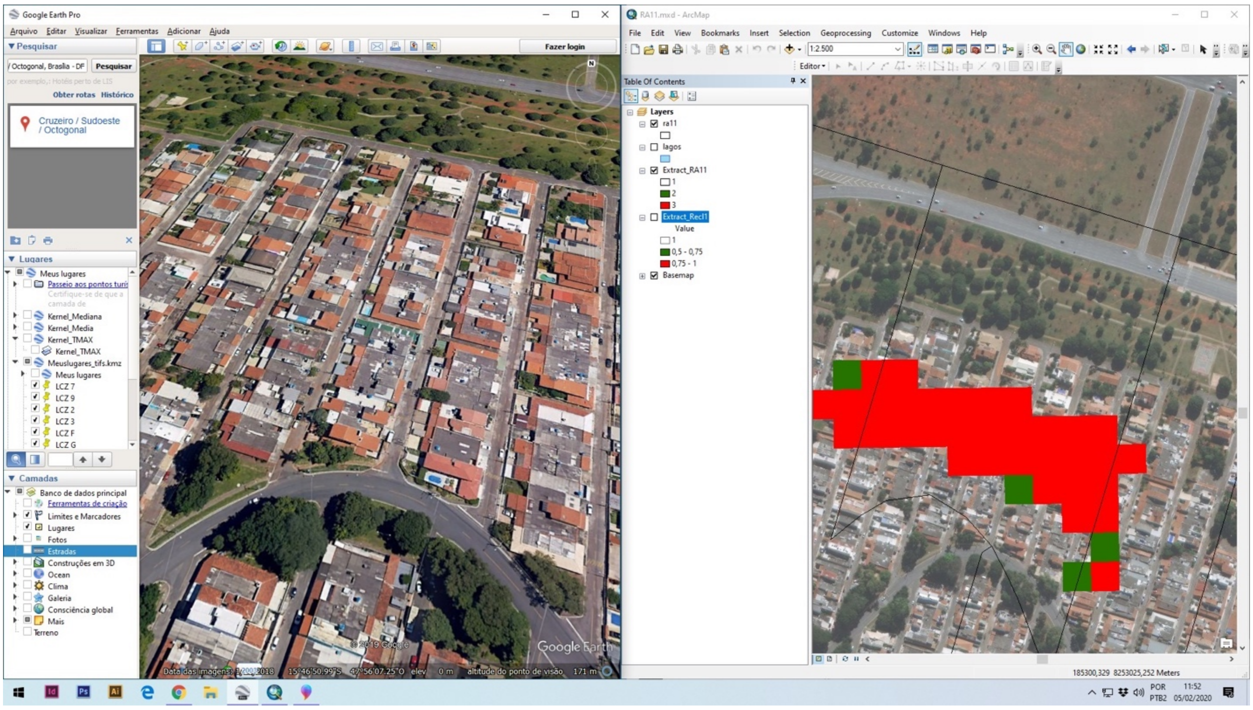




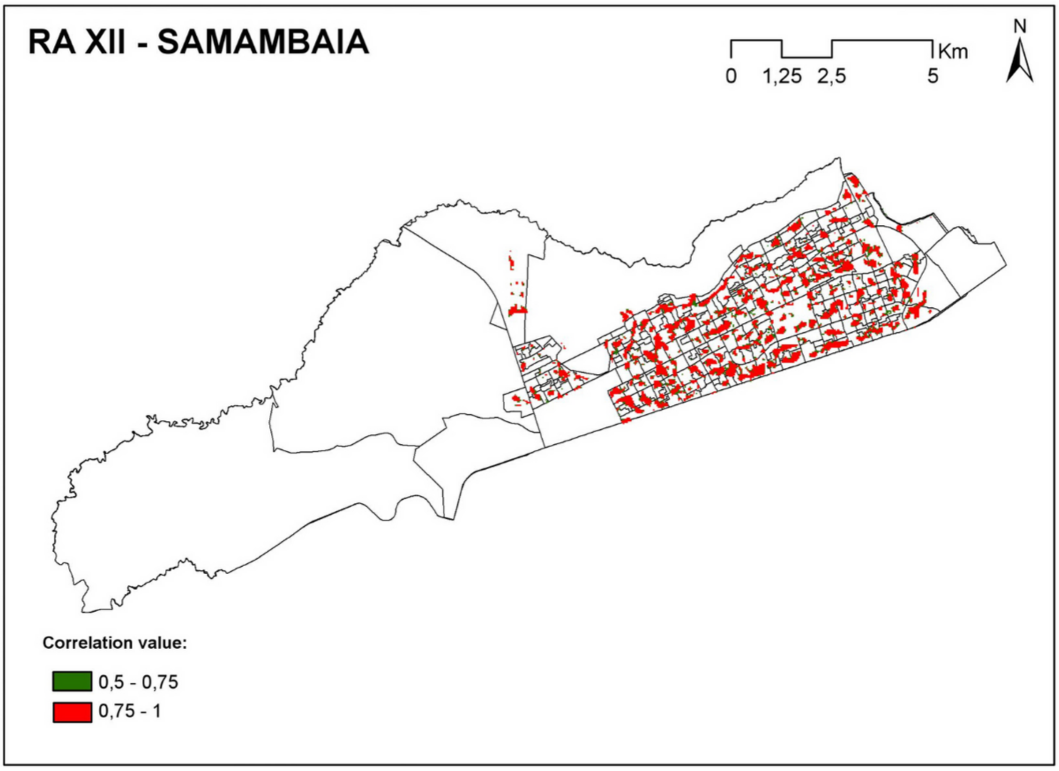


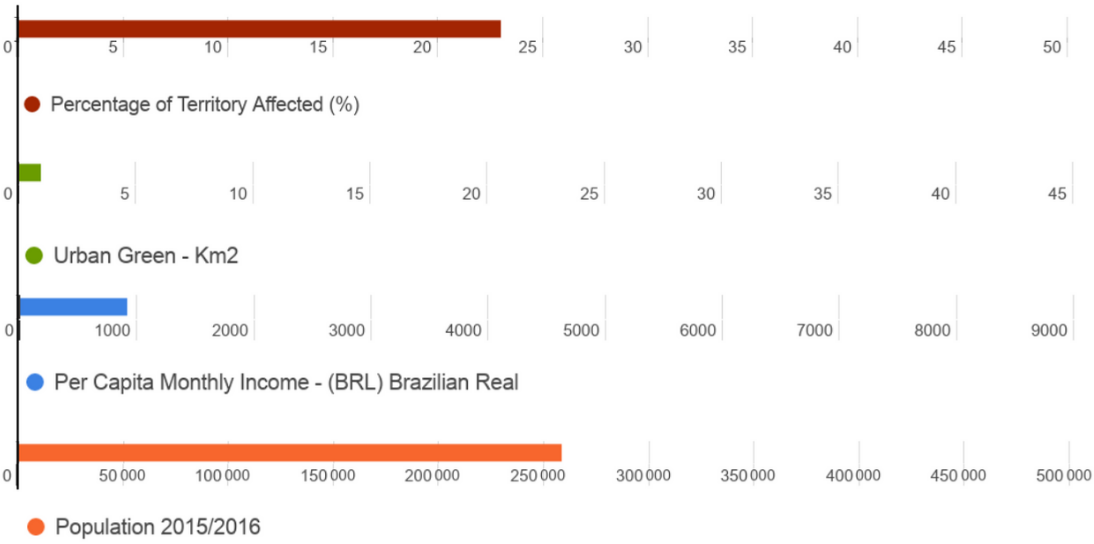

Google Earth Pro
RA11.mxd - ArcMap
Cruzeiro / Sudoeste / Octogonal
Cruzeiro Novo
Table Of Contents
Layers
ra11
lagos
Extract_RA11
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

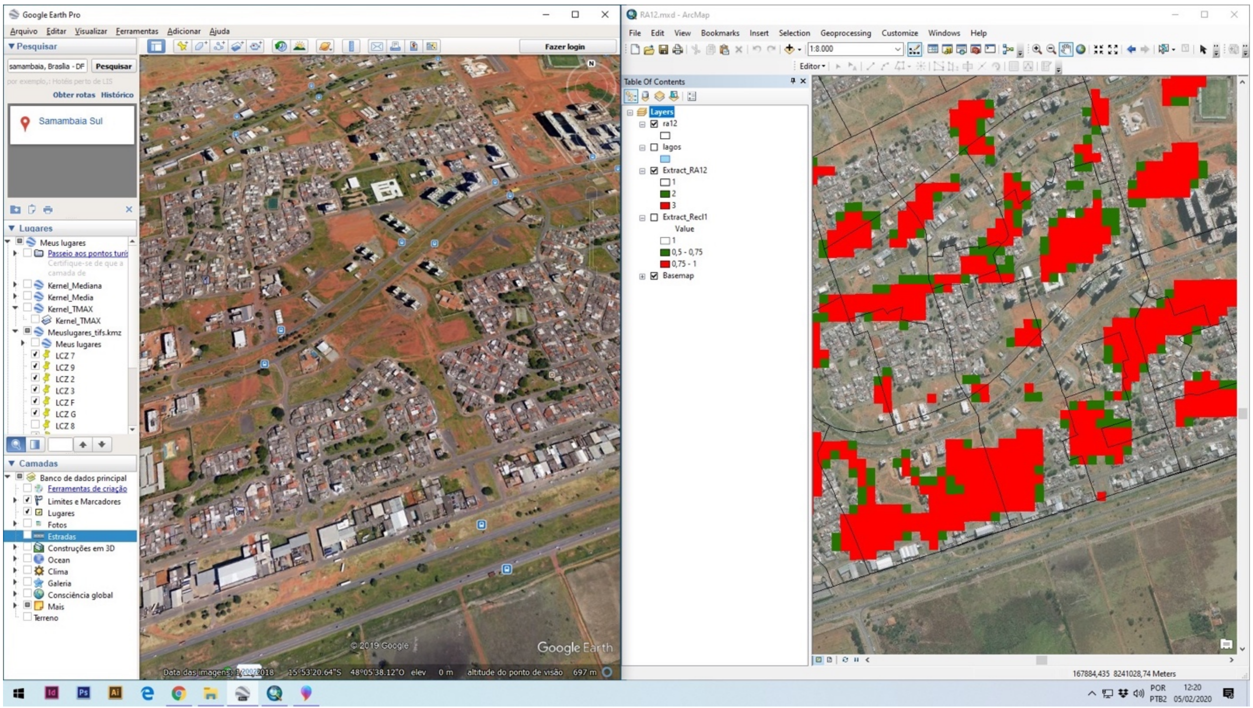

Google Earth Pro
RA11.mxd - ArcMap
Cruzeiro / Sudoeste / Octogonal
Table Of Contents
Layers
ra11
lagos
Extract_RA11
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

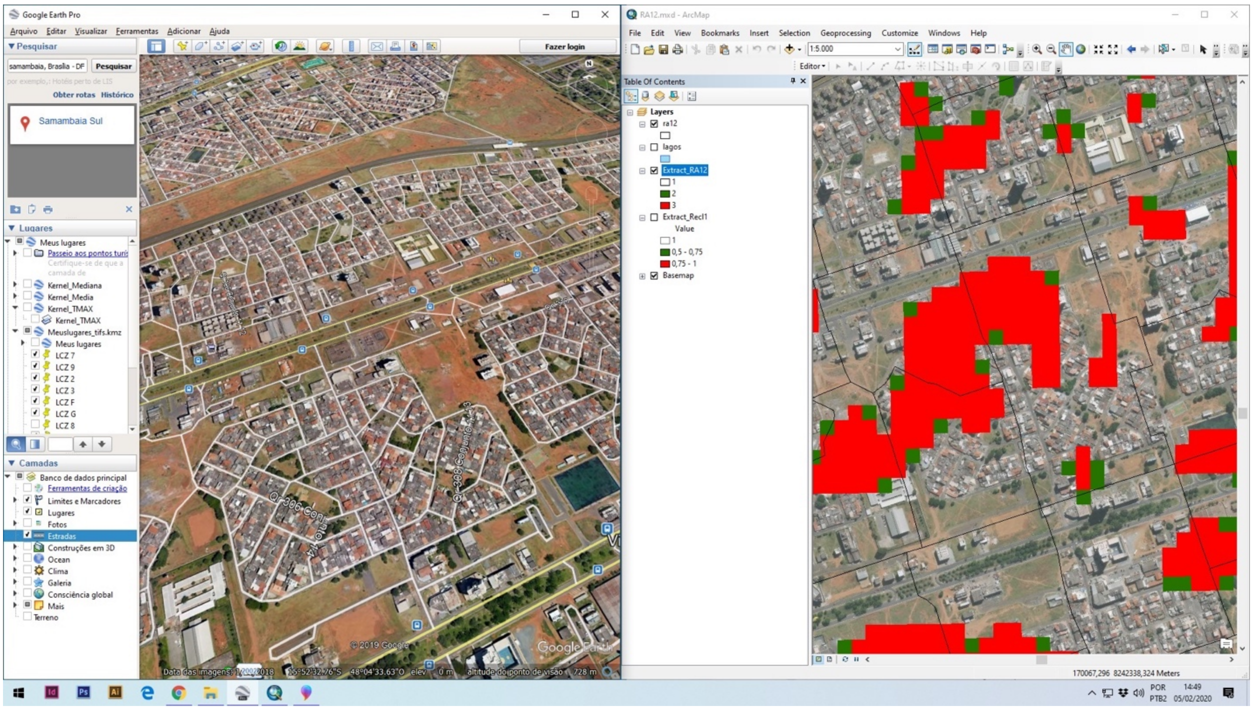

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Cruzeiro / Sudoeste / Octogonal
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
RA11.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra11
lagos
Extract_RA11
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
185300,329 8253025,252 Meters

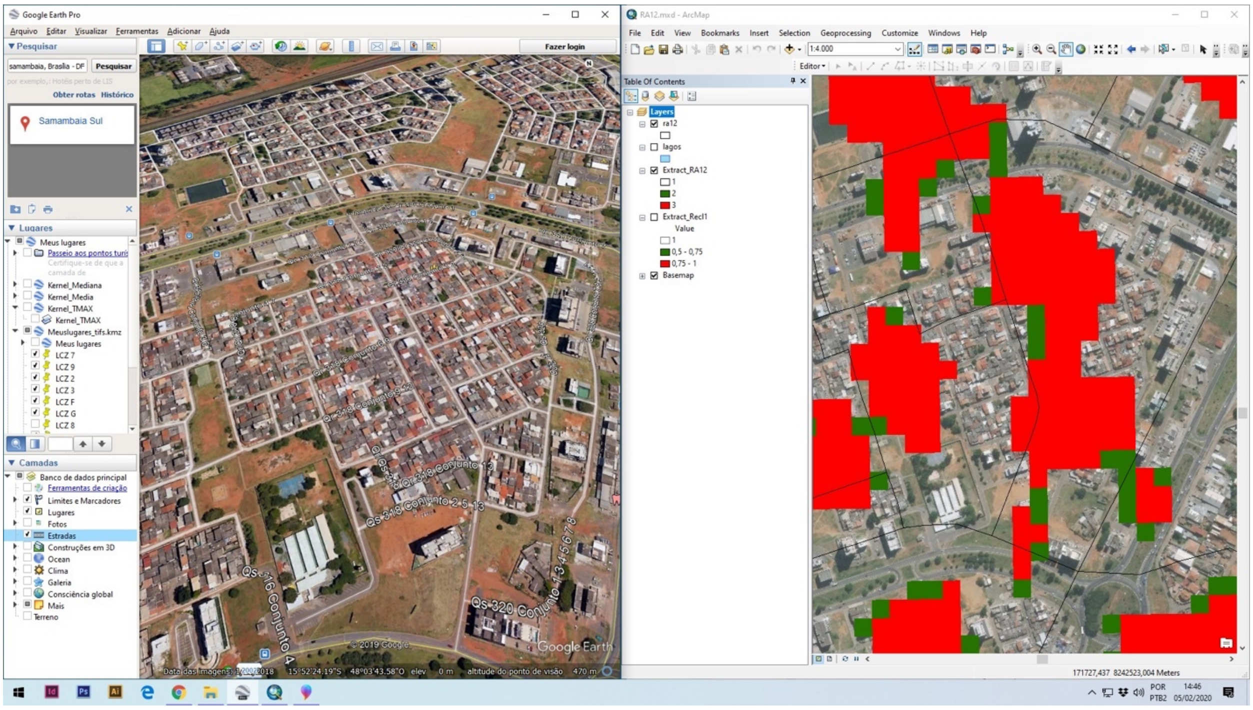
Appendix 12 RA XII - Samambaia



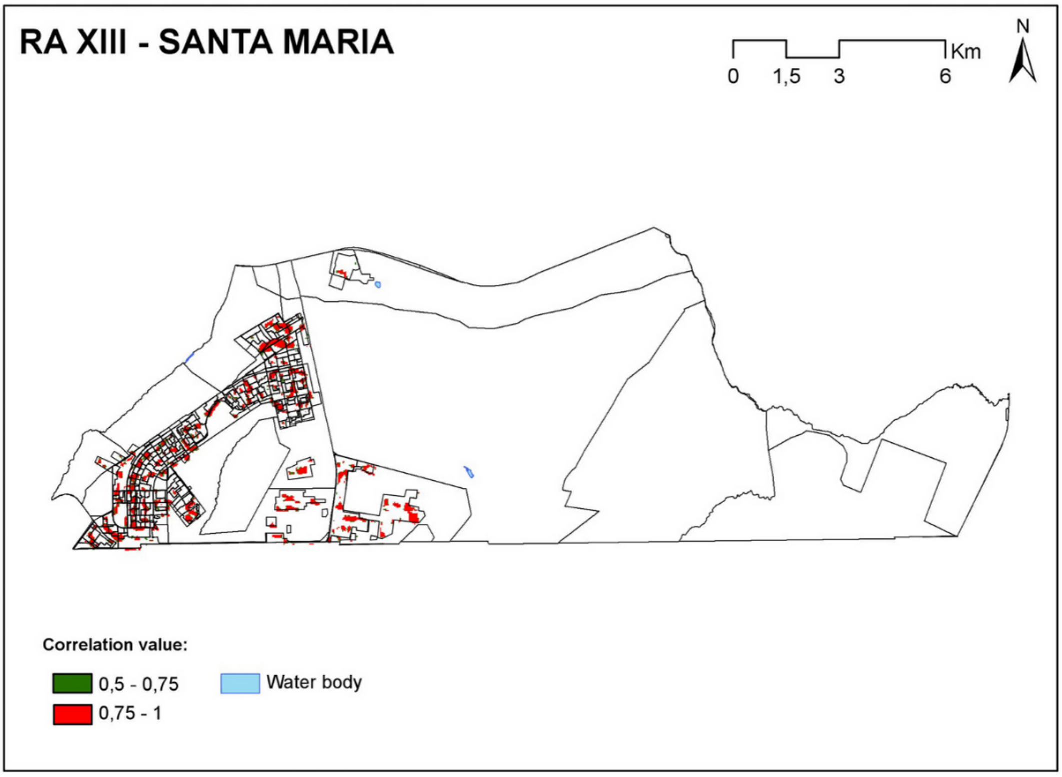


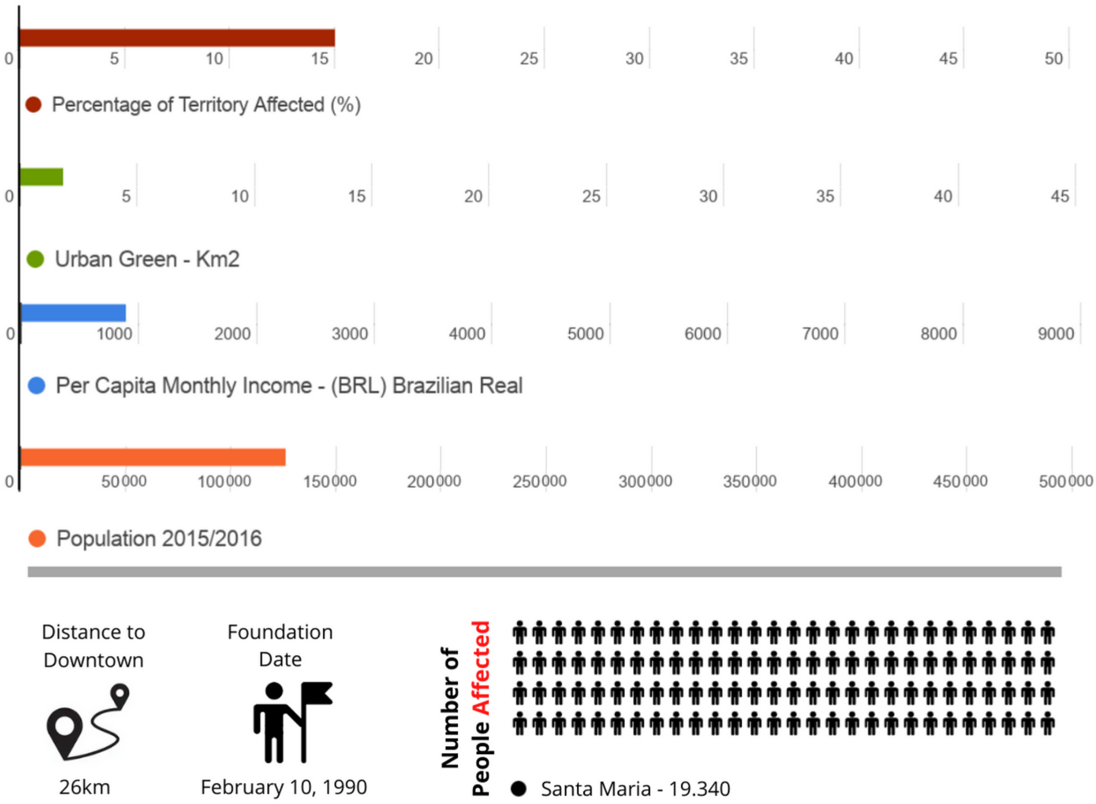

Google Earth Pro
RA12.mxd - ArcMap
Samambaia Sul
Table Of Contents
Layers
Google Earth

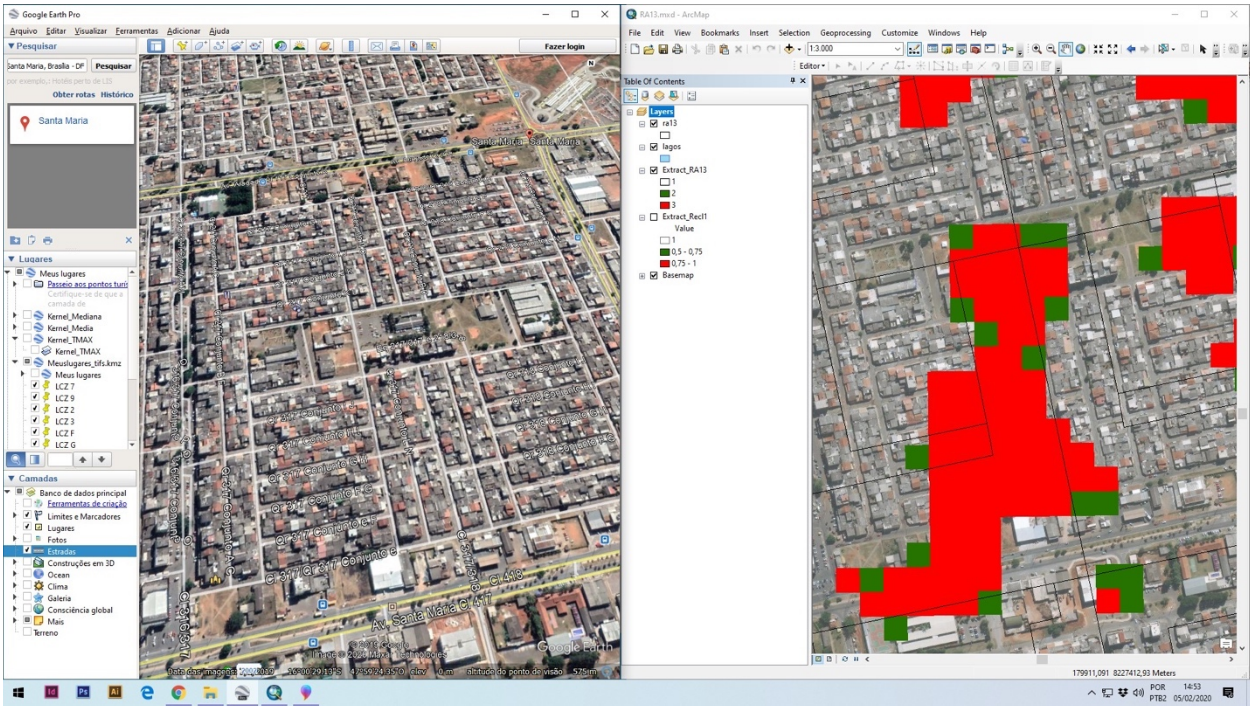

Google Earth Pro
RA12.mxd - ArcMap
Samambaia Sul
Table Of Contents
Layers
Google Earth


Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Samambaia Sul
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Google Earth
RA12.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra12
lagos
Extract_RA12
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

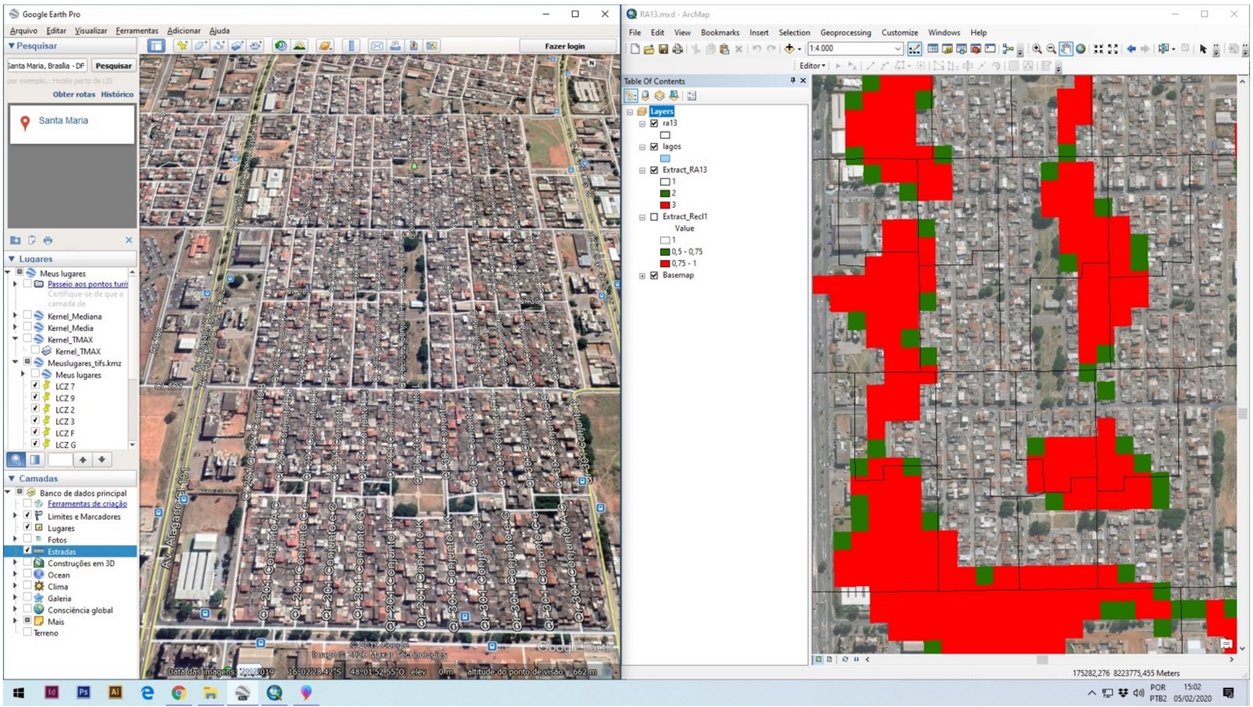
Appendix 13 RA XIII - Santa Maria



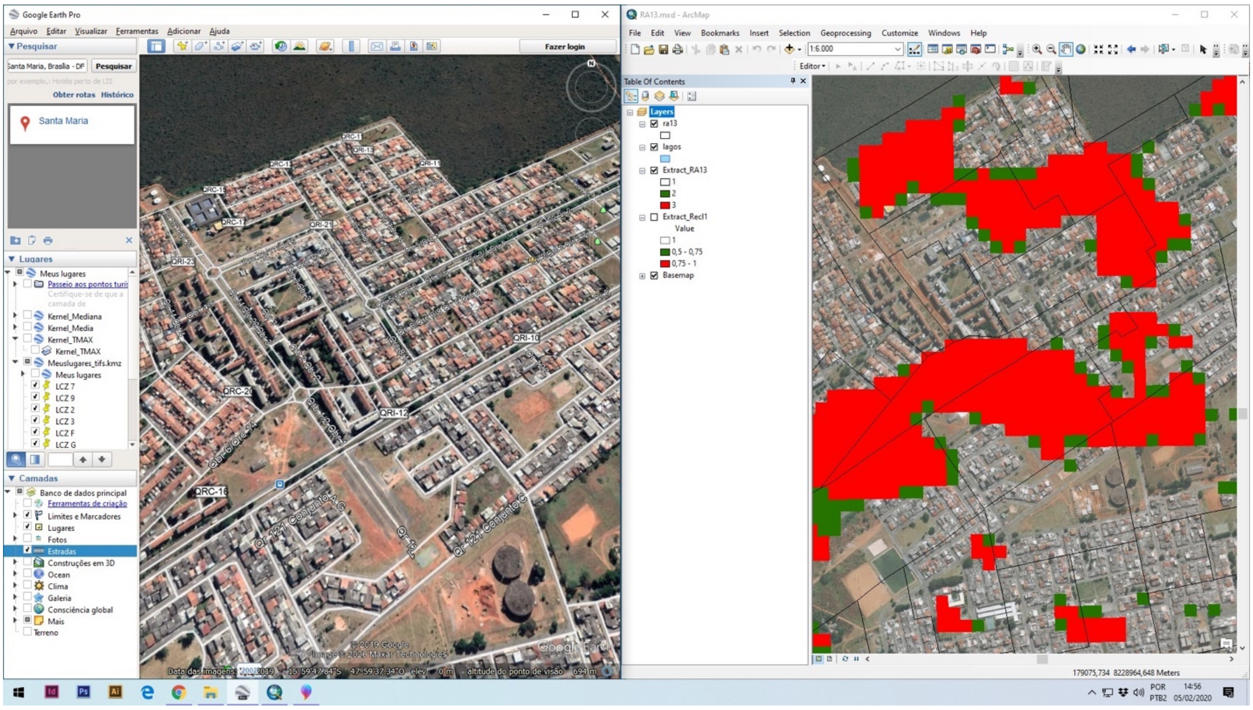




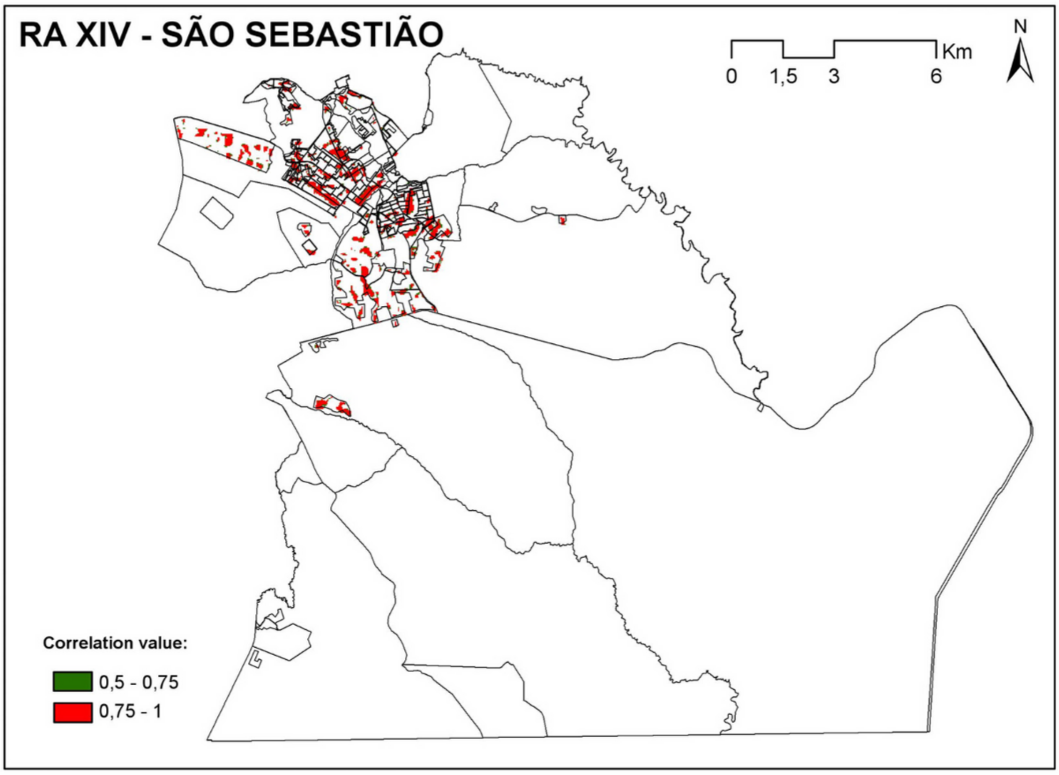
Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Santa Maria, Brasília - DF
Pesquisar
Obter rotas Histórico
Santa Maria
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
Av. Santa Maria
Google Earth
RA13.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:3.000
Table Of Contents
Layers
ra13
lagos
Extract_RA13
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
179911,091 8227412,93 Meters

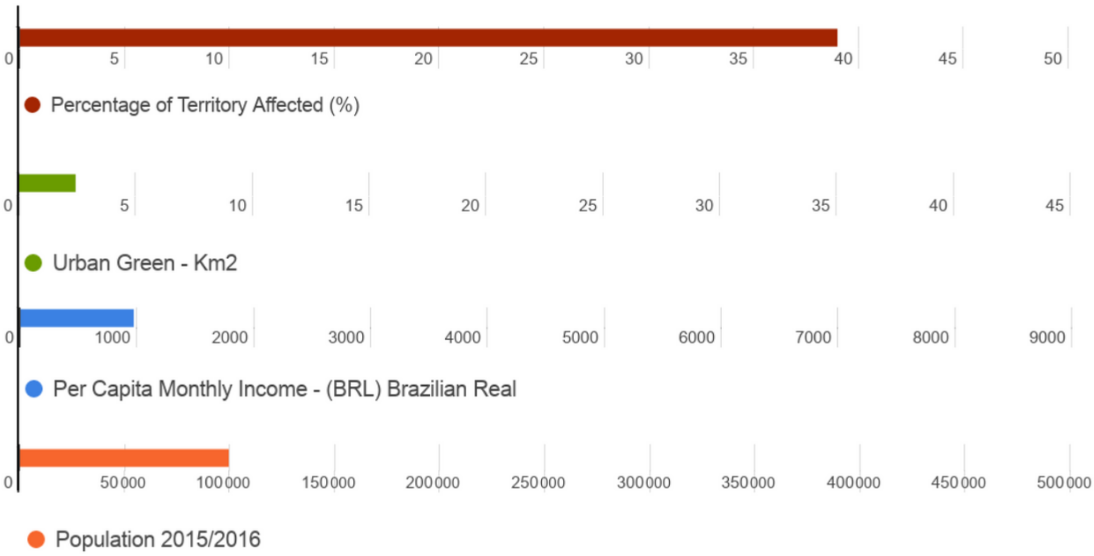


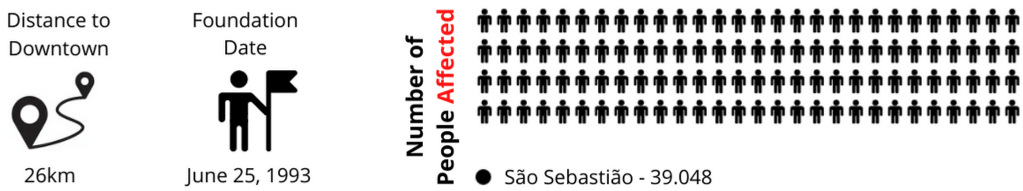
Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Santa Maria, Brasília - DF
Pesquisar
Obter rotas Histórico
Santa Maria
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
Google Earth
RA13.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4.000
Table Of Contents
Layers
ra13
lagos
Extract_RA13
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
175282,276 8223775,455 Meters

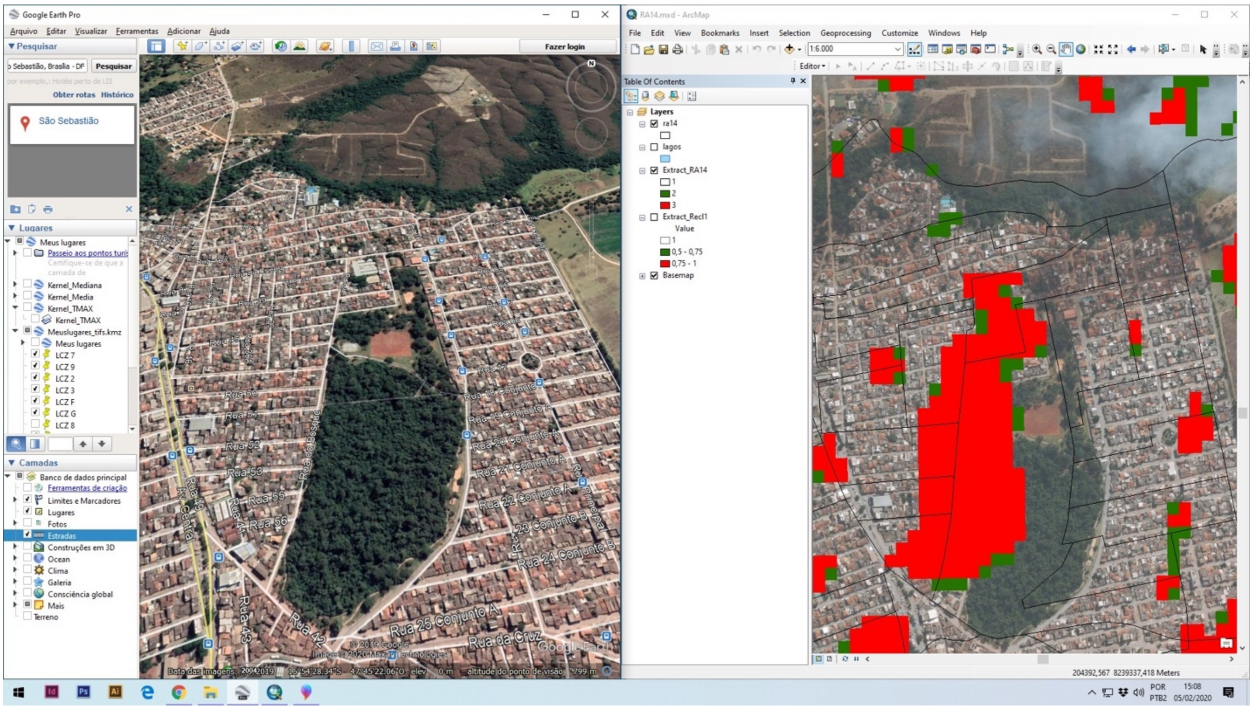


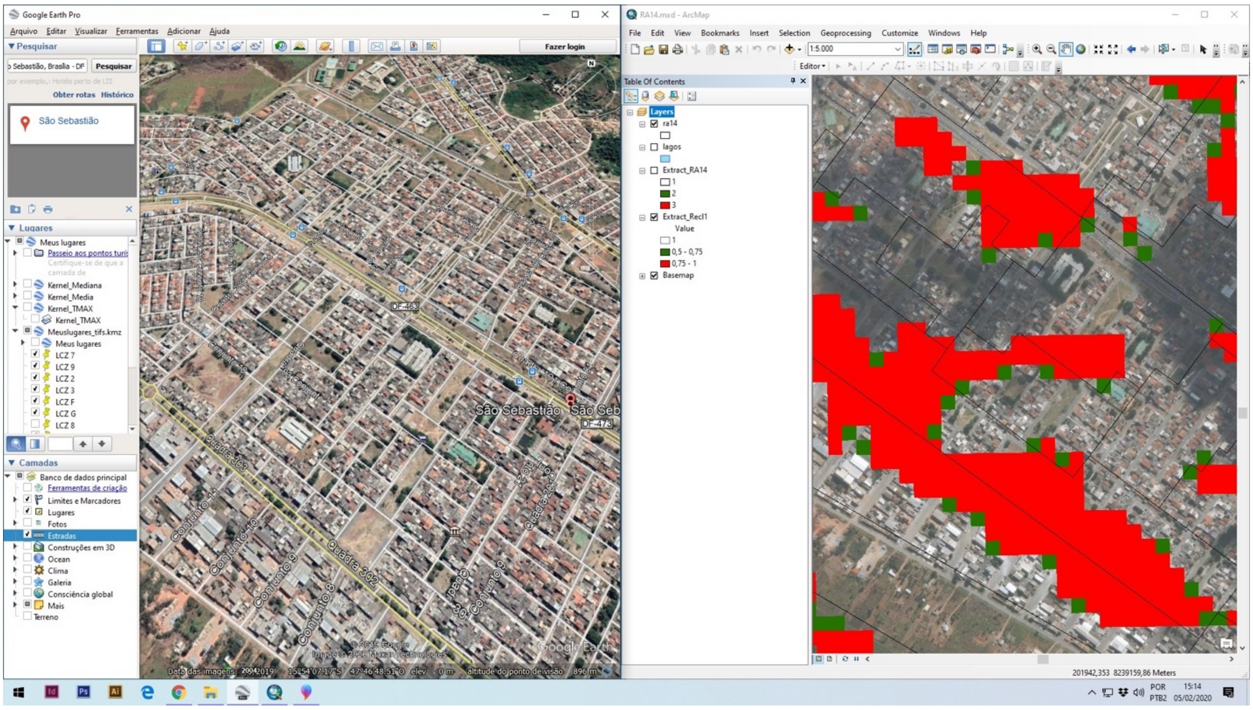
Appendix 14 RA XIV - São Sebastião

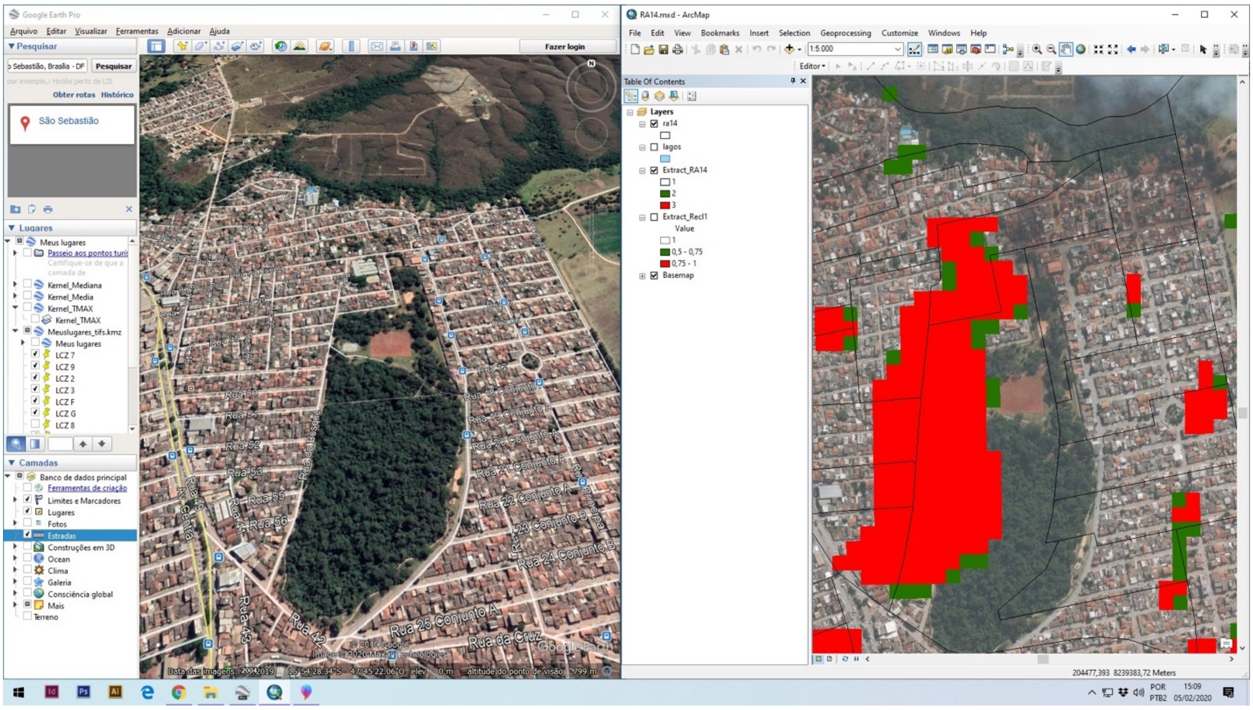




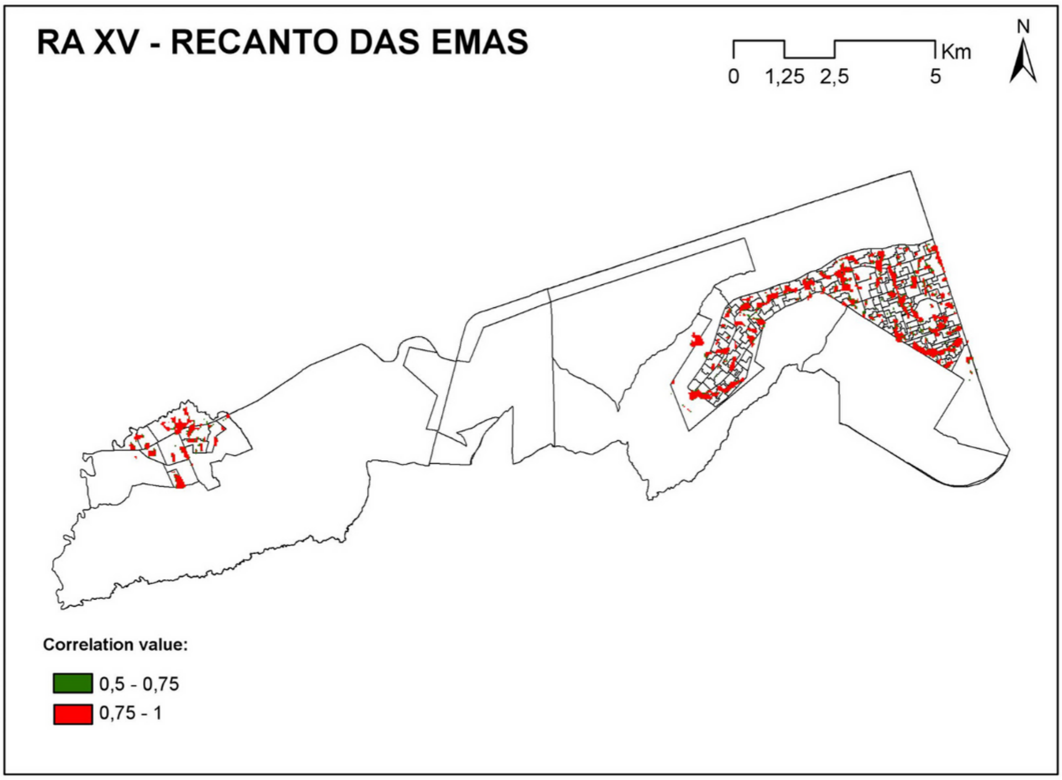


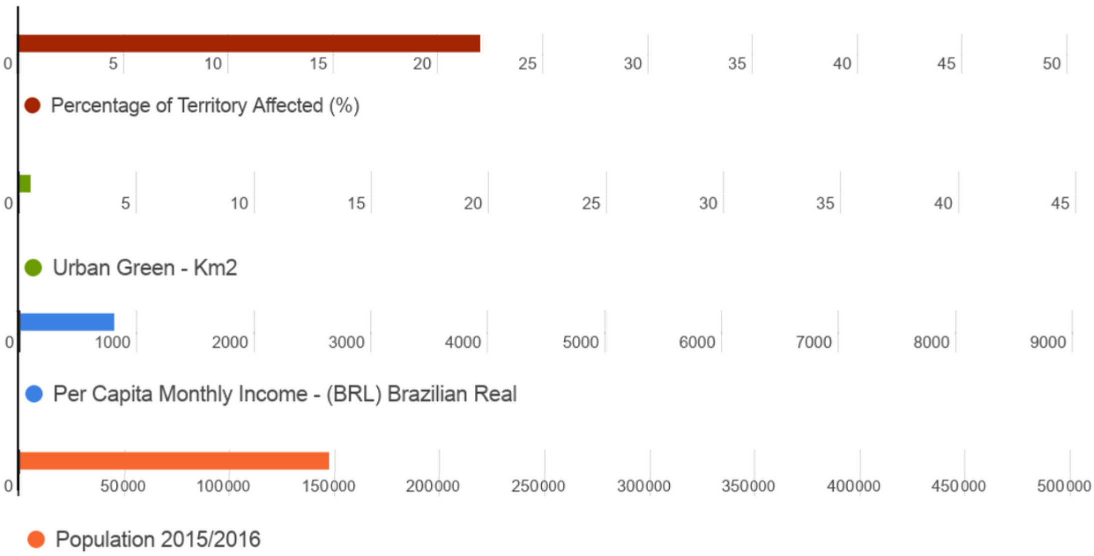

Google Earth Pro
RA14.mxd - ArcMap
São Sebastião
Table Of Contents
Layers
ra14
lagos
Extract_RA14
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Rua 25 Conjunto A
Rua da Cruz

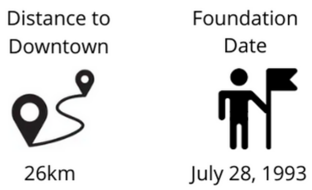

Google Earth Pro
RA14.mxd - ArcMap
São Sebastião
Table Of Contents
Layers
ra14
lagos
Extract_RA14
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

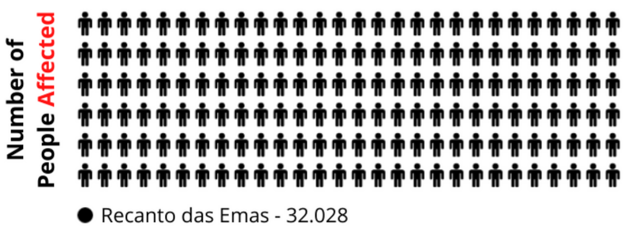

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Obter rotas Histórico
São Sebastião
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
RA14.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra14
lagos
Extract_RA14
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

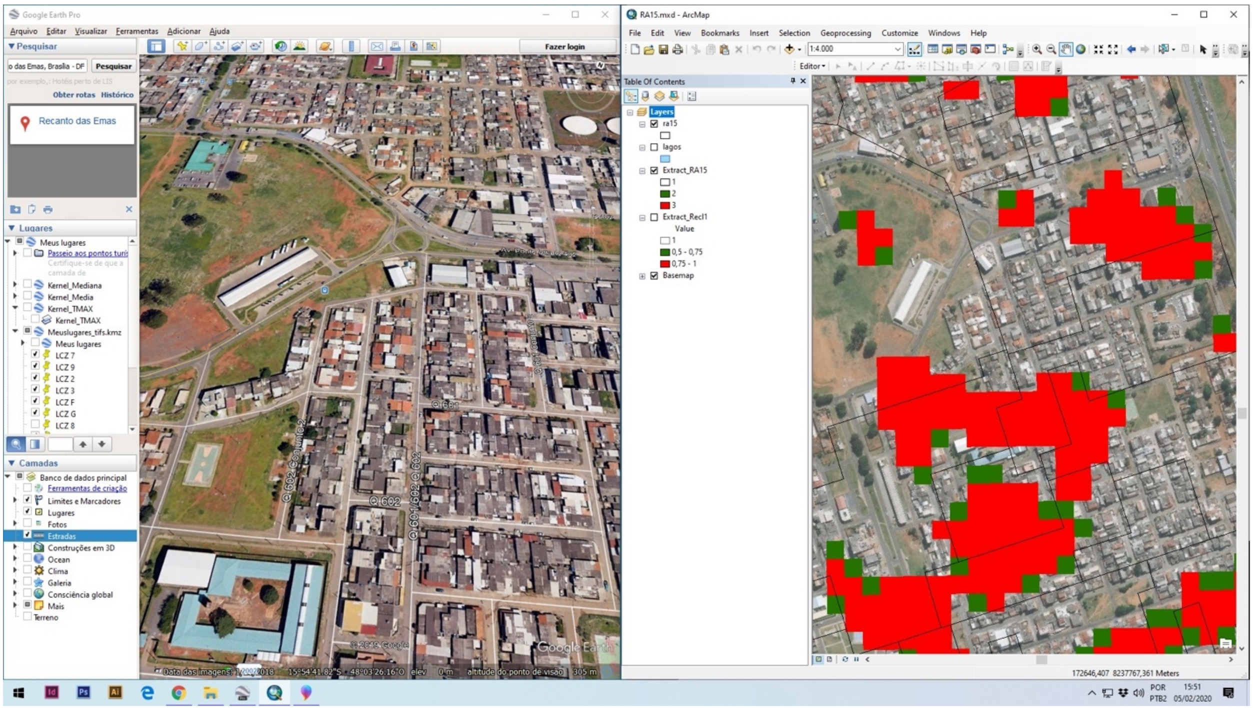
Appendix 15 RA XV - Recanto das Emas

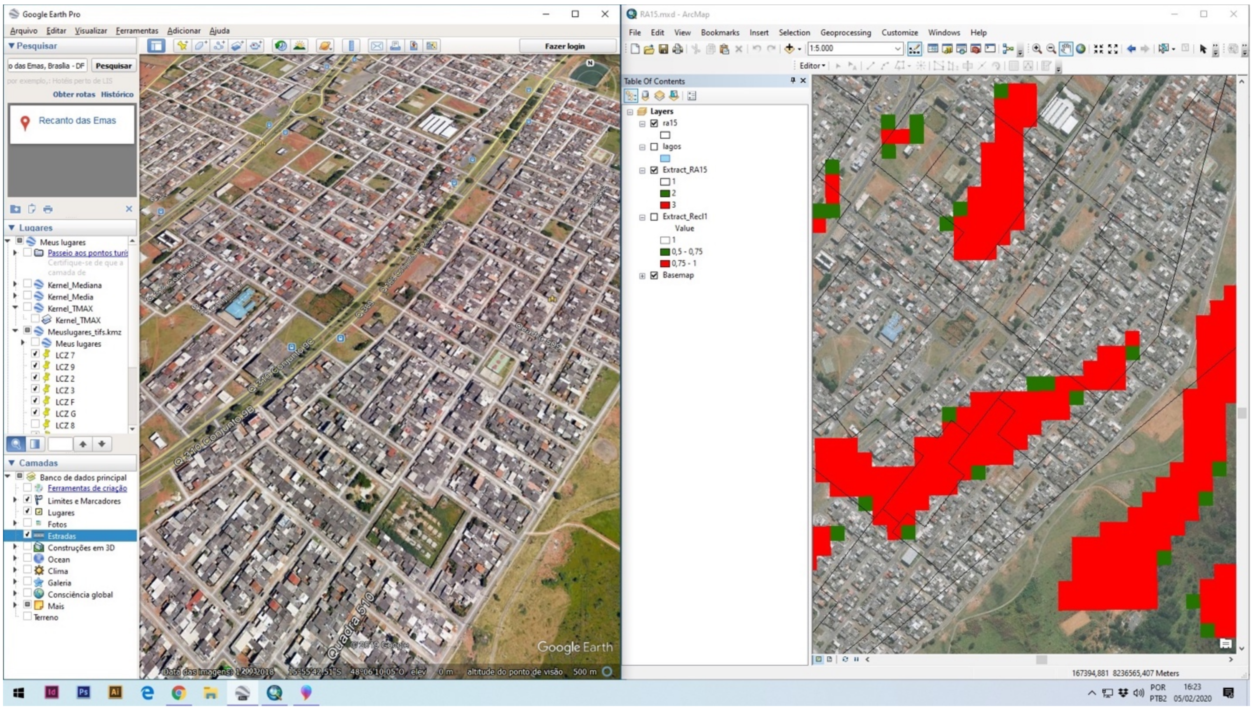


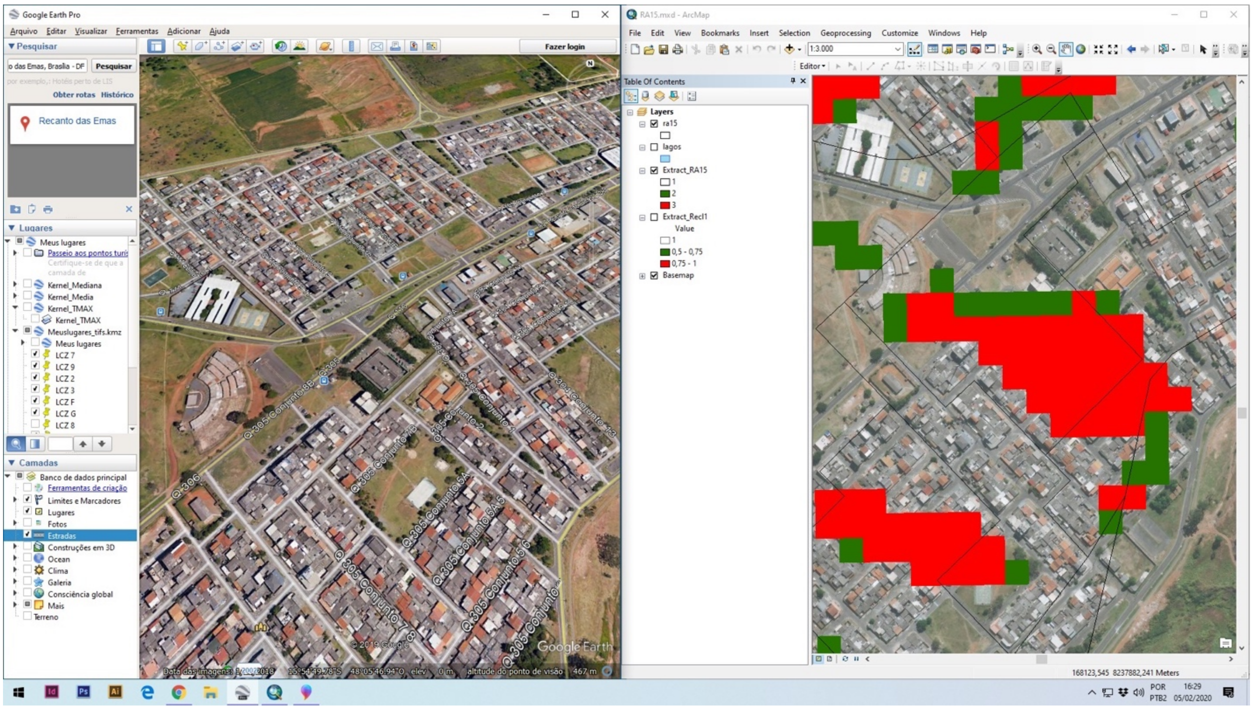




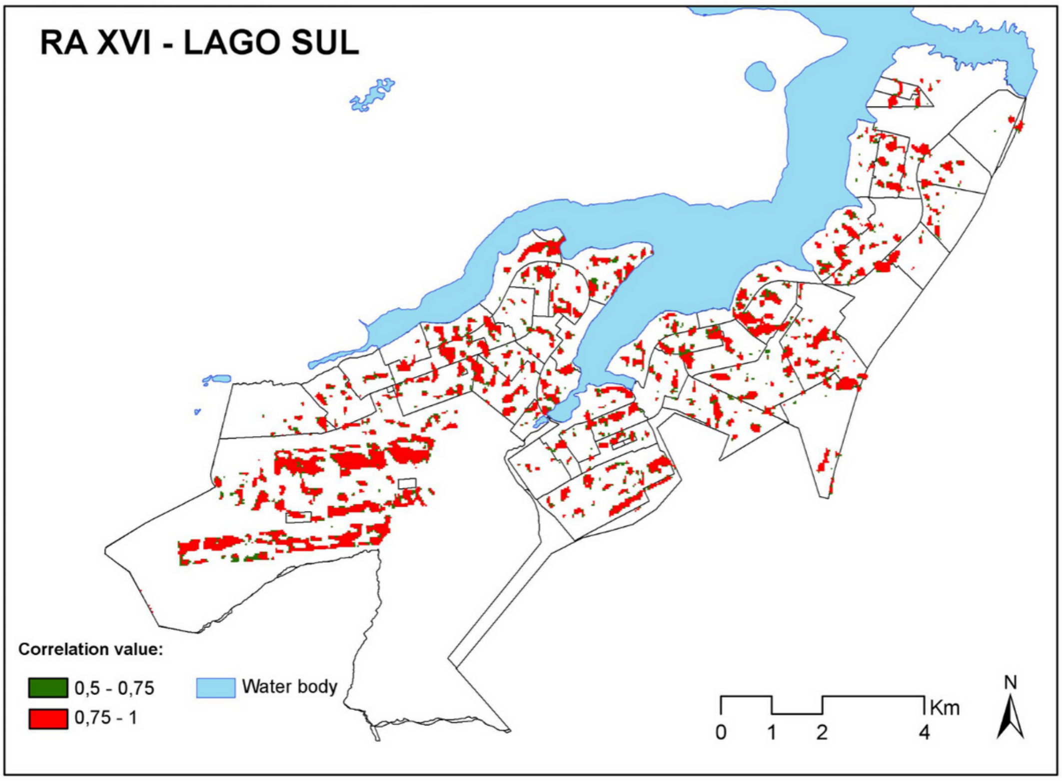


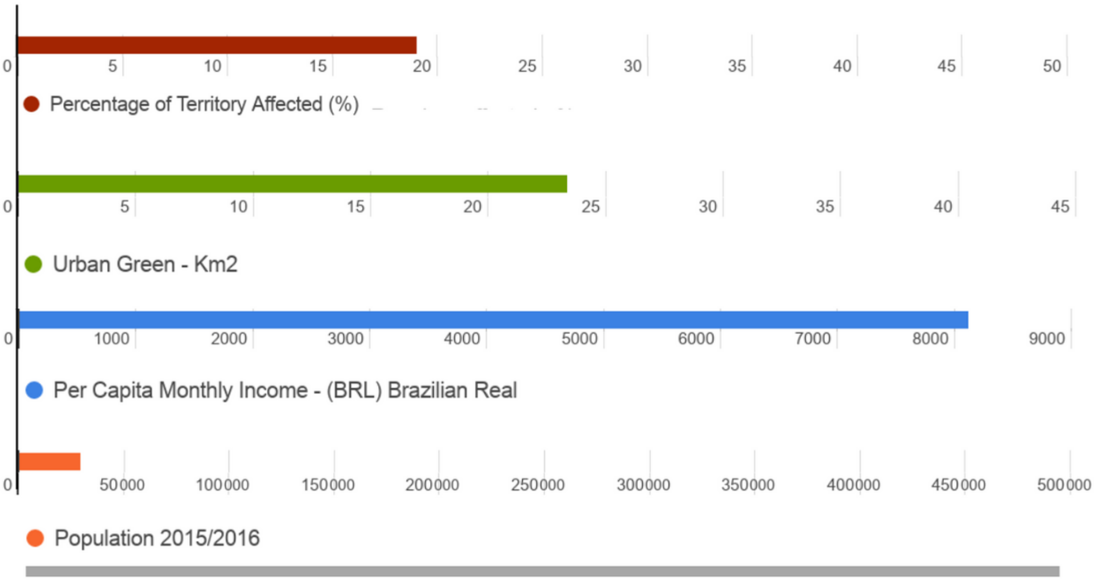

Google Earth Pro
Recanto das Emas
RA15.mxd - ArcMap
Table Of Contents
Layers
ra15
lagos
Extract_RA15
Extract_Recl1
Basemap
Google Earth

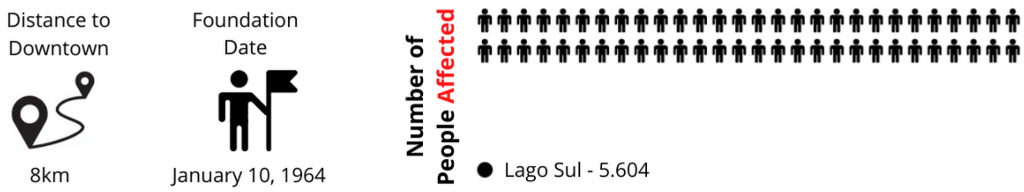

Google Earth Pro
Recanto das Emas
RA15.mxd - ArcMap
Table Of Contents
Layers
ra15
lagos
Extract_RA15
Extract_Recl1
Basemap
Google Earth

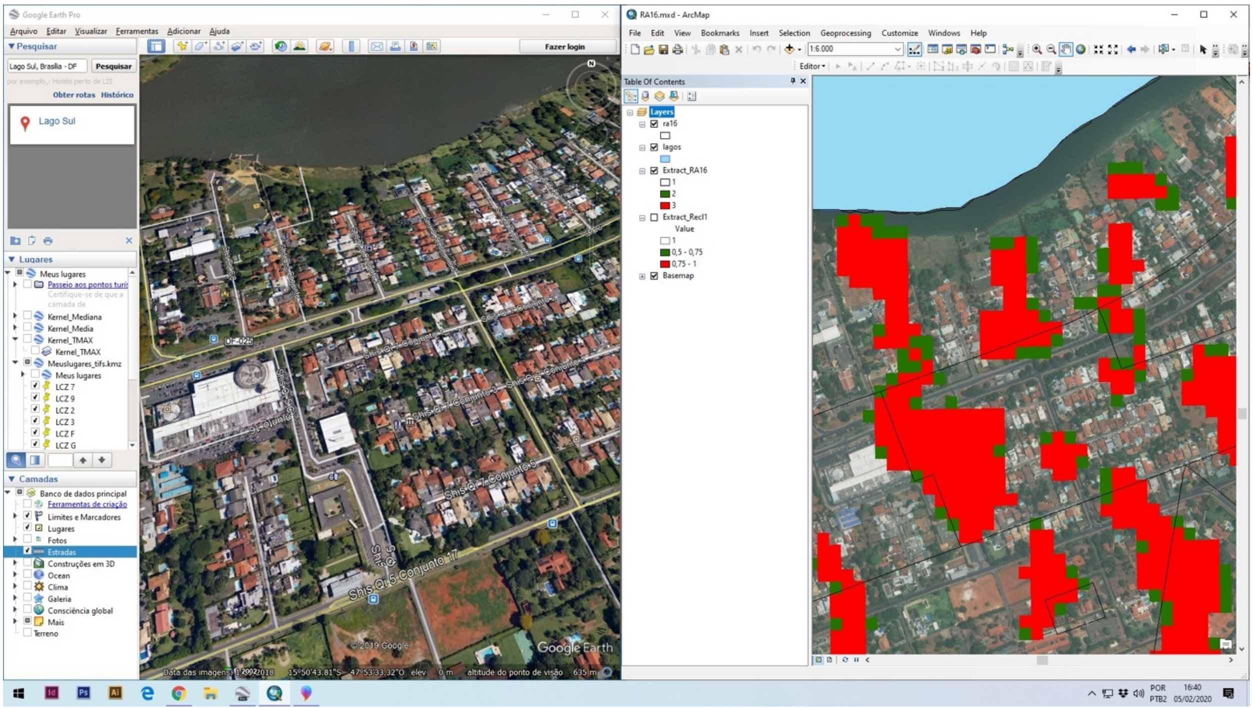

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Recanto das Emas
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Google Earth
RA15.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra15
lagos
Extract_RA15
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
168123,545 8237882,241 Meters

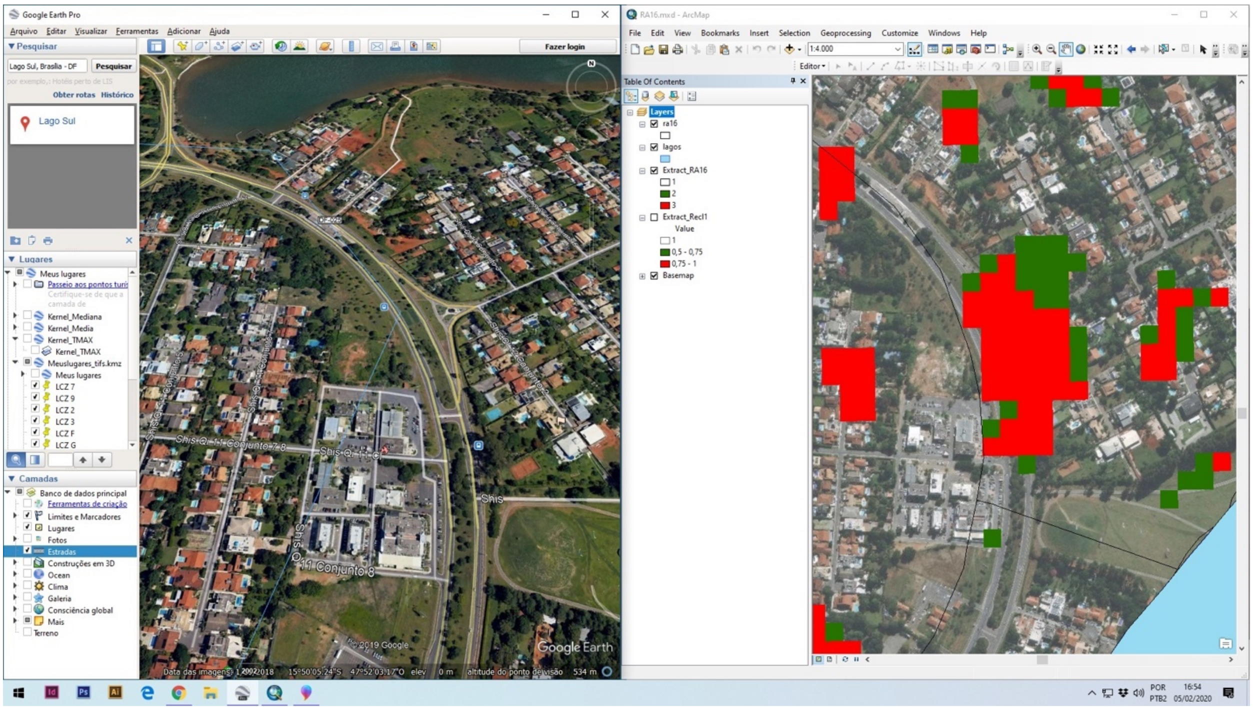
Appendix 16 RA XVI - Lago Sul

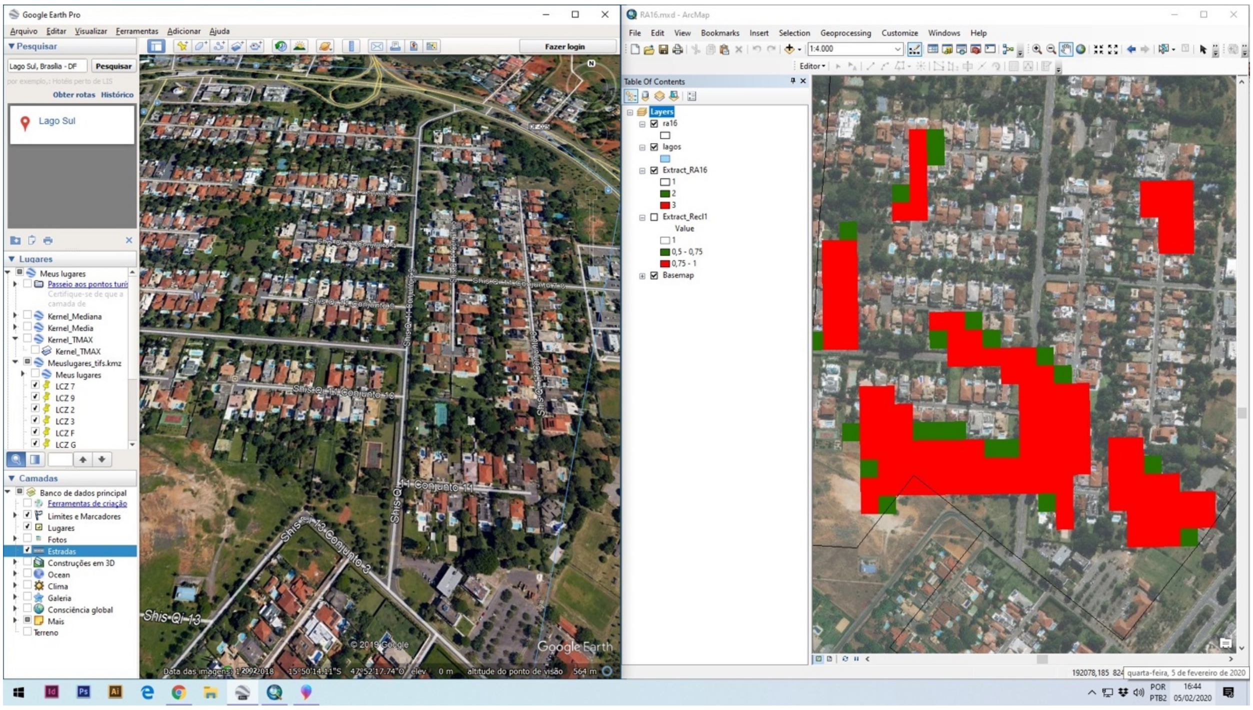




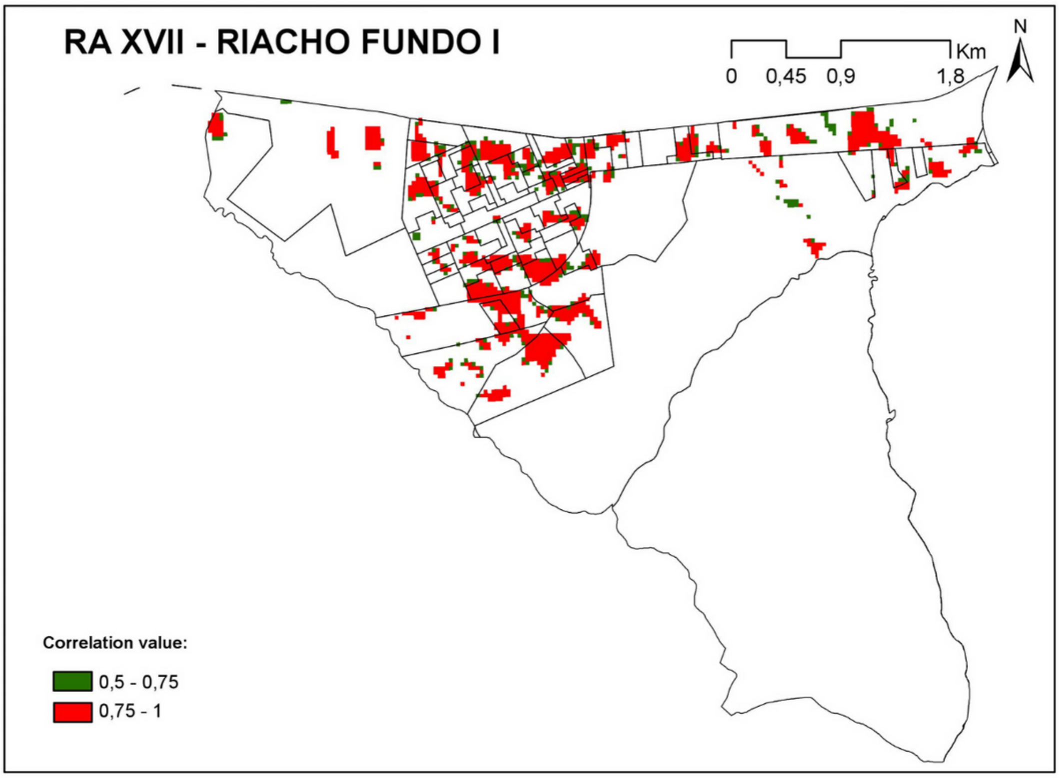


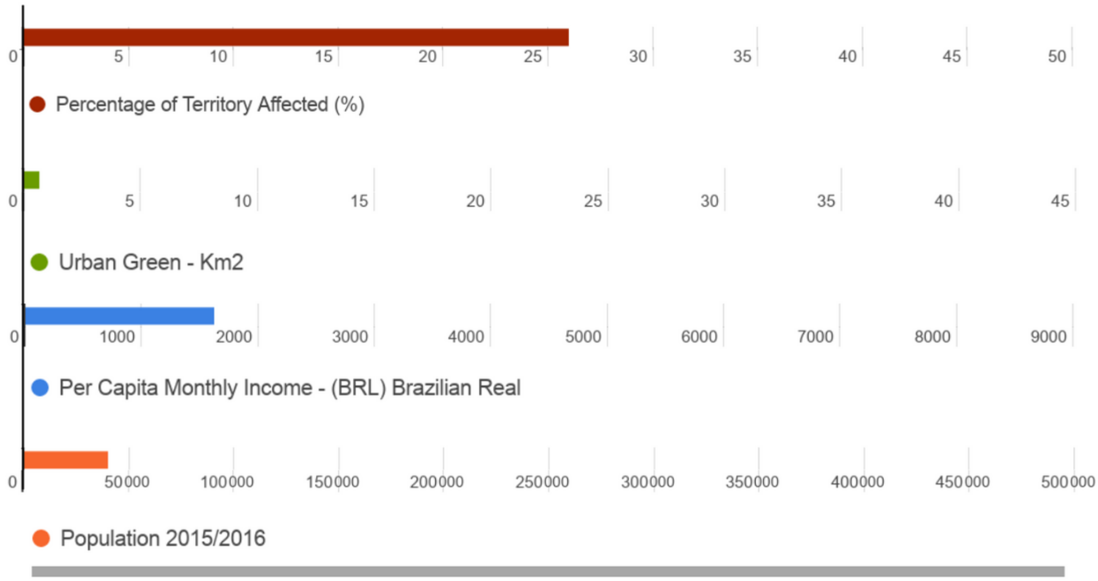

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Lago Sul
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Google Earth
RA16.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:6.000
Table Of Contents
Layers
ra16
lagos
Extract_RA16
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

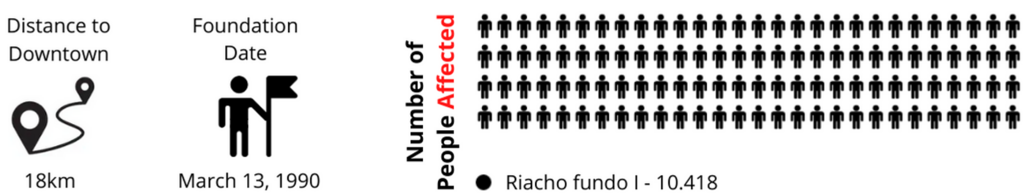

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Lago Sul
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Google Earth
RA16.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4.000
Table Of Contents
Layers
ra16
lagos
Extract_RA16
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

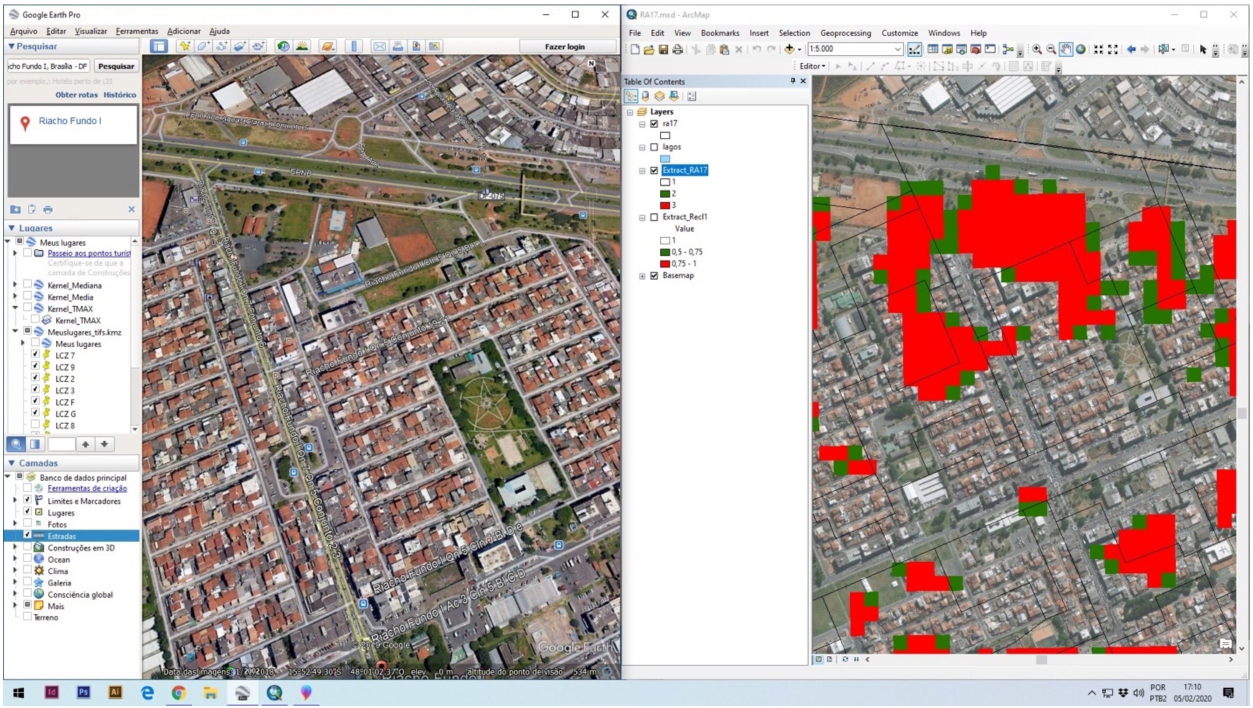

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Lago Sul, Brasília - DF
Pesquisar
Obter rotas Histórico
Lago Sul
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
Camadas
Banco de dados principal
Ferramentas de criação
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
Google Earth
RA16.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4.000
Table Of Contents
Layers
ra16
lagos
Extract_RA16
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
quarta-feira, 5 de fevereiro de 2020
16:44
05/02/2020

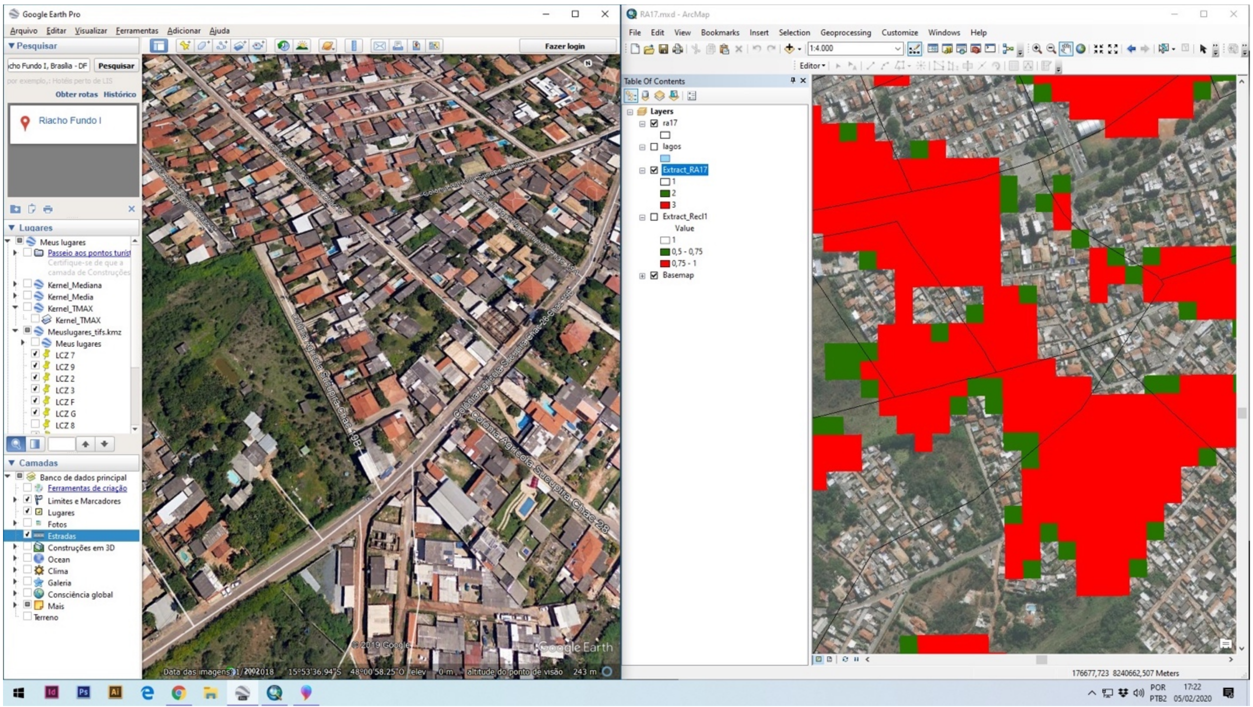
Appendix 17 RA XVII - Riacho Fundo I

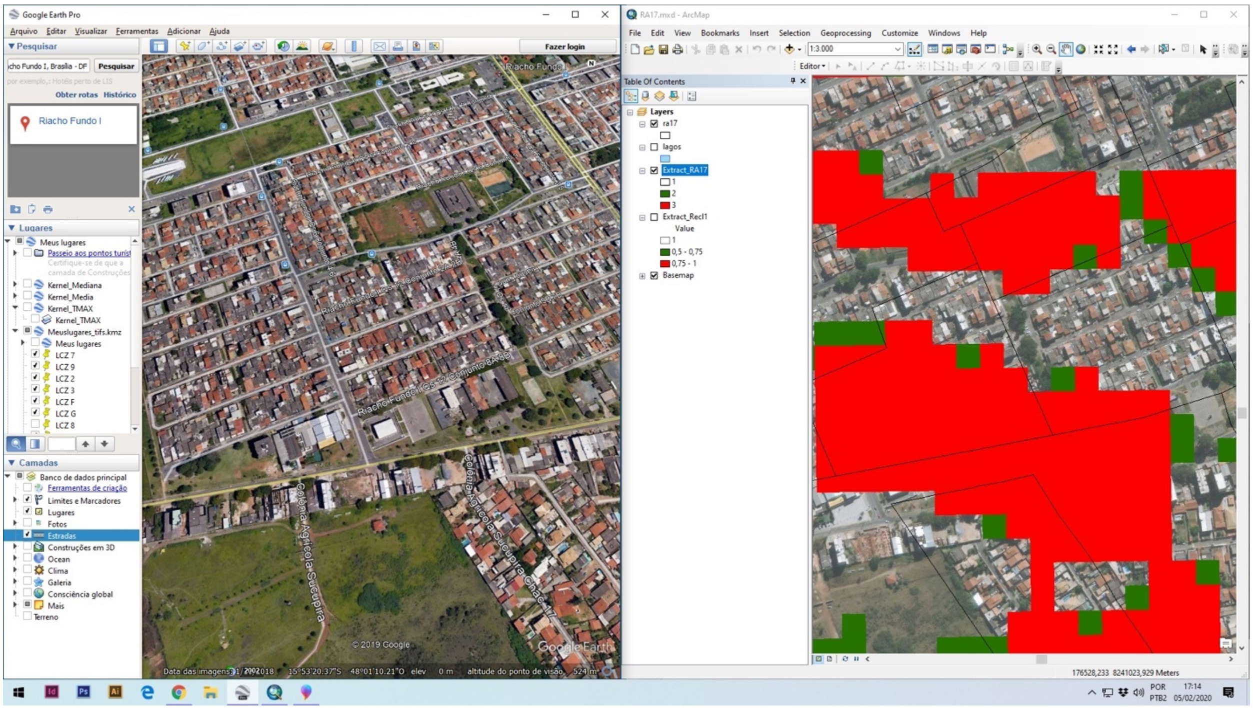




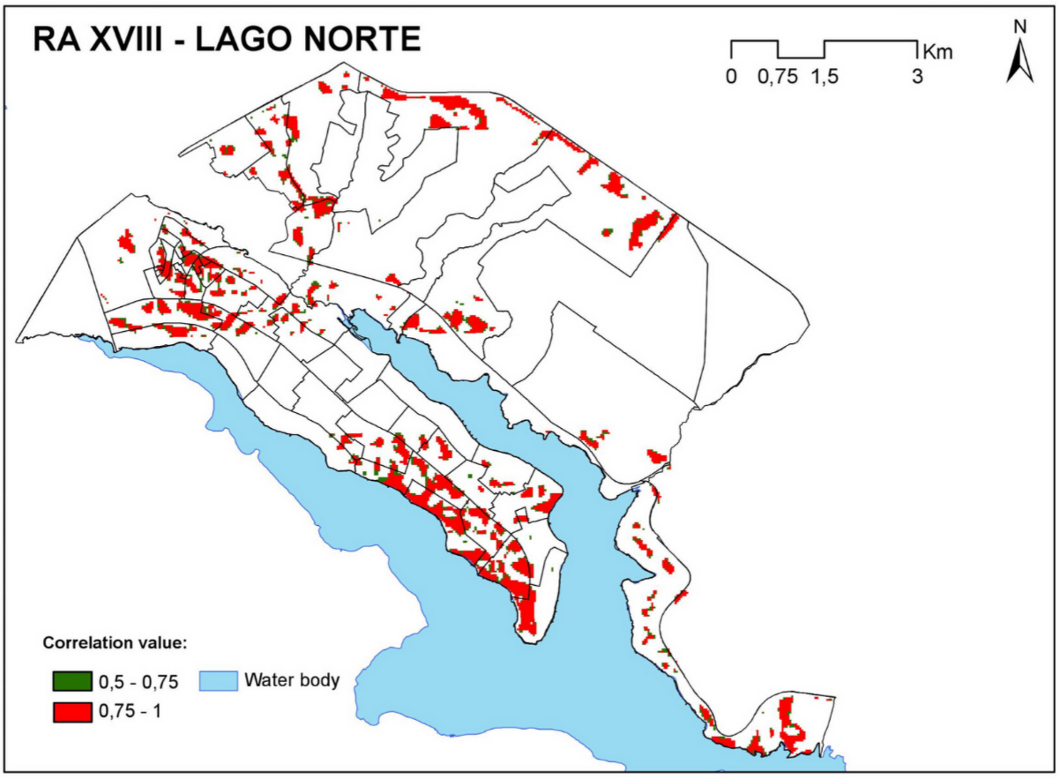


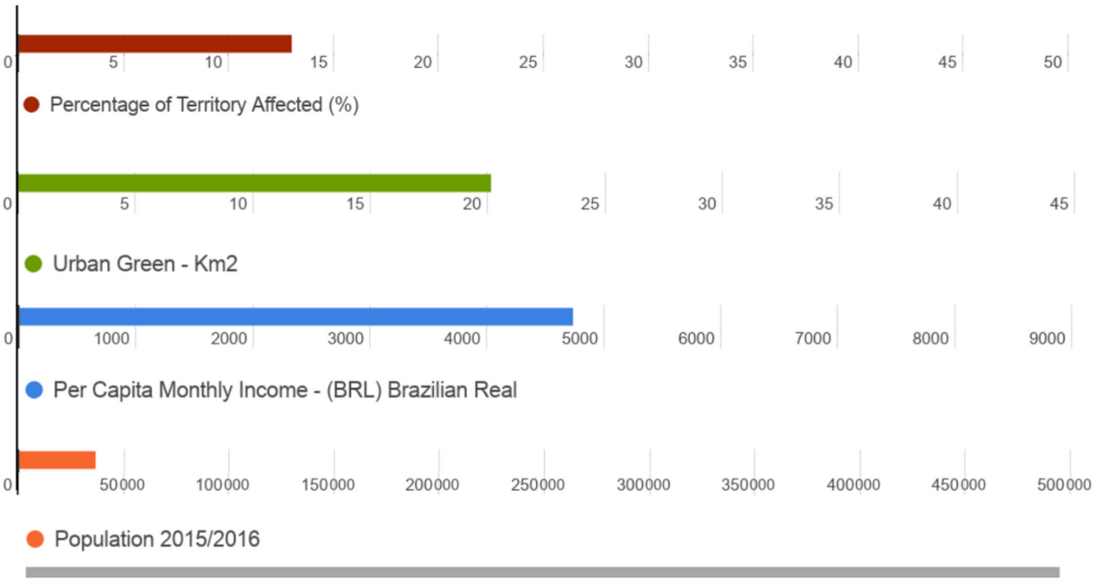

Google Earth Pro
RA17.mxd - ArcMap
Riacho Fundo I
Table Of Contents
Layers
ra17
lagos
Extract_RA17
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
1:5.000

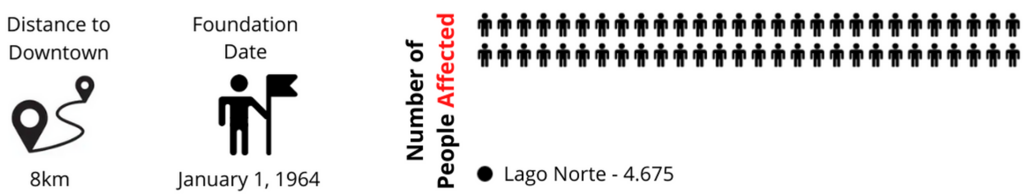

Google Earth Pro
RA17.mxd - ArcMap
Riacho Fundo I
Table Of Contents
Layers
ra17
lagos
Extract_RA17
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
1:4.000

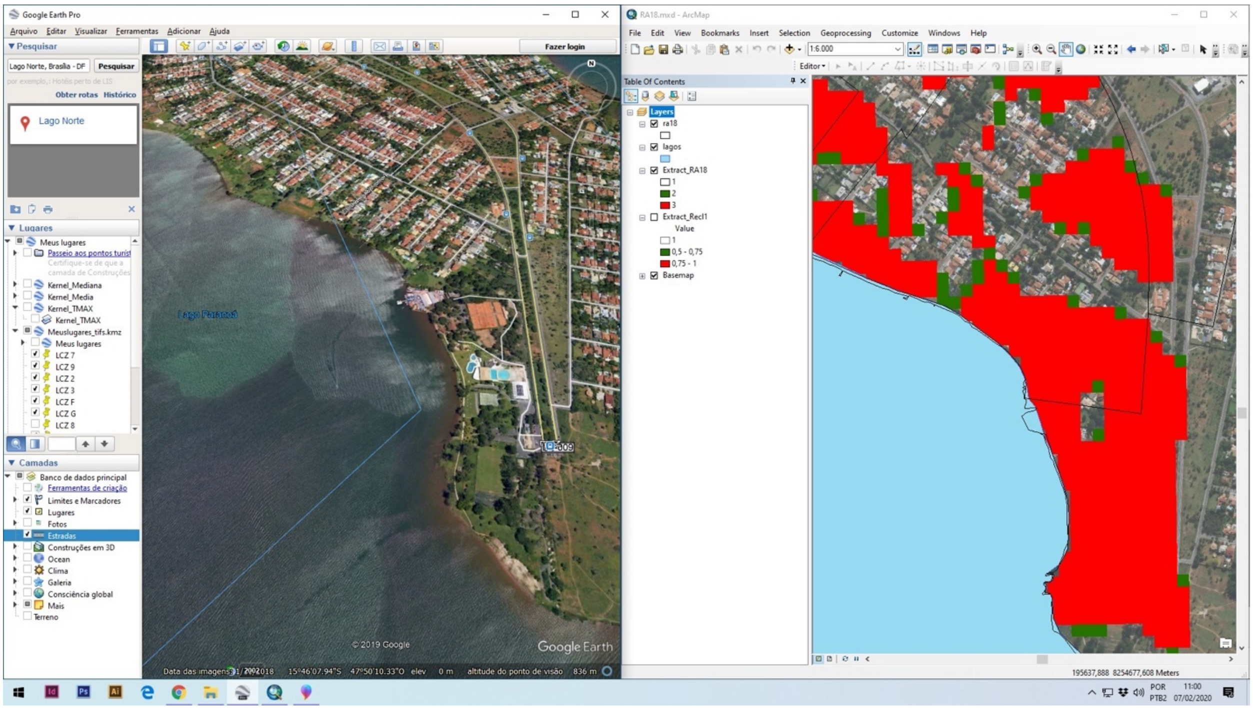


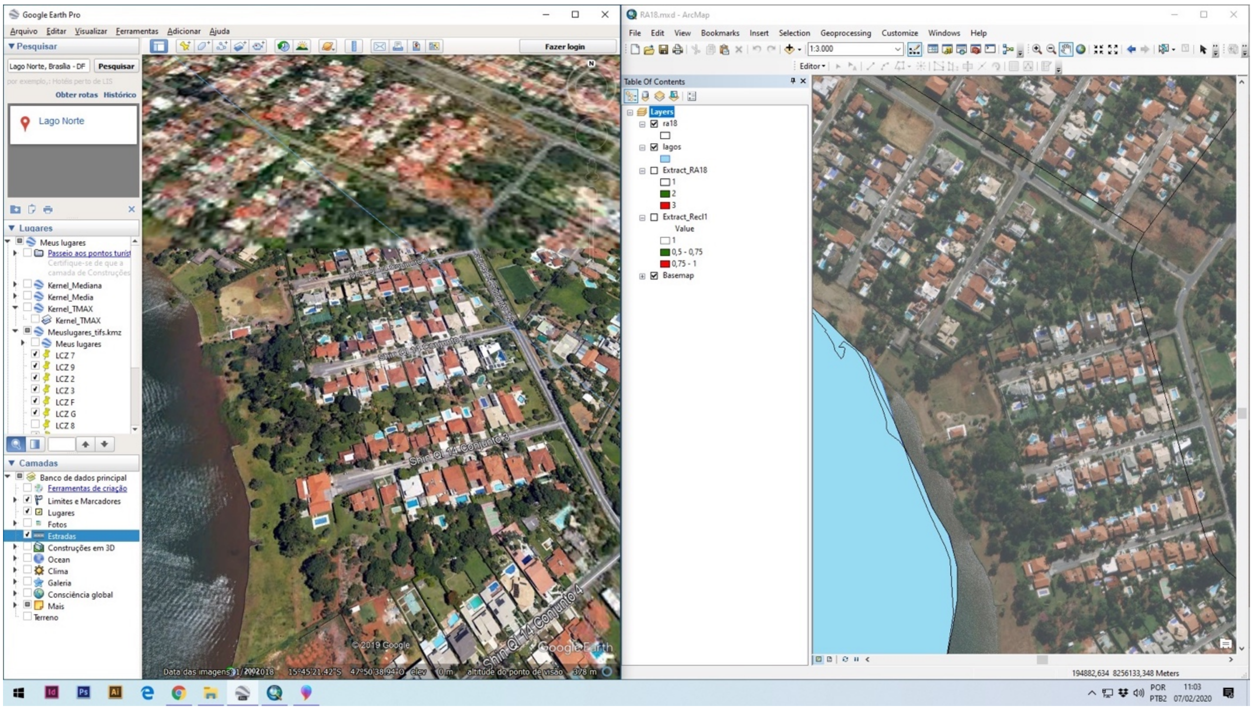
Appendix 18 RA XVIII Lago Norte

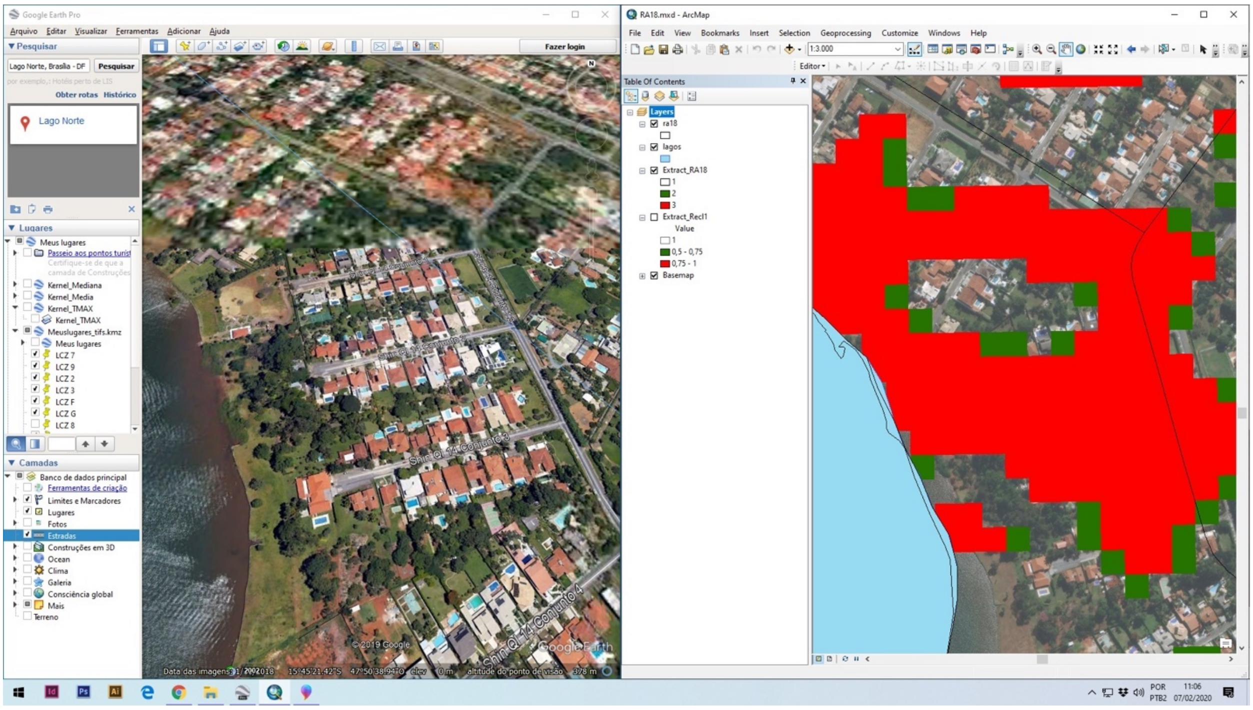




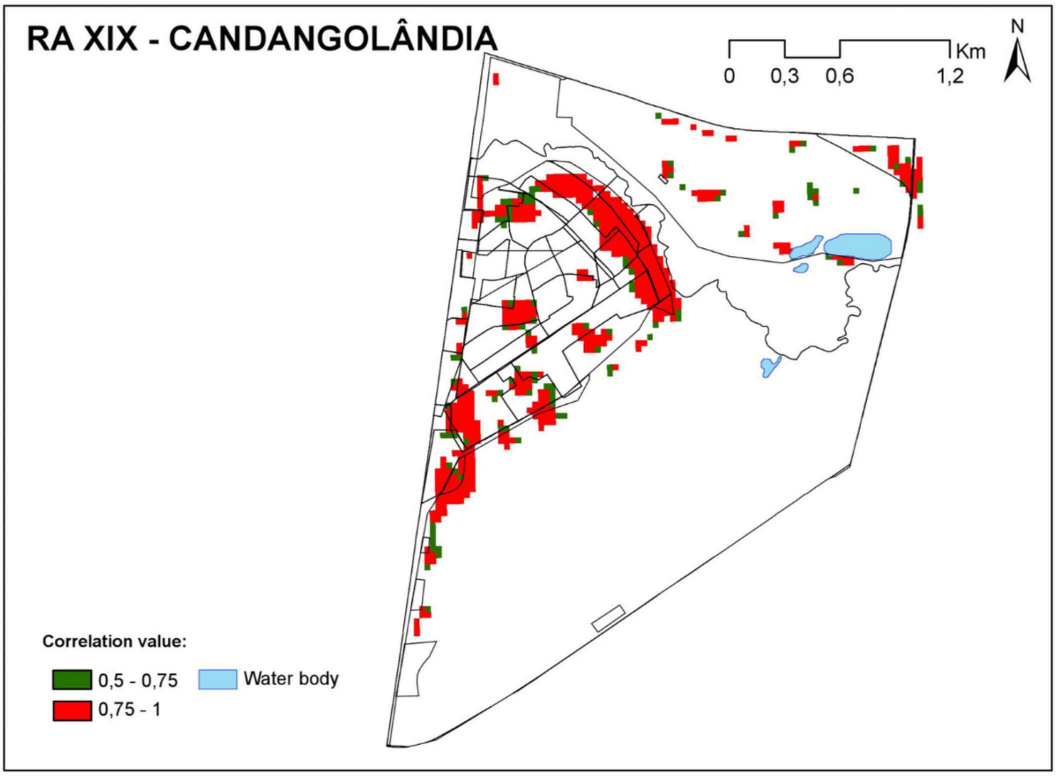


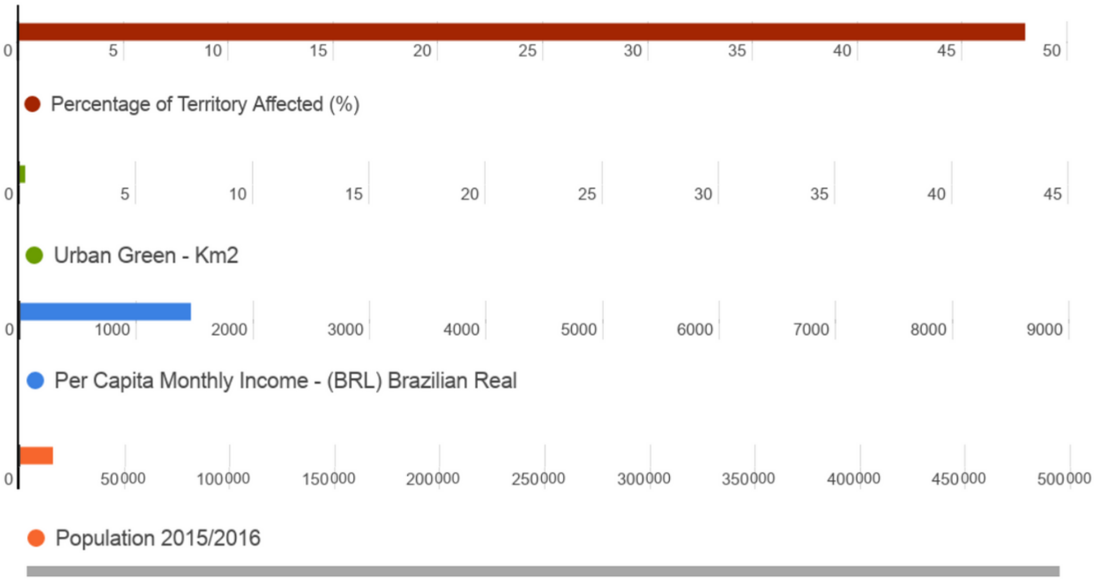

Google Earth Pro
RA18.mxd - ArcMap
Lago Norte
Table Of Contents
Layers
ra18
lagos
Extract_RA18
Extract_Recl1
Basemap
© 2019 Google
Google Earth

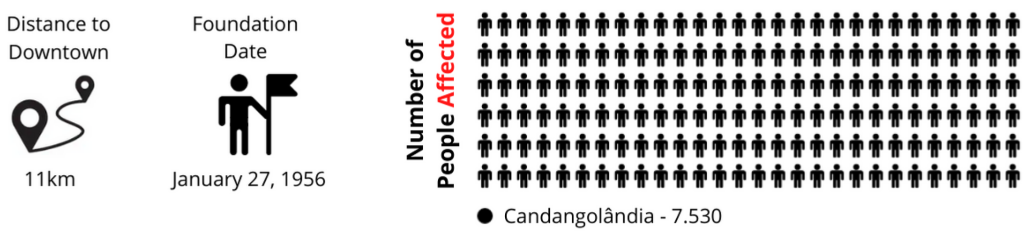

Google Earth Pro
RA18.mxd - ArcMap
Lago Norte
Table Of Contents
Layers
ra18
lagos
Extract_RA18
Extract_Recl1
Basemap
© 2019 Google

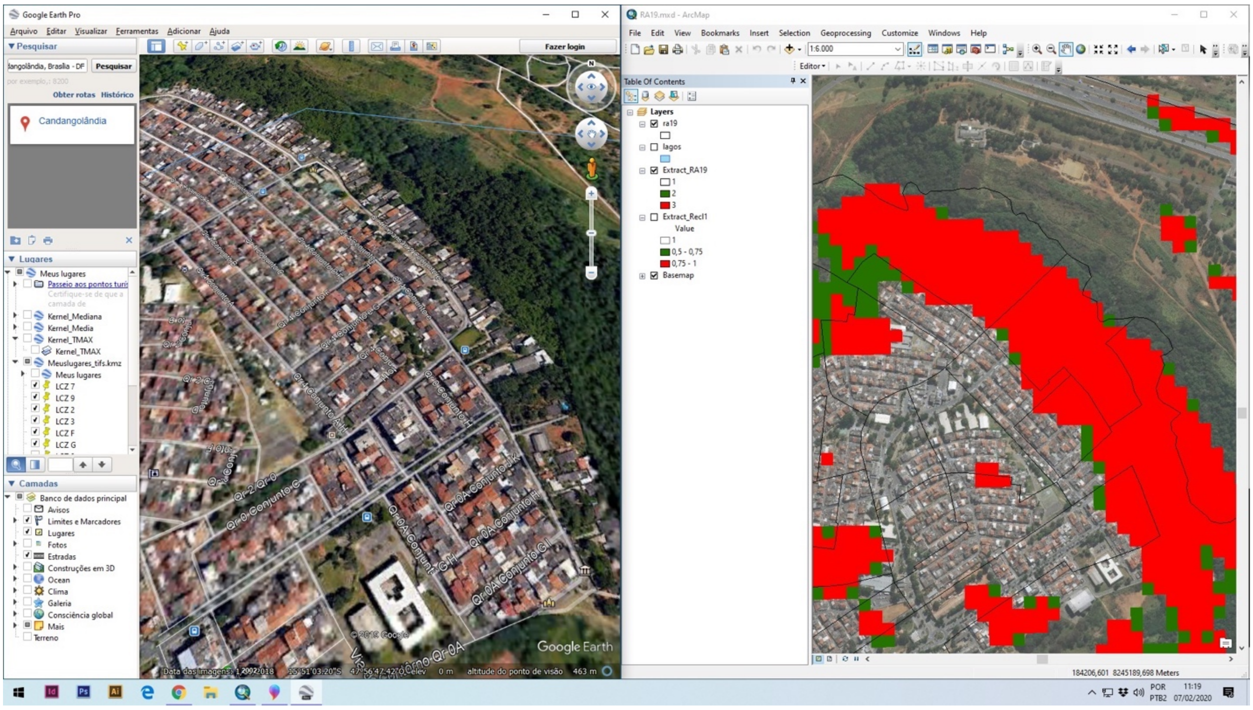

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Lago Norte
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
RA18.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra18
lagos
Extract_RA18
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap

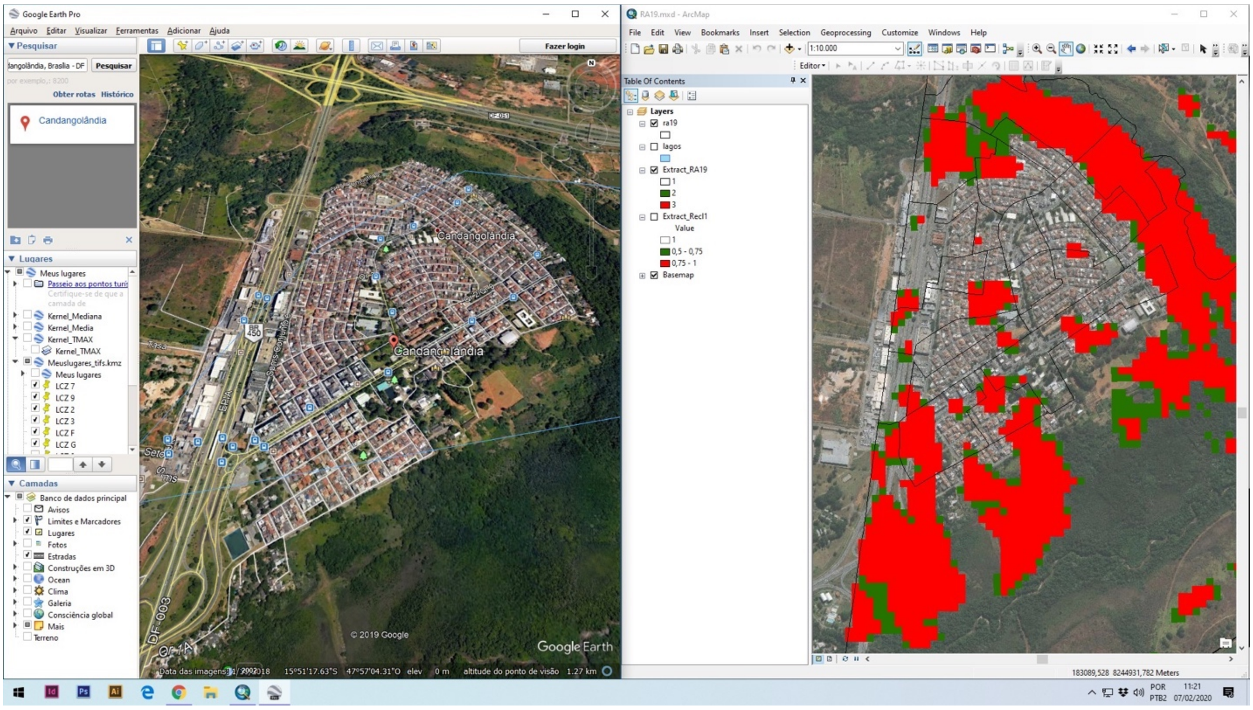
Appendix 19 RA XIX - Candangolândia



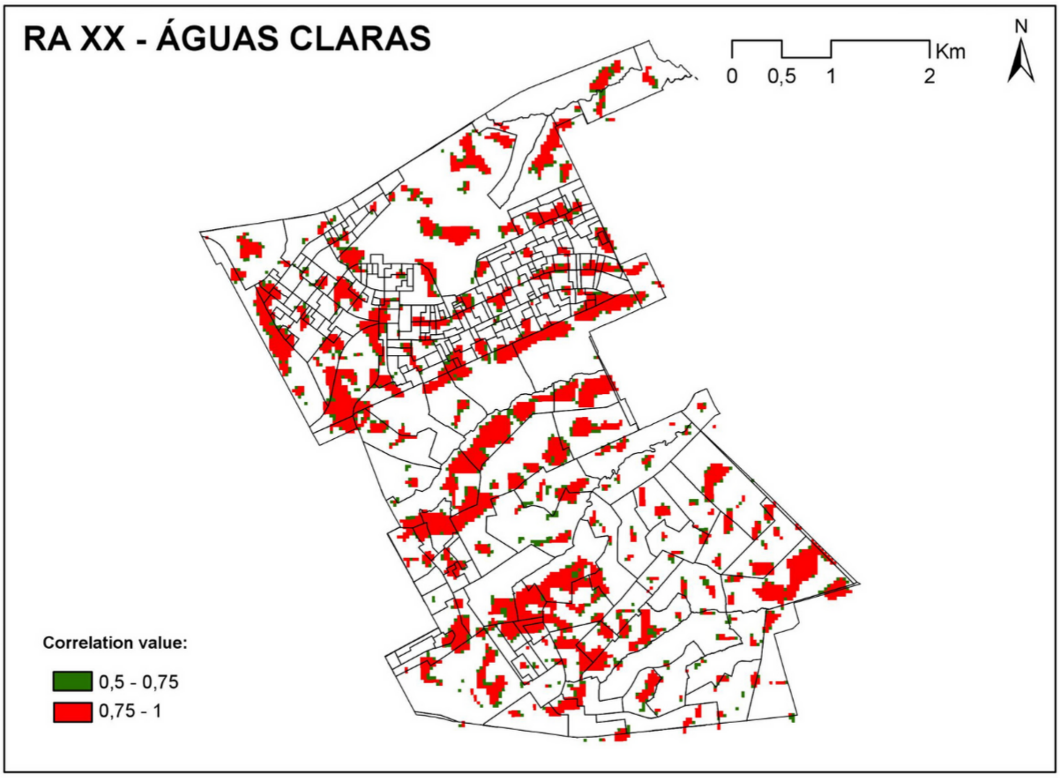


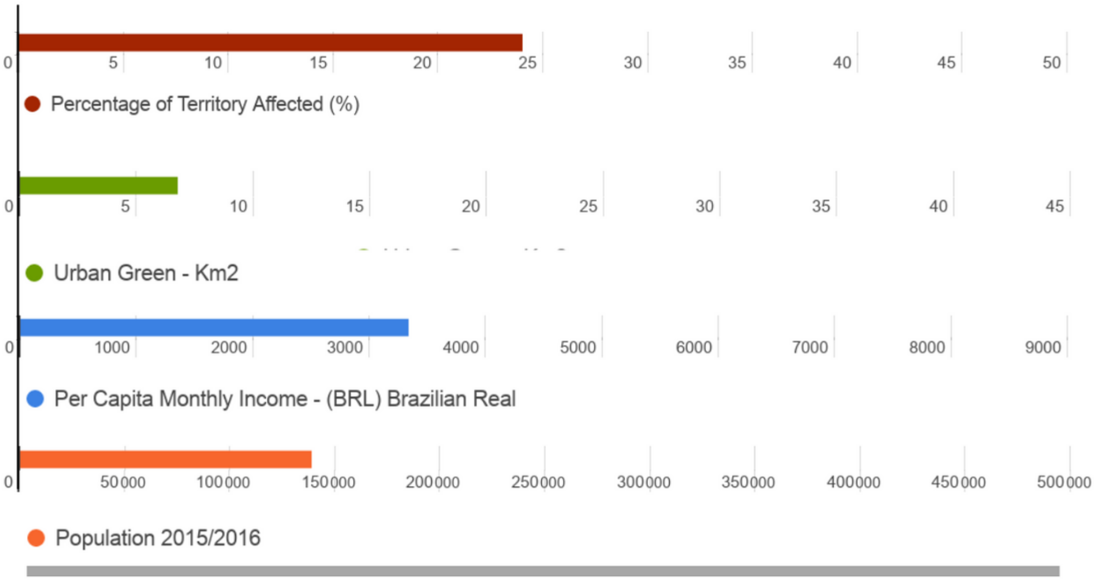


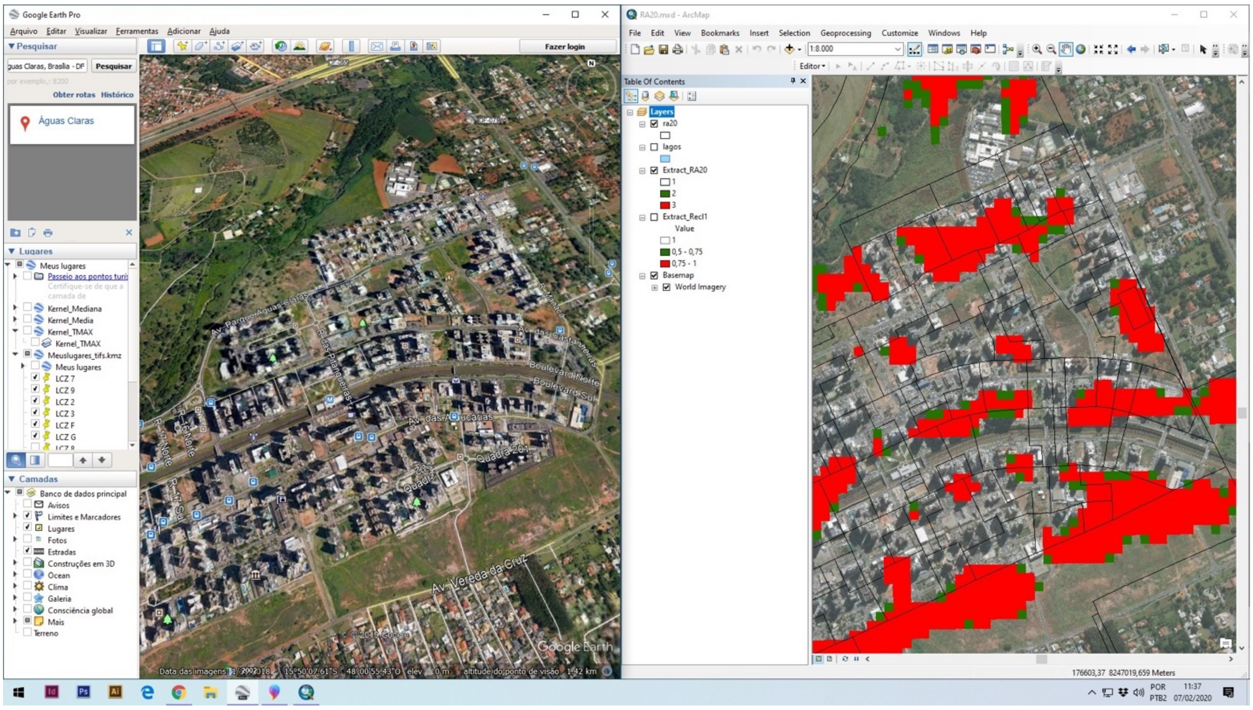

Google Earth Pro
RA19.mxd - ArcMap
Candangolândia
Table Of Contents
Layers
ra19
lagos
Extract_RA19
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Google Earth
184206,601 8245189,698 Meters

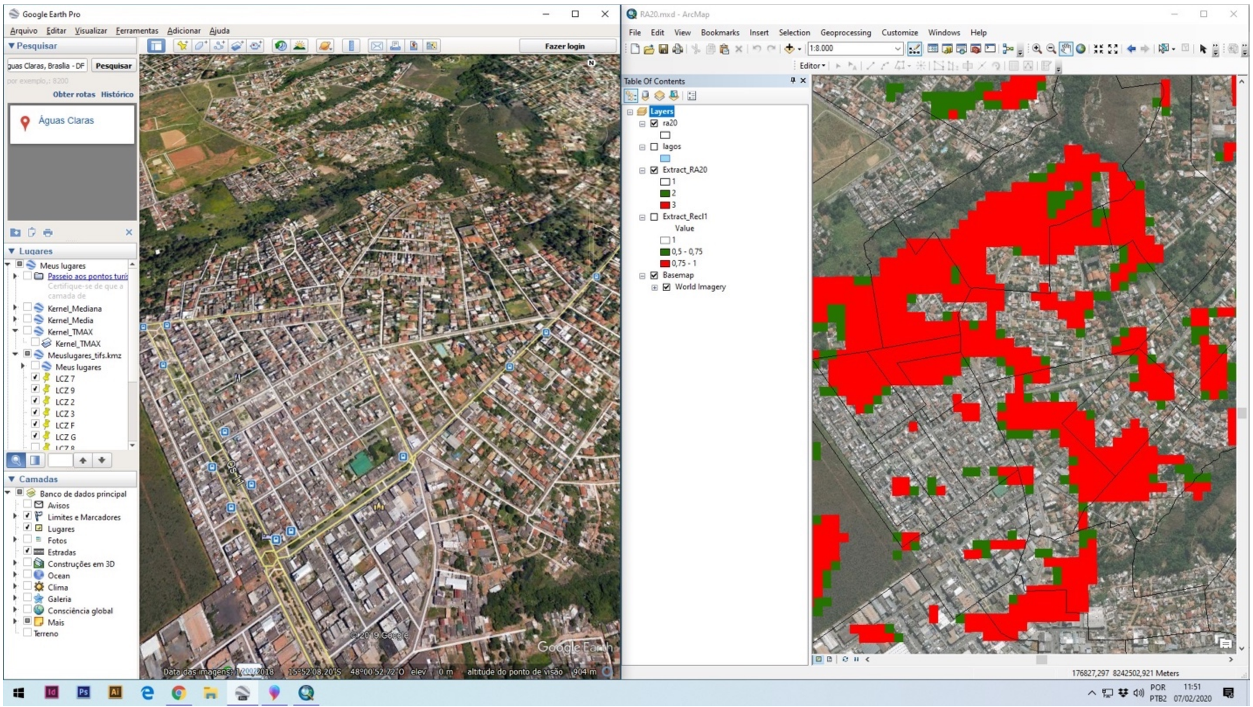

Google Earth Pro
RA19.mxd - ArcMap
Candangolândia
Table Of Contents
Layers
ra19
lagos
Extract_RA19
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
© 2019 Google
Google Earth
183089,528 8244931,782 Meters

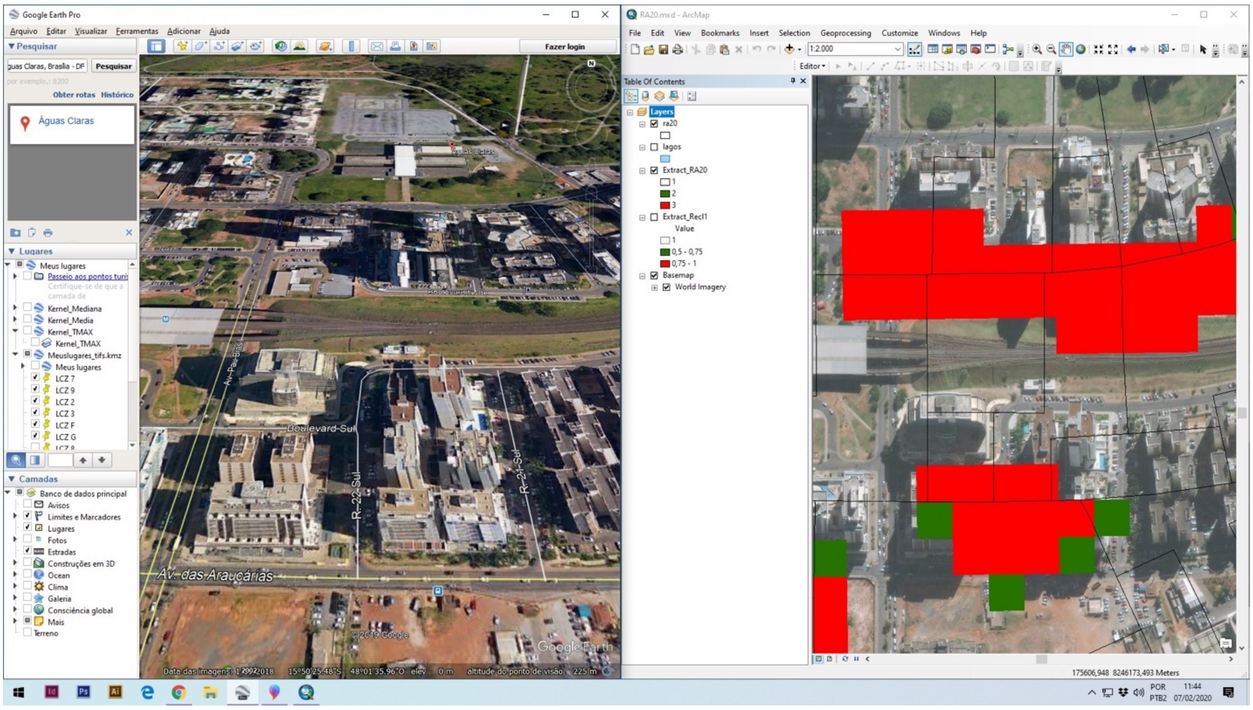
Appendix 20 RA XX - Águas Claras



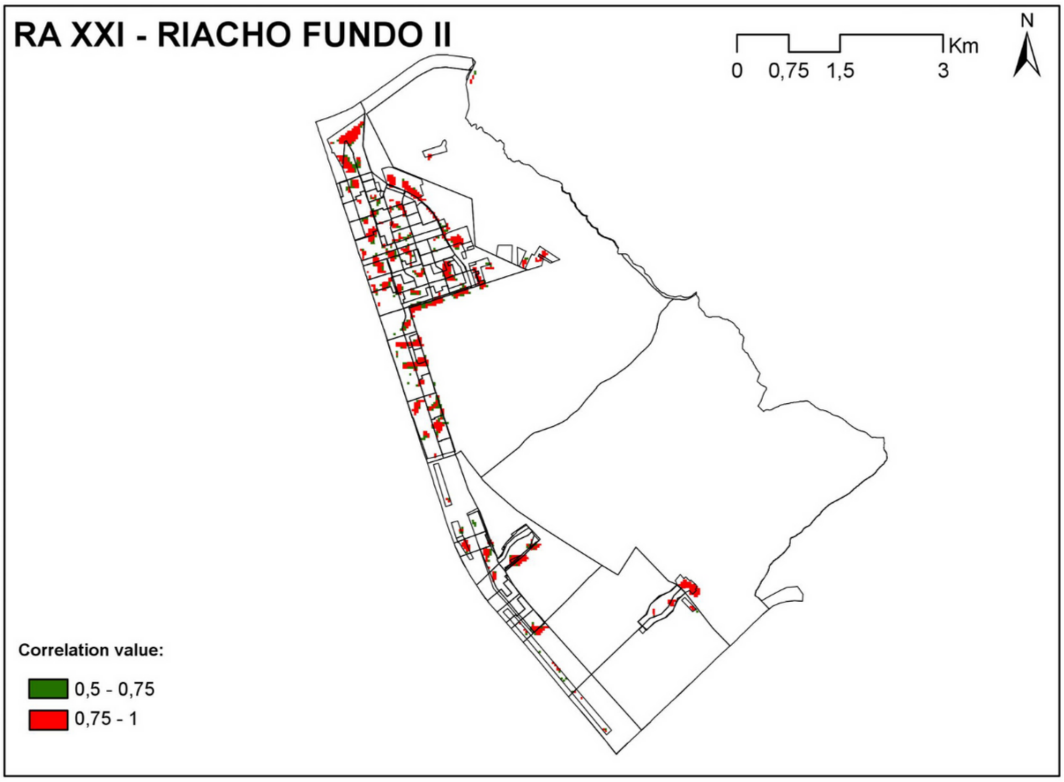


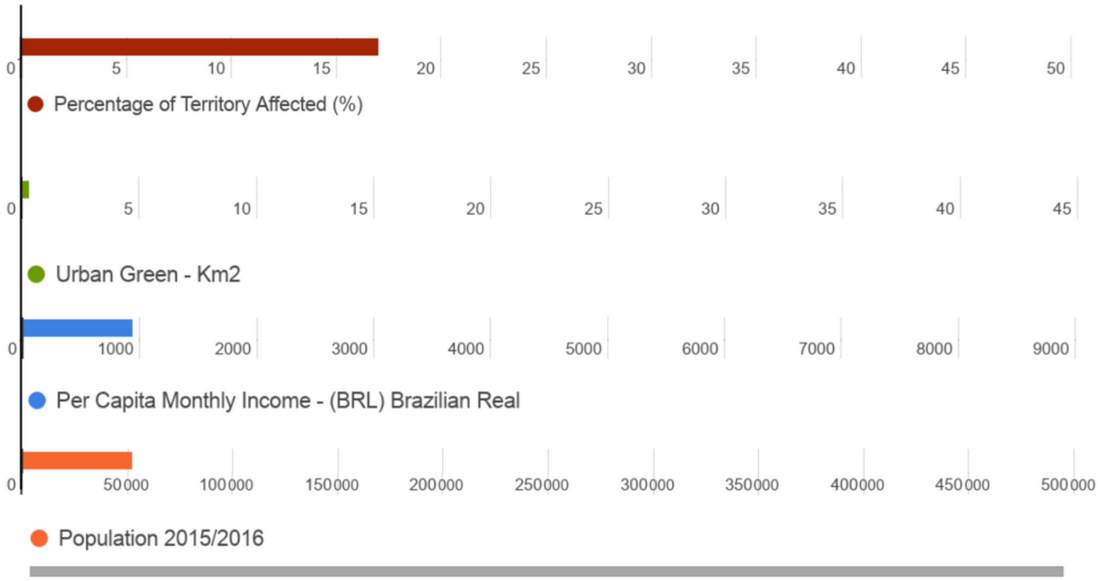

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Águas Claras
Lugares
Camadas
RA20.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra20
lagos
Extract_RA20
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
World Imagery
Av. das Araucárias
Av. Vereda da Cruz
Google Earth

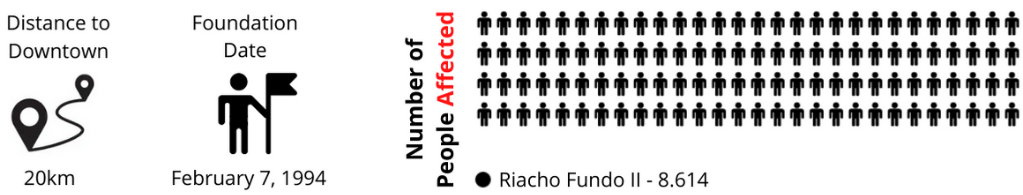

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Águas Claras
Lugares
Camadas
RA20.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra20
lagos
Extract_RA20
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
World Imagery
Google Earth

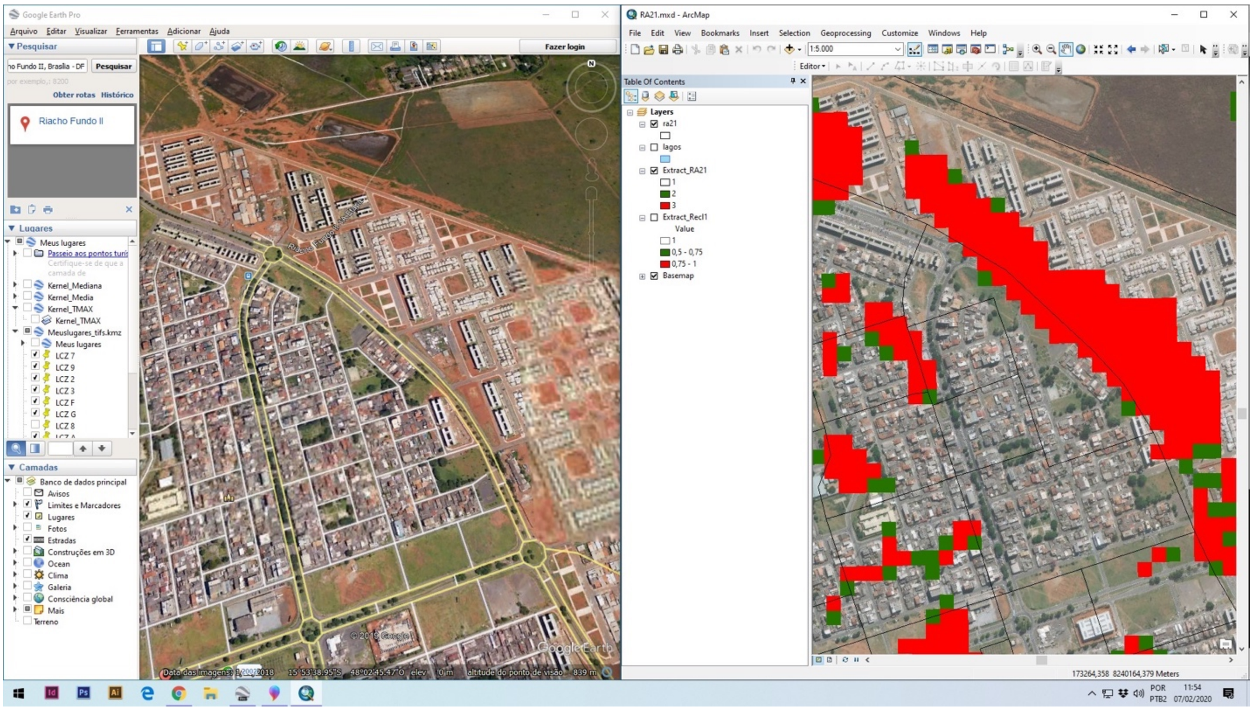


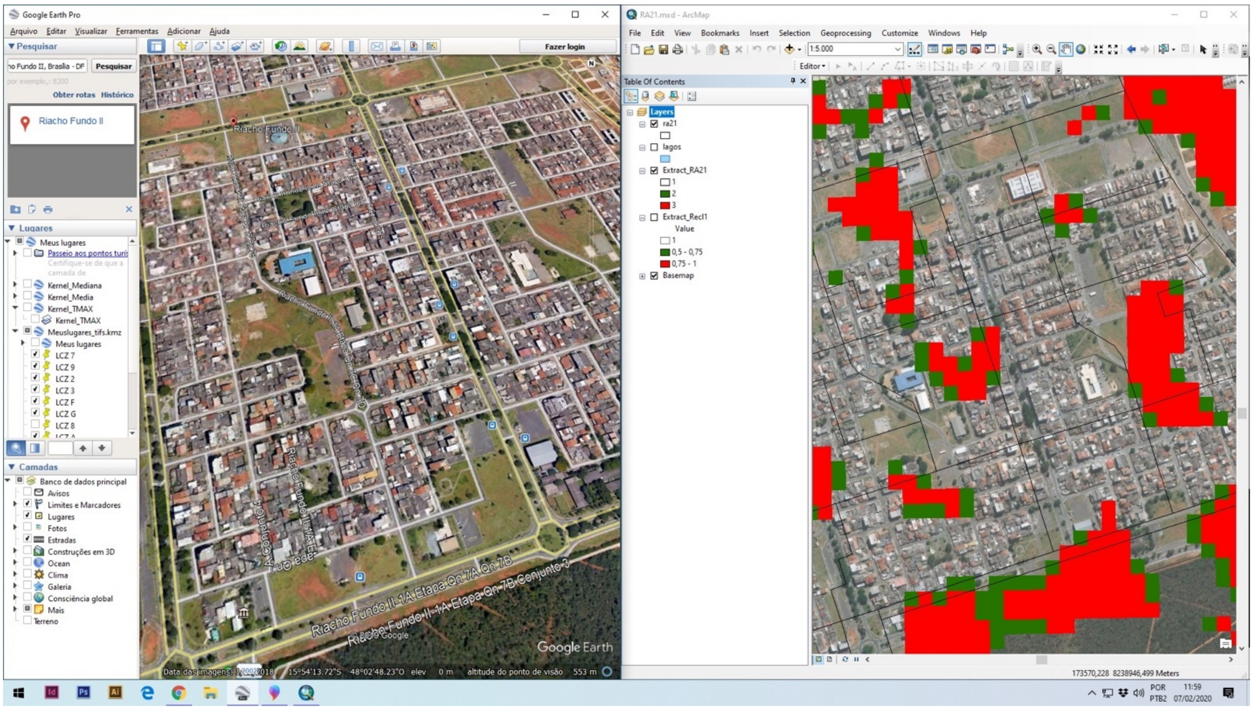
Appendix 21 RA XXI - Riacho Fundo II

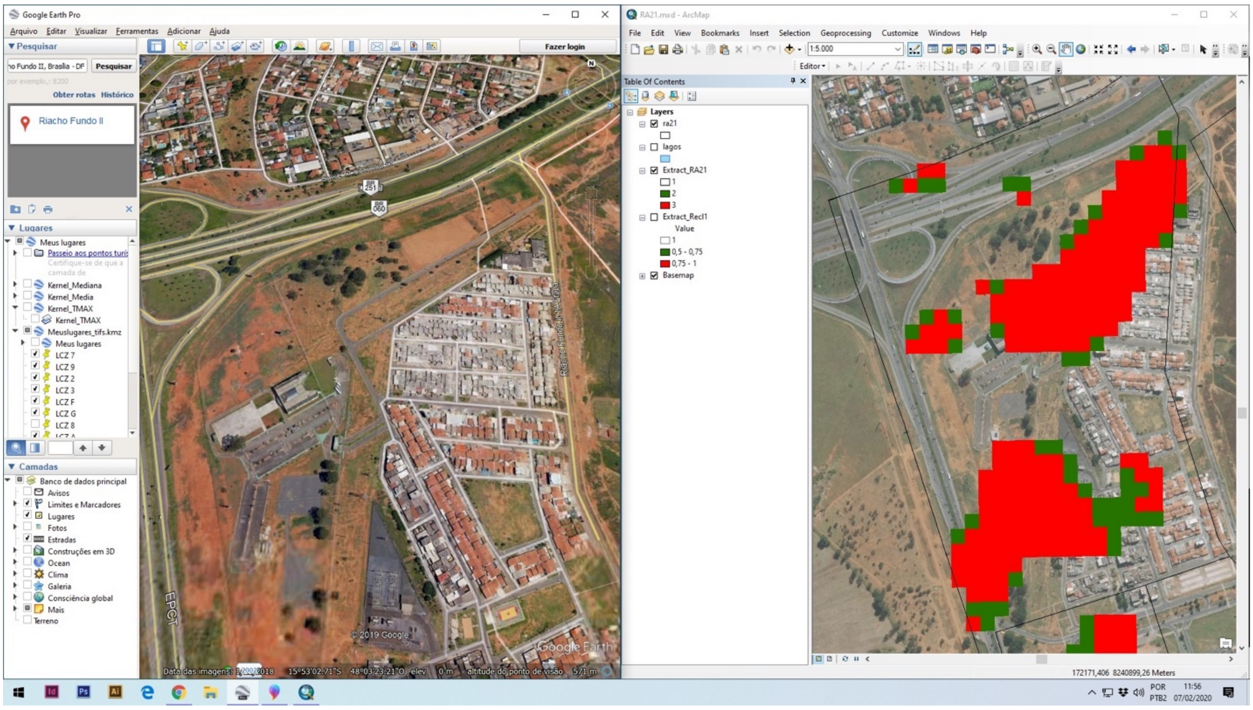




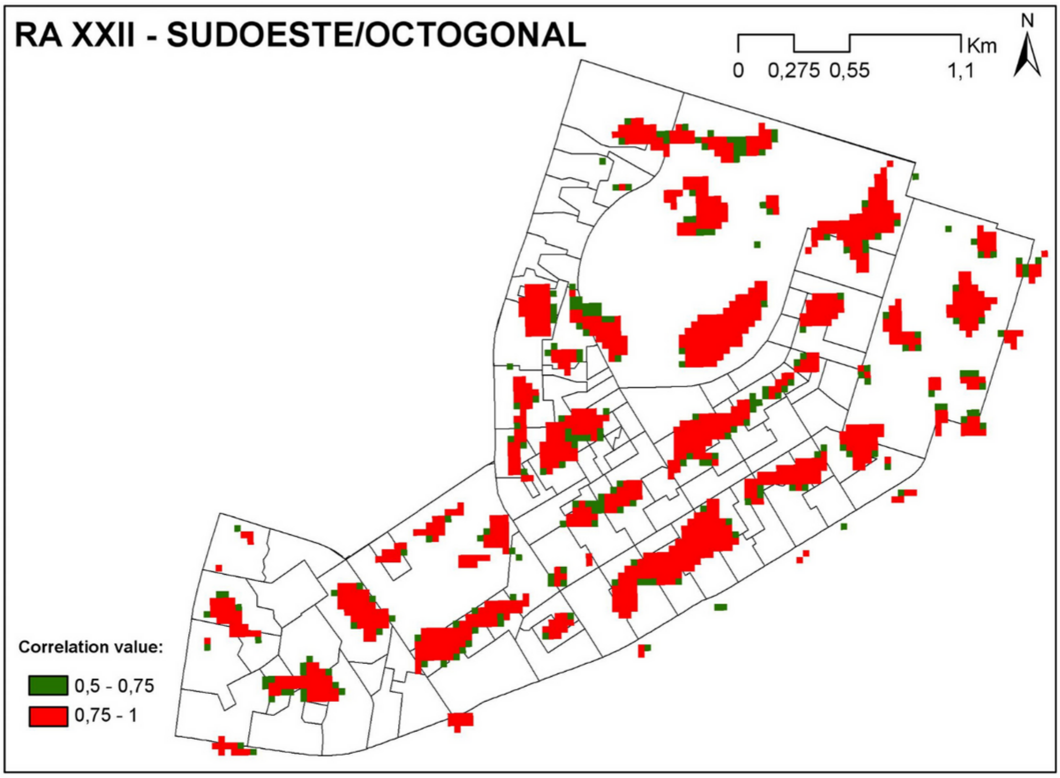


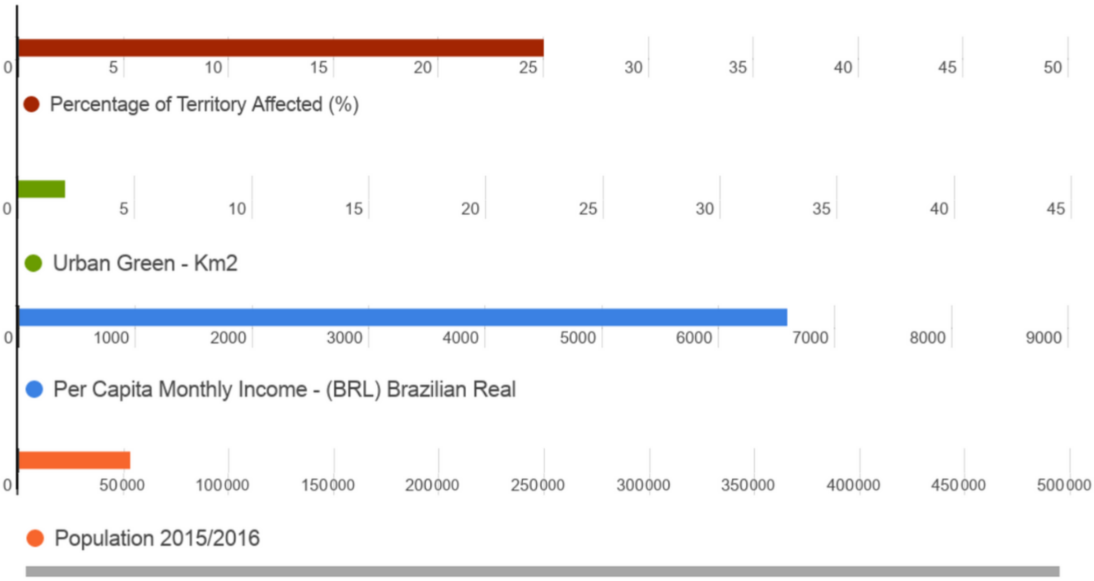

Google Earth Pro
RA21.mxd - ArcMap
Riacho Fundo II
Table Of Contents
Layers
ra21
lagos
Extract_RA21
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
1:5.000
173264,358 8240164,379 Meters
Google Earth

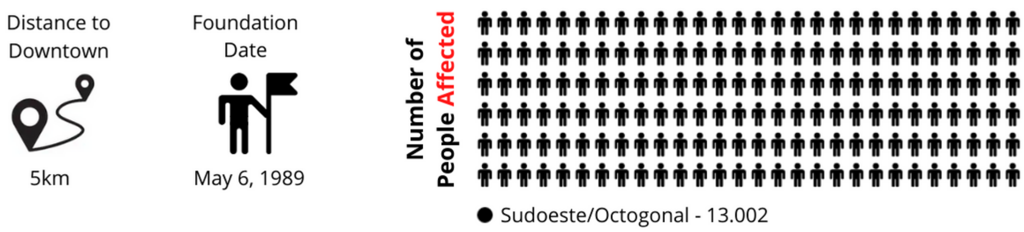

Google Earth Pro
RA21.mxd - ArcMap
Riacho Fundo II
Table Of Contents
Layers
ra21
lagos
Extract_RA21
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
1:5.000
173570,228 8238946,499 Meters
Google Earth

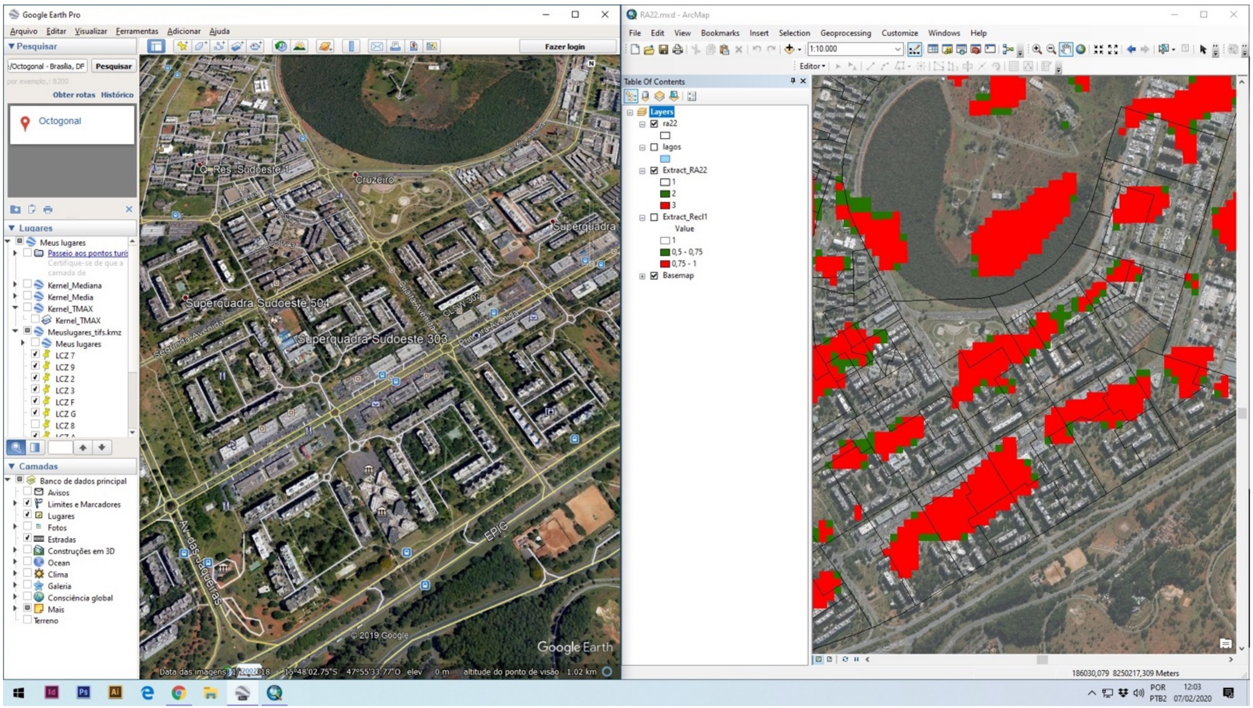


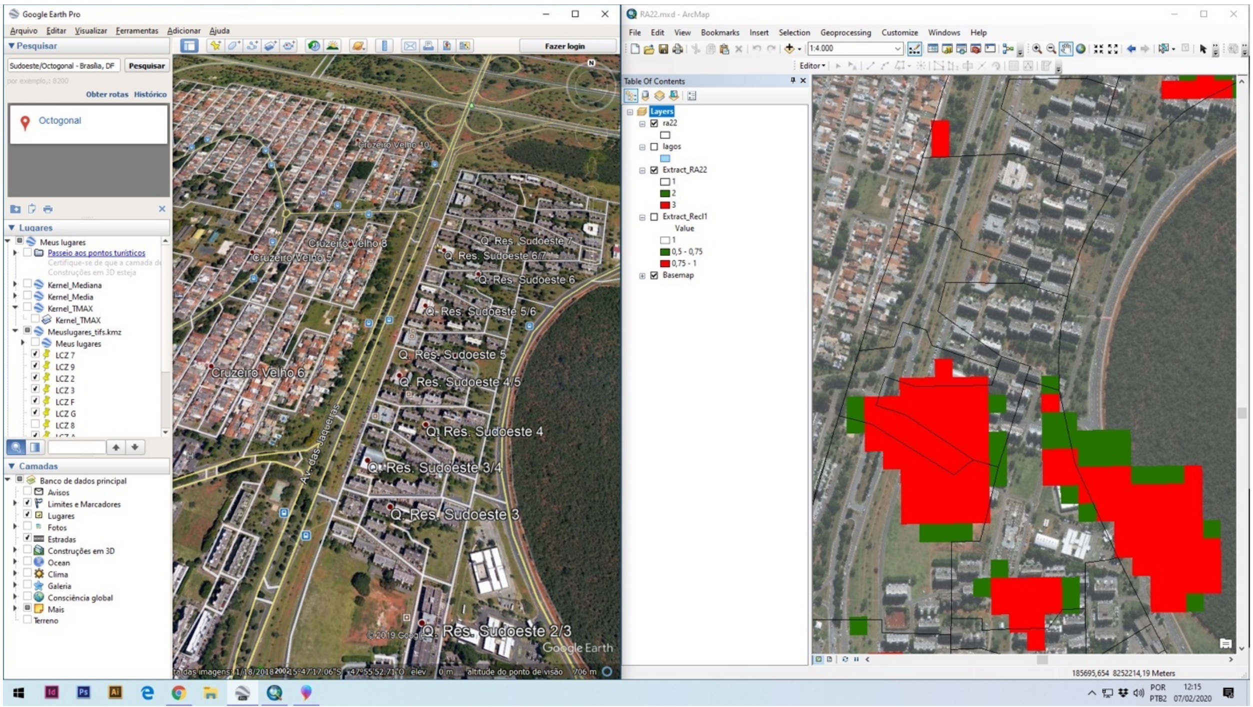
Appendix 22 RA XXII - Sudoeste/ Octogonal

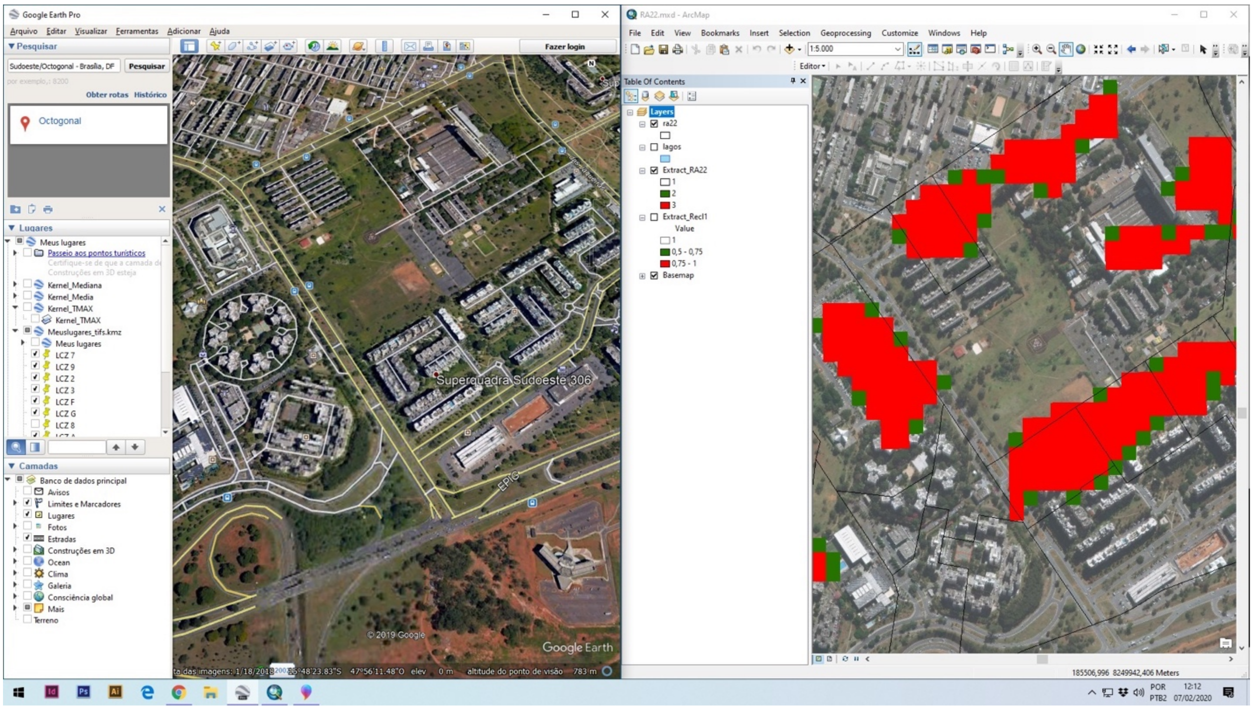




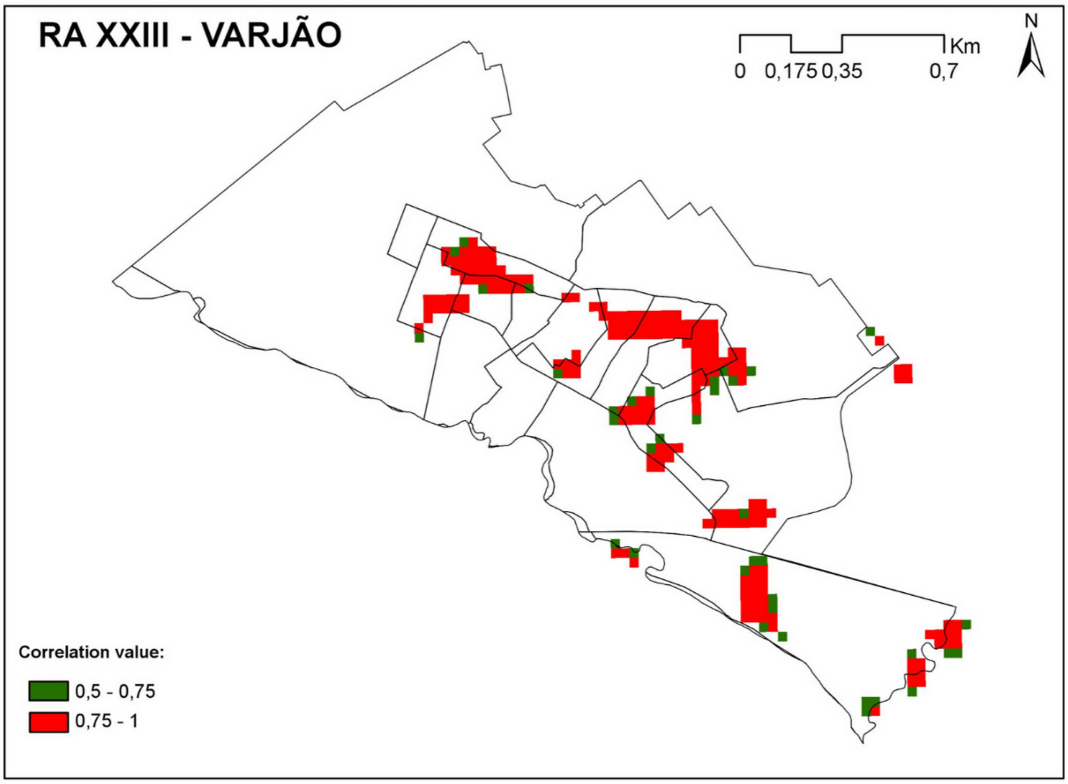


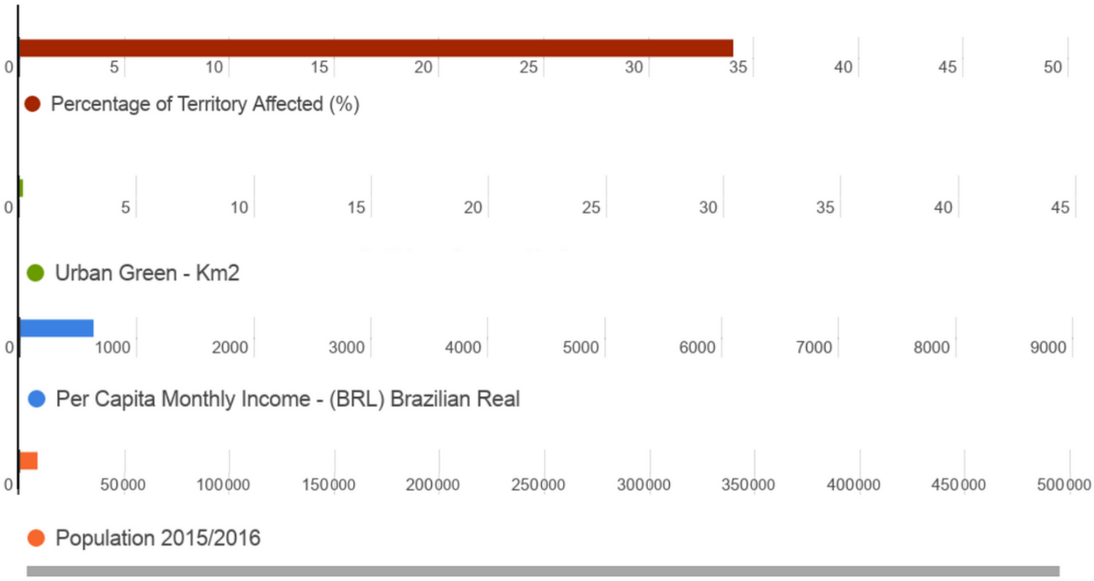

Google Earth Pro
Octogonal
Q. Res. Sudoeste
Cruzeiro
Superquadra
Superquadra Sudoeste 501
Superquadra Sudoeste 303
EPIG
Av. das Palmeiras
© 2019 Google
Google Earth
RA22.mxd - ArcMap
Table Of Contents
Layers
ra22
lagos
Extract_RA22
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

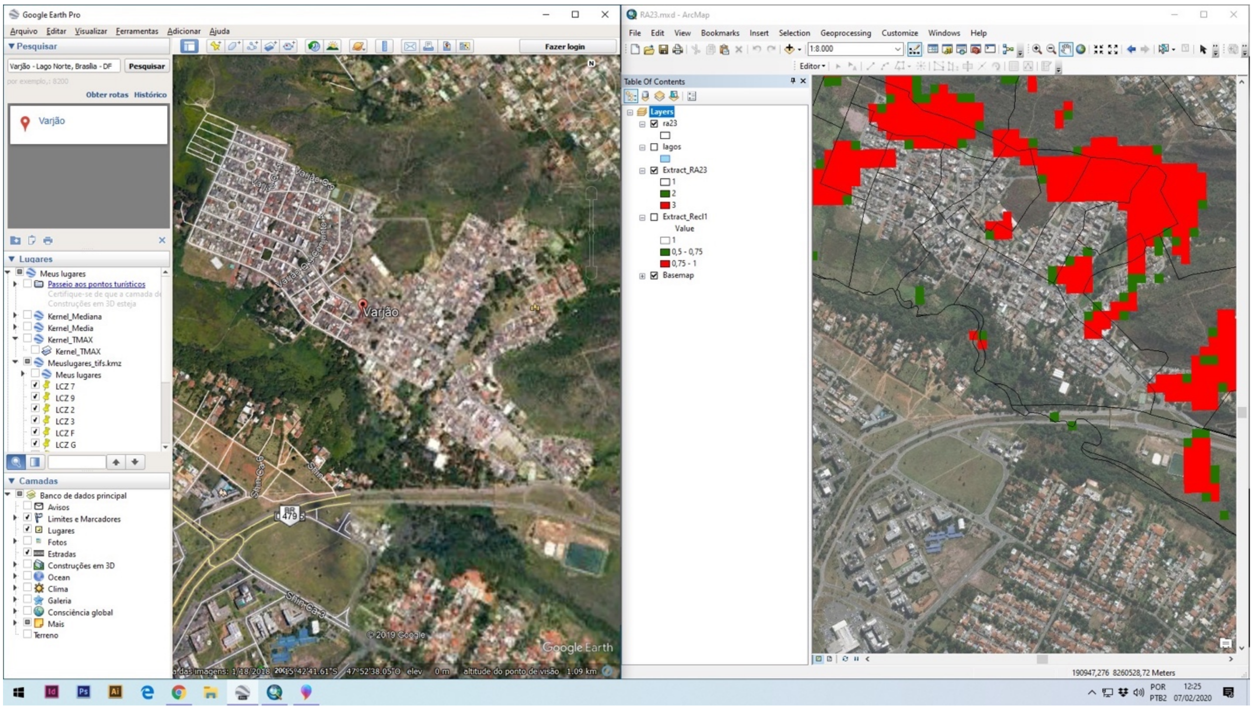

Google Earth Pro
Octogonal
Cruzeiro Velho 8
Cruzeiro Velho 7
Cruzeiro Velho 6
Q. Res. Sudoeste 7
Q. Res. Sudoeste 6/7
Q. Res. Sudoeste 6
Q. Res. Sudoeste 5/6
Q. Res. Sudoeste 5
Q. Res. Sudoeste 4/5
Q. Res. Sudoeste 4
Q. Res. Sudoeste 3/4
Q. Res. Sudoeste 3
Q. Res. Sudoeste 2/3
Google Earth
RA22.mxd - ArcMap
Table Of Contents
Layers
ra22
lagos
Extract_RA22
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

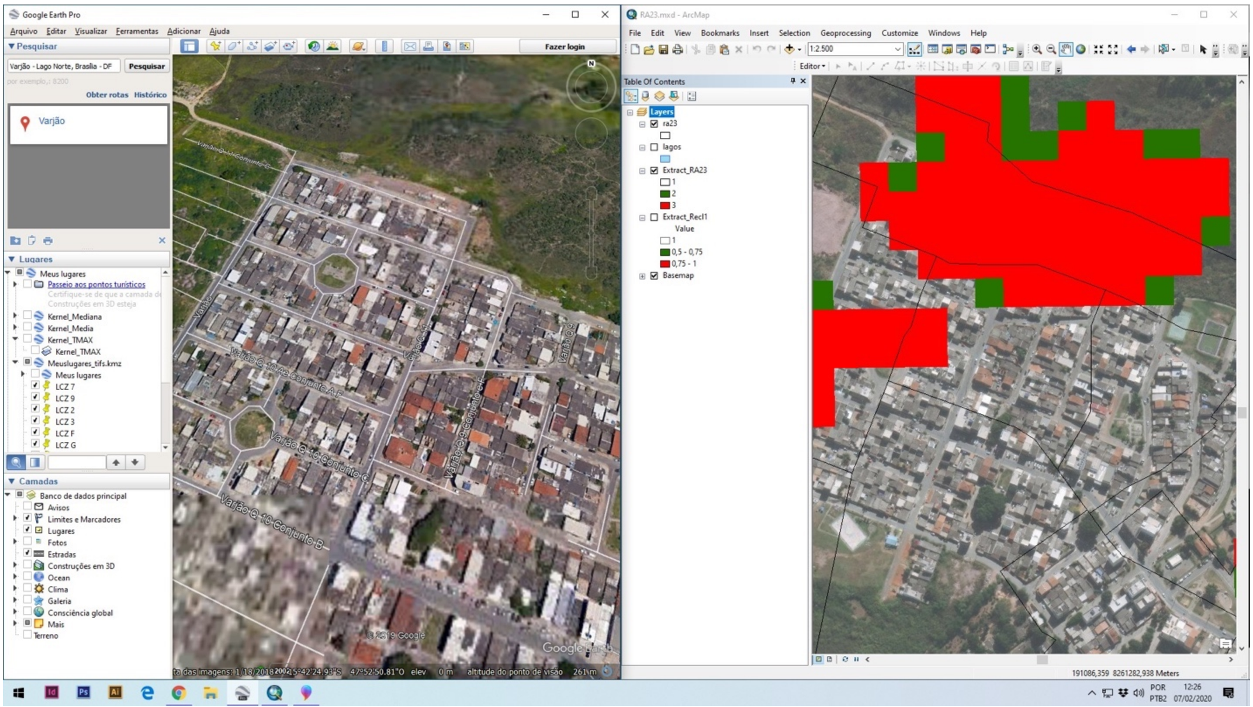

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Sudoeste/Octogonal - Brasília, DF
Pesquisar
Obter rotas Histórico
Octogonal
Lugares
Meus lugares
Passeio aos pontos turísticos
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Avisos
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
Superquadra Sudoeste 306
EPIG
© 2019 Google
Google Earth
RA22.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:5.000
Editor
Table Of Contents
Layers
ra22
lagos
Extract_RA22
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
185506,996 8249942,406 Meters
POR
PTB2
12:12
07/02/2020

Appendix 23 RA XXIII - Varjão

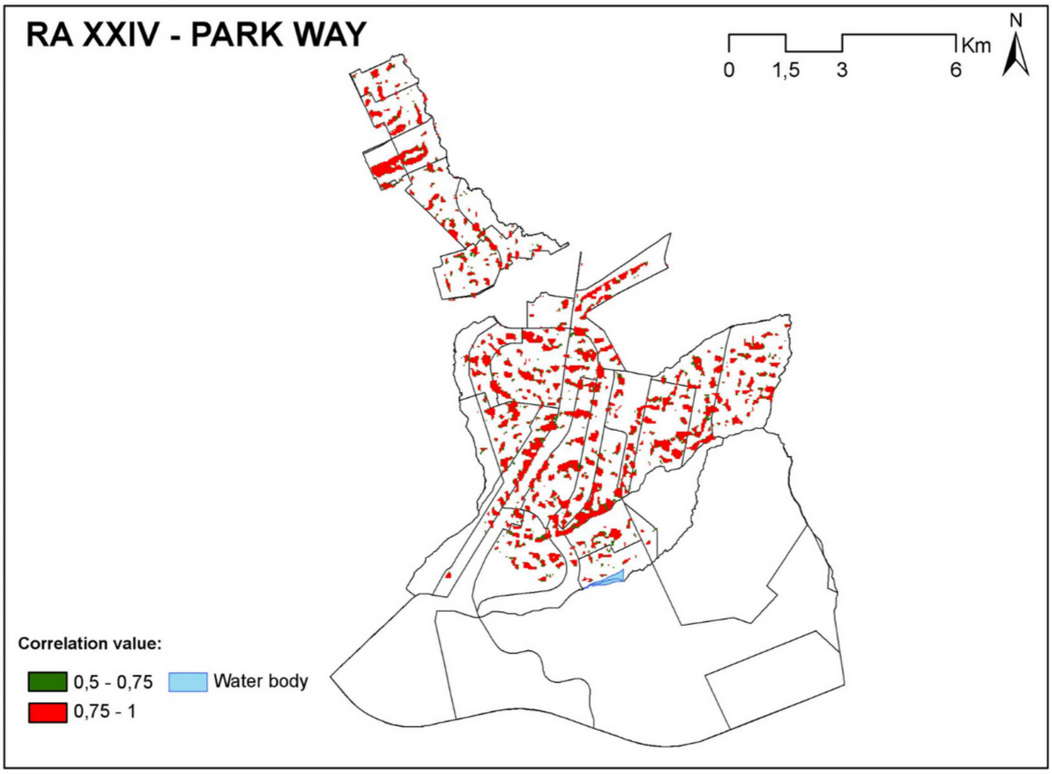


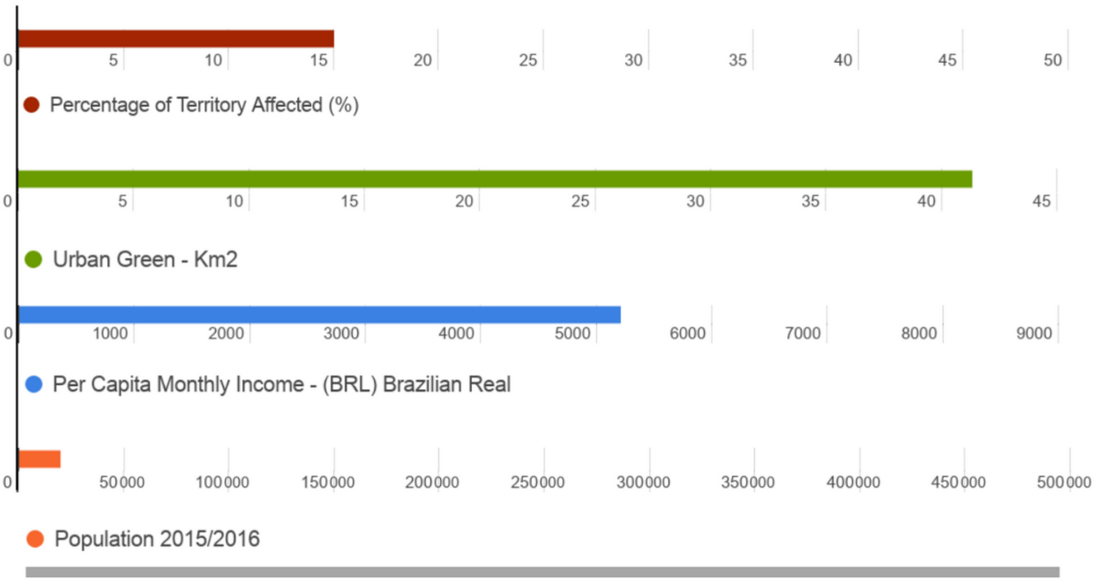


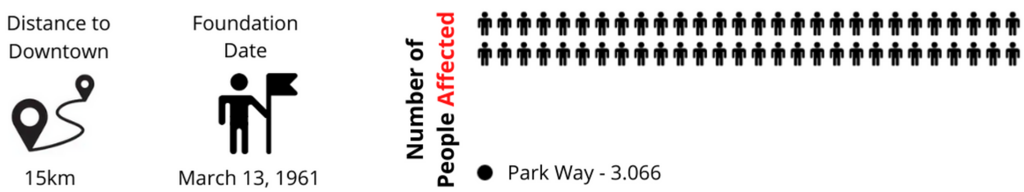

Google Earth Pro
Pesquisar
Varjão
Lugares
Camadas
Kernel_Mediana
Kernel_Media
Kernel_TMAX
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
RA23.mxd - ArcMap
Table Of Contents
Layers
ra23
lagos
Extract_RA23
1
2
3
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

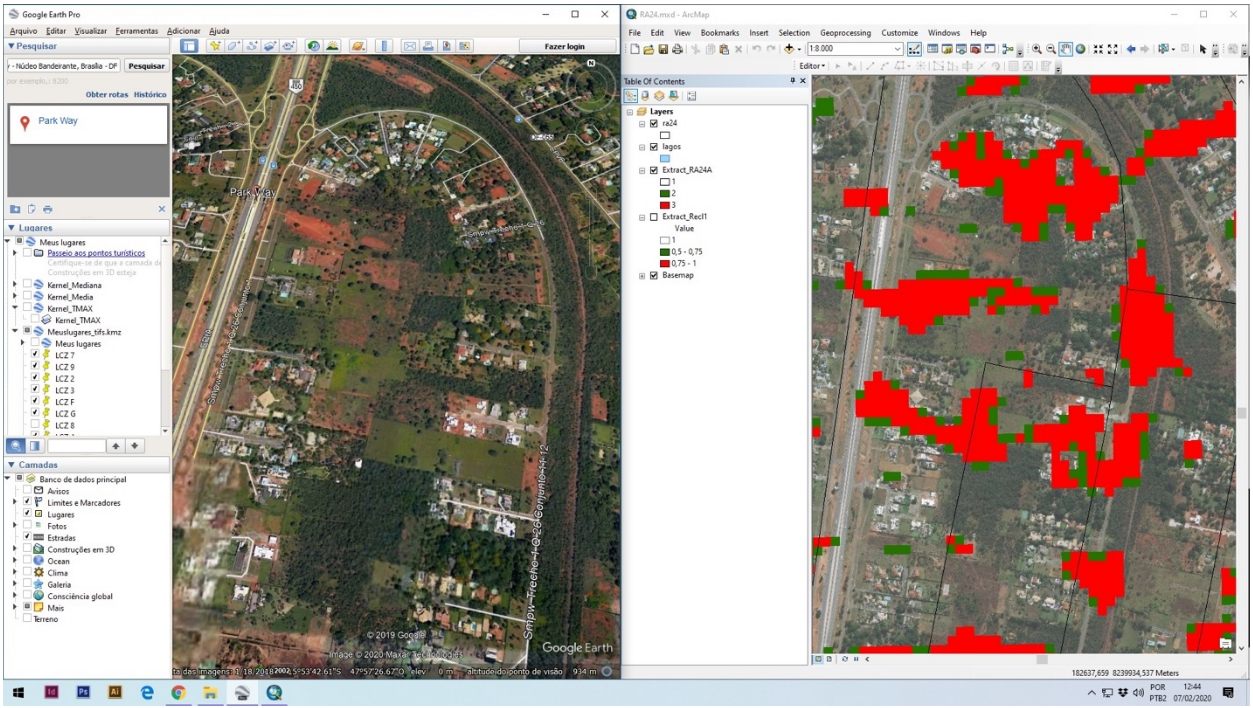

Google Earth Pro
Pesquisar
Varjão
Lugares
Camadas
RA23.mxd - ArcMap
Table Of Contents
Layers
ra23
lagos
Extract_RA23
1
2
3
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

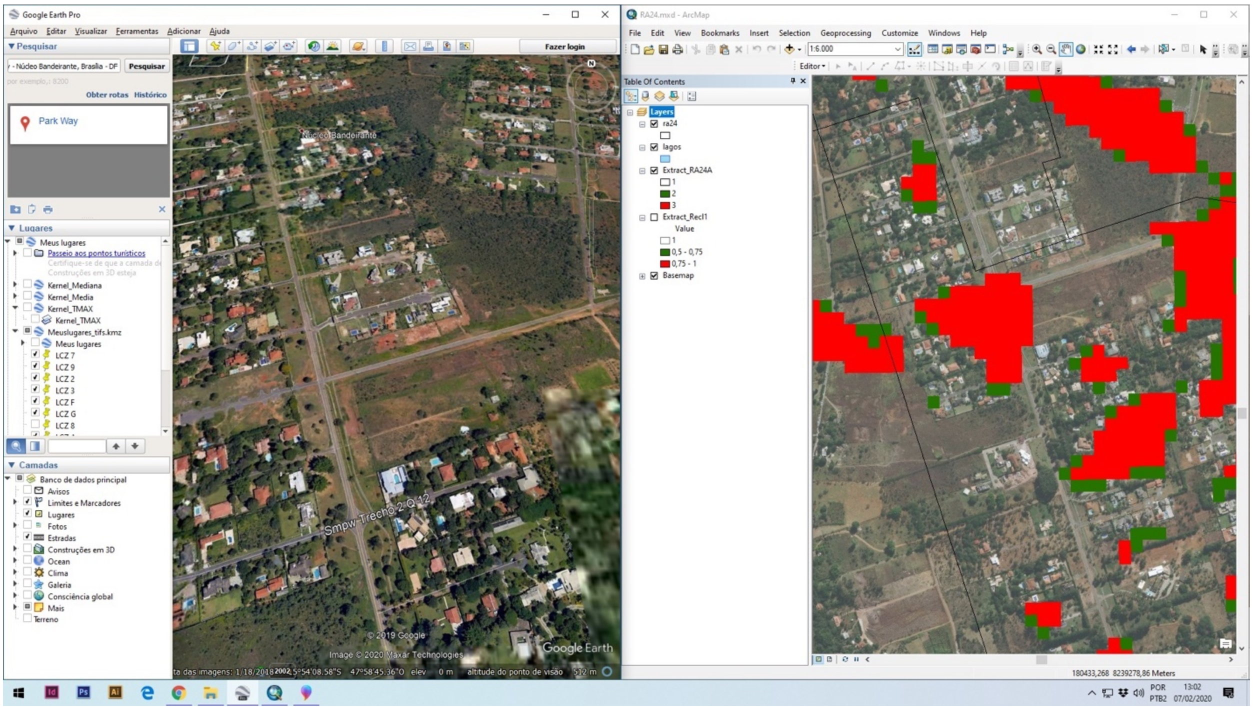
Appendix 24 RA XXIV - Park Way

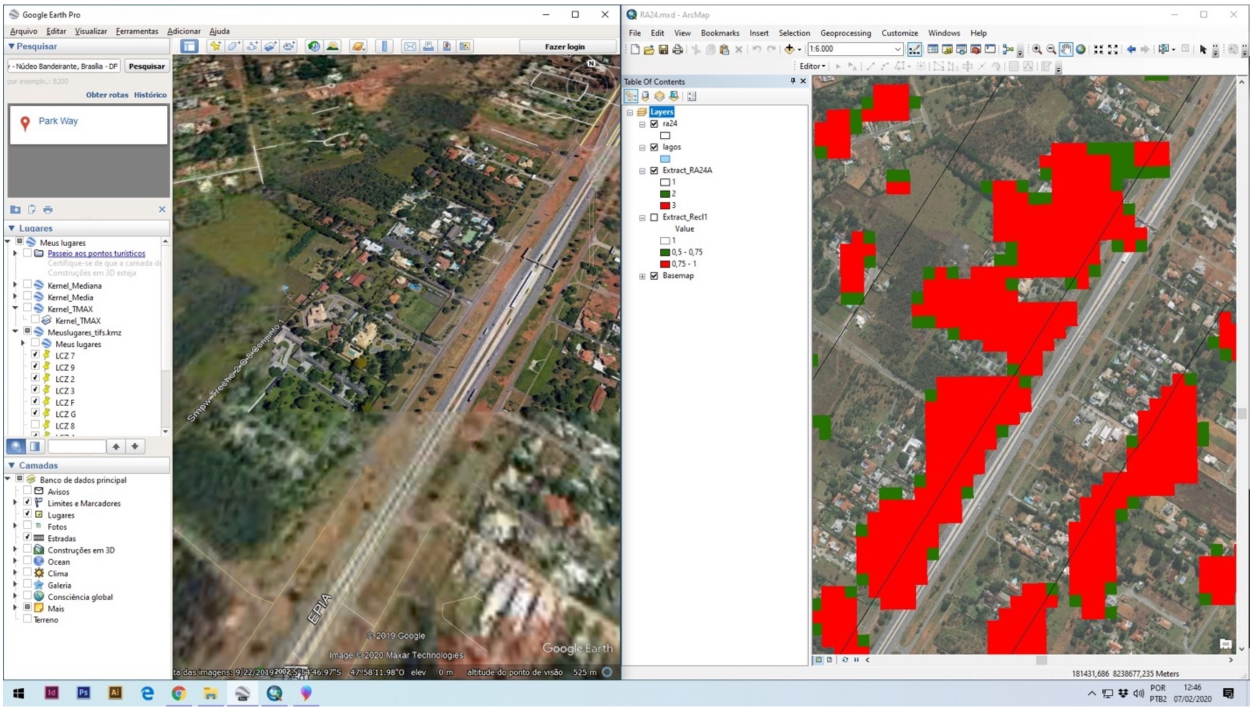




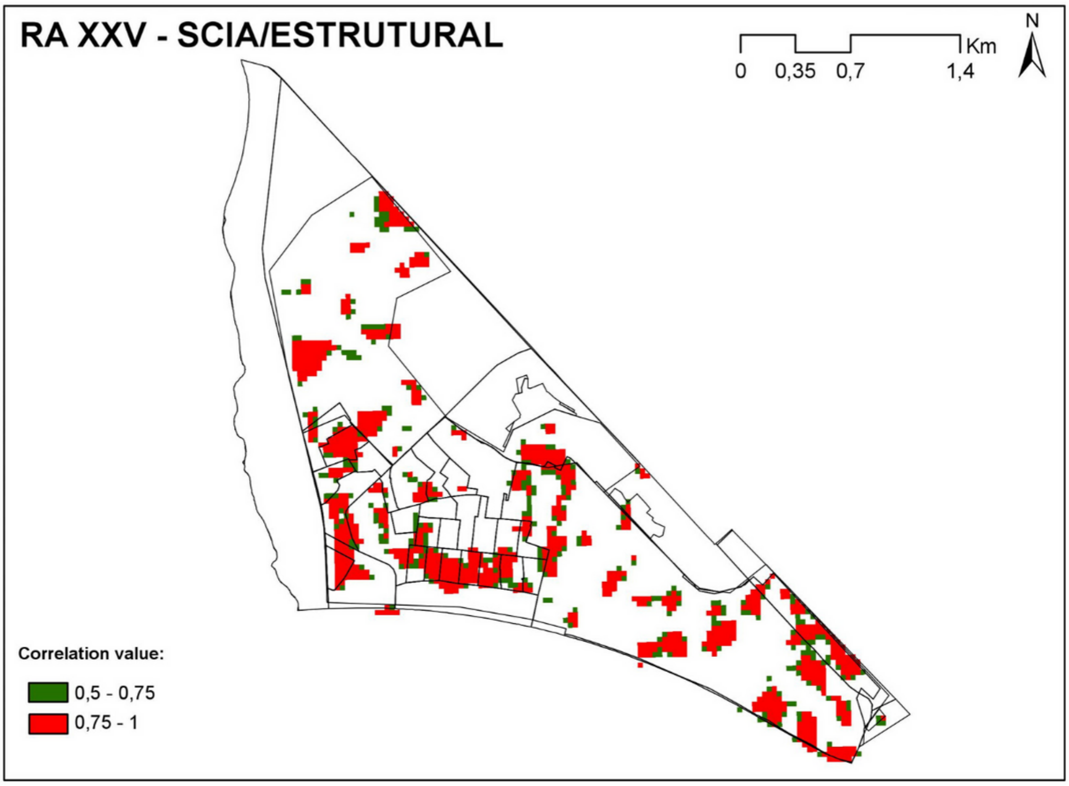


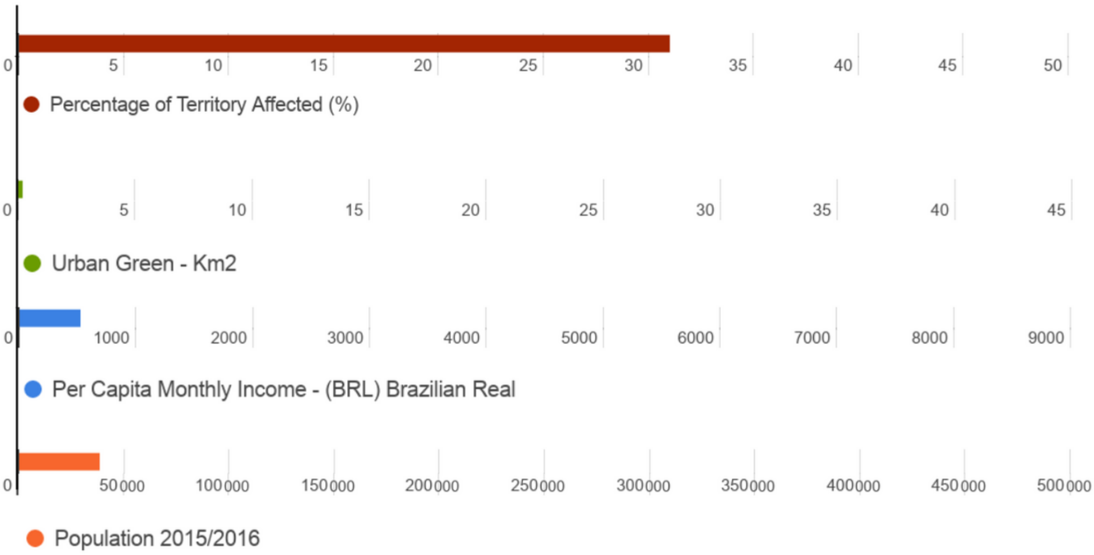

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Park Way
Lugares
Camadas
Google Earth
RA24.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra24
lagos
Extract_RA24A
Extract_Recl1
Basemap

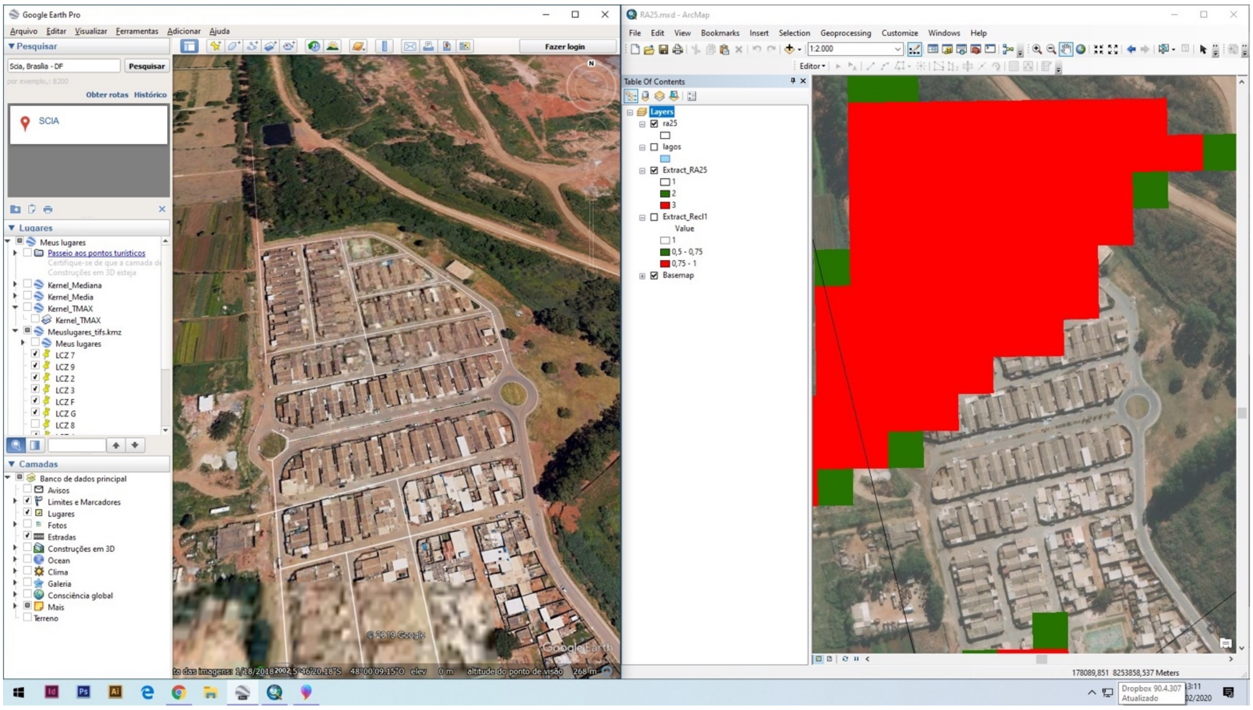

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Park Way
Lugares
Camadas
Google Earth
RA24.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra24
lagos
Extract_RA24A
Extract_Recl1
Basemap

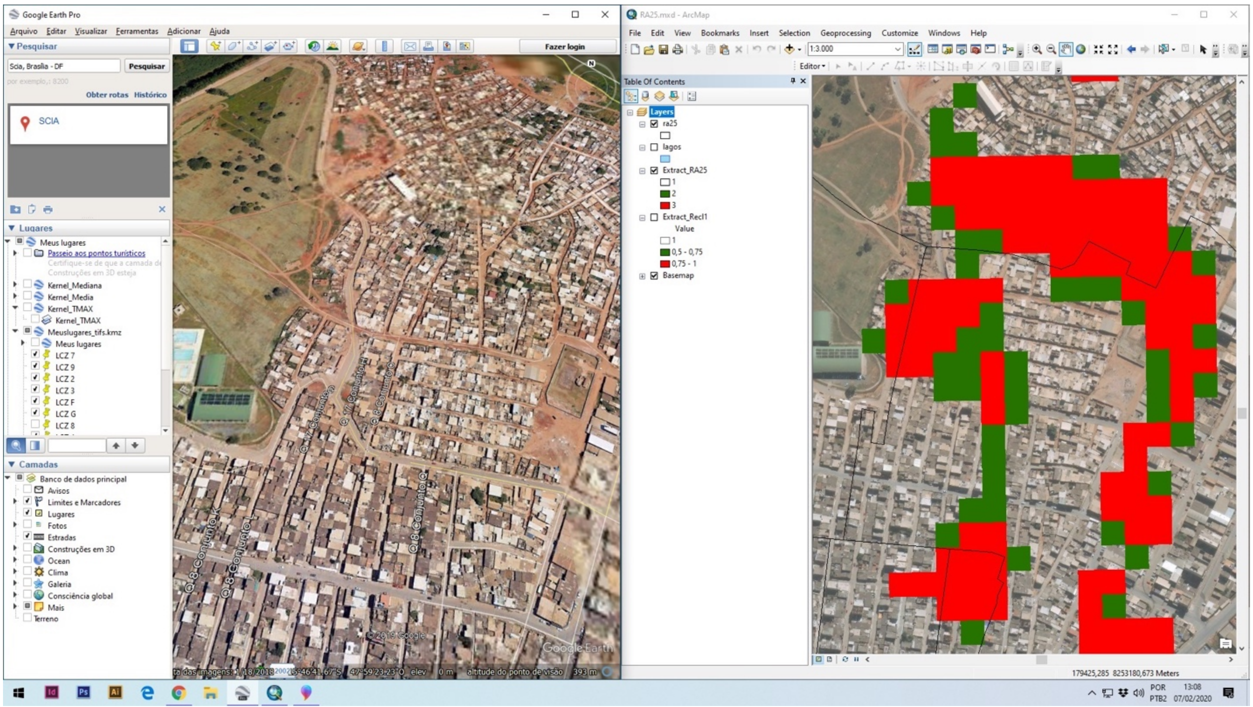

Google Earth Pro
Pesquisar
Park Way
Lugares
Meus lugares
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Meuslugares_tifs.kmz
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Avisos
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
© 2019 Google
Image © 2020 Maxar Technologies
Google Earth
RA24.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra24
lagos
Extract_RA24A
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
181431,686 8238677,235 Meters

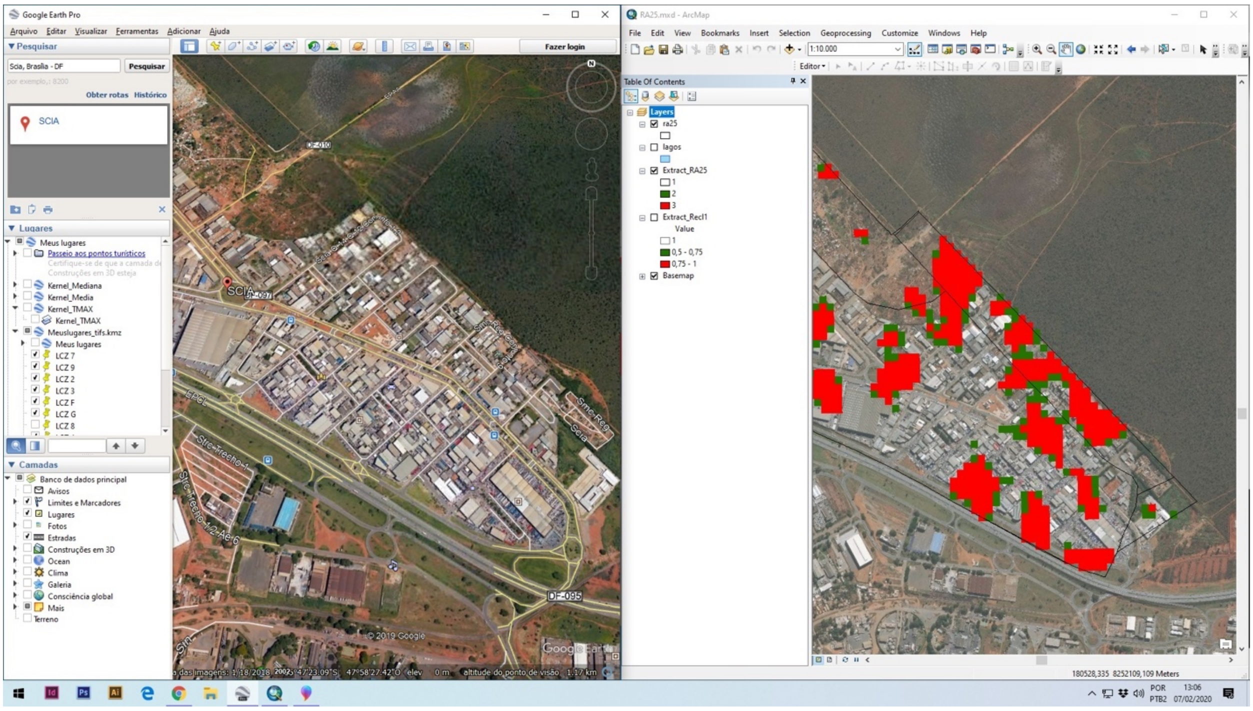
Appendix 25 RA XXV - SCIA/Estrutural



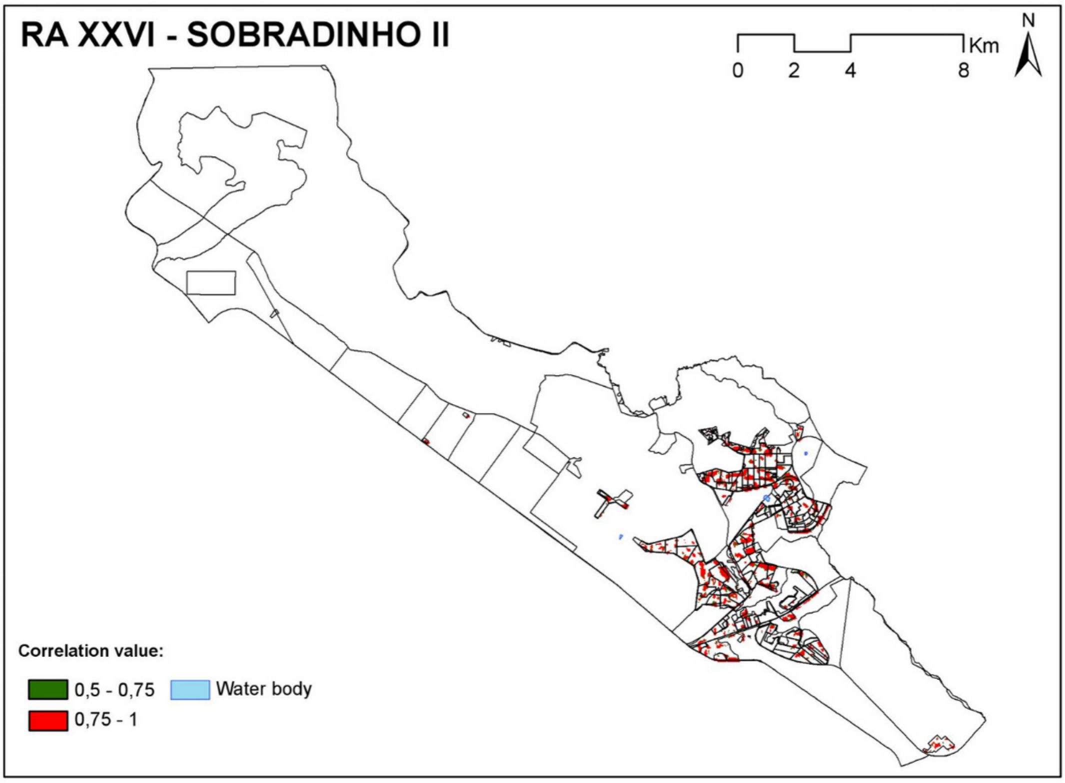


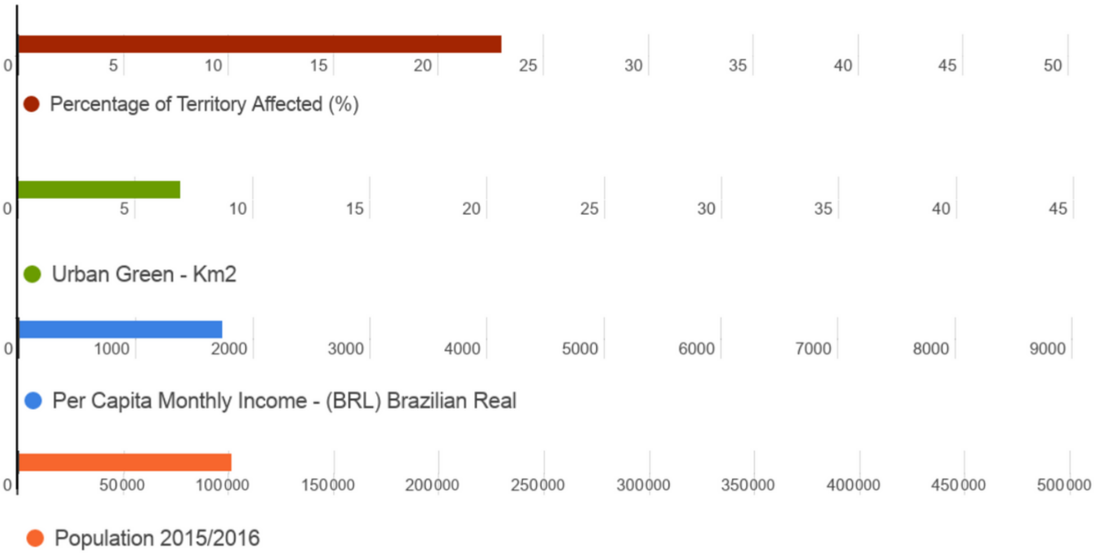

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
SCIA
Lugares
Camadas
RA25.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra25
lagos
Extract_RA25
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

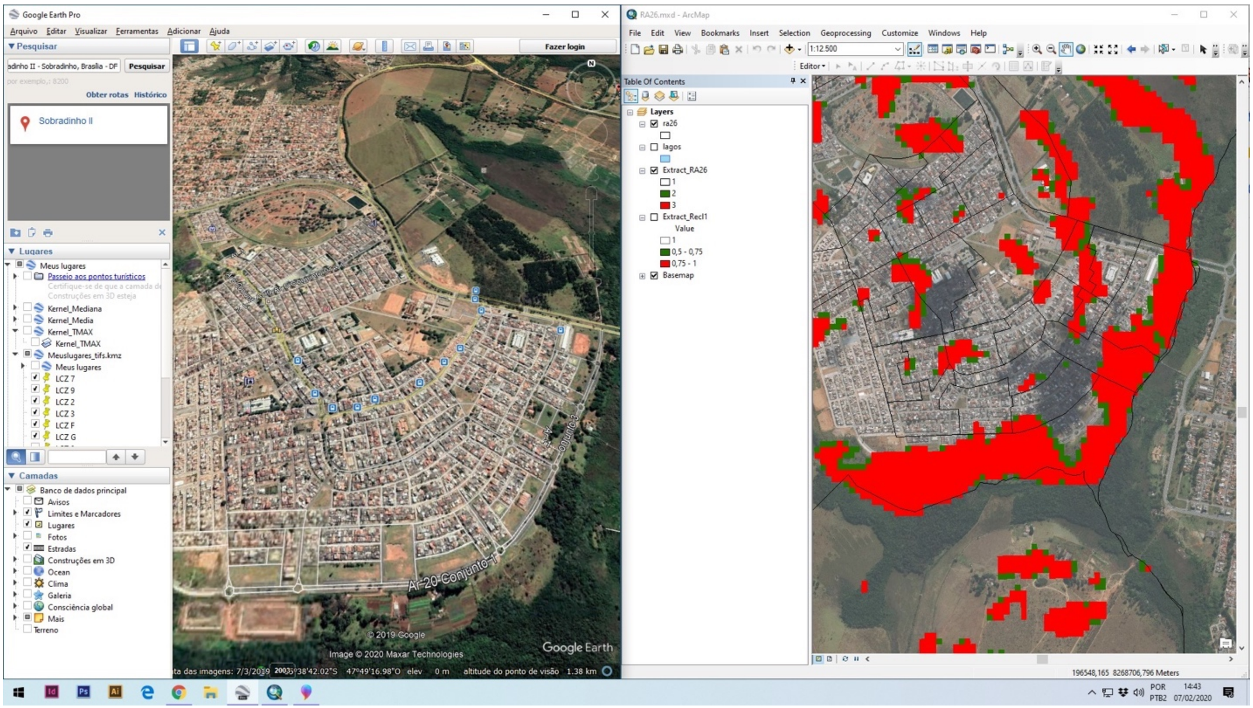

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
SCIA
Lugares
Camadas
RA25.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra25
lagos
Extract_RA25
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

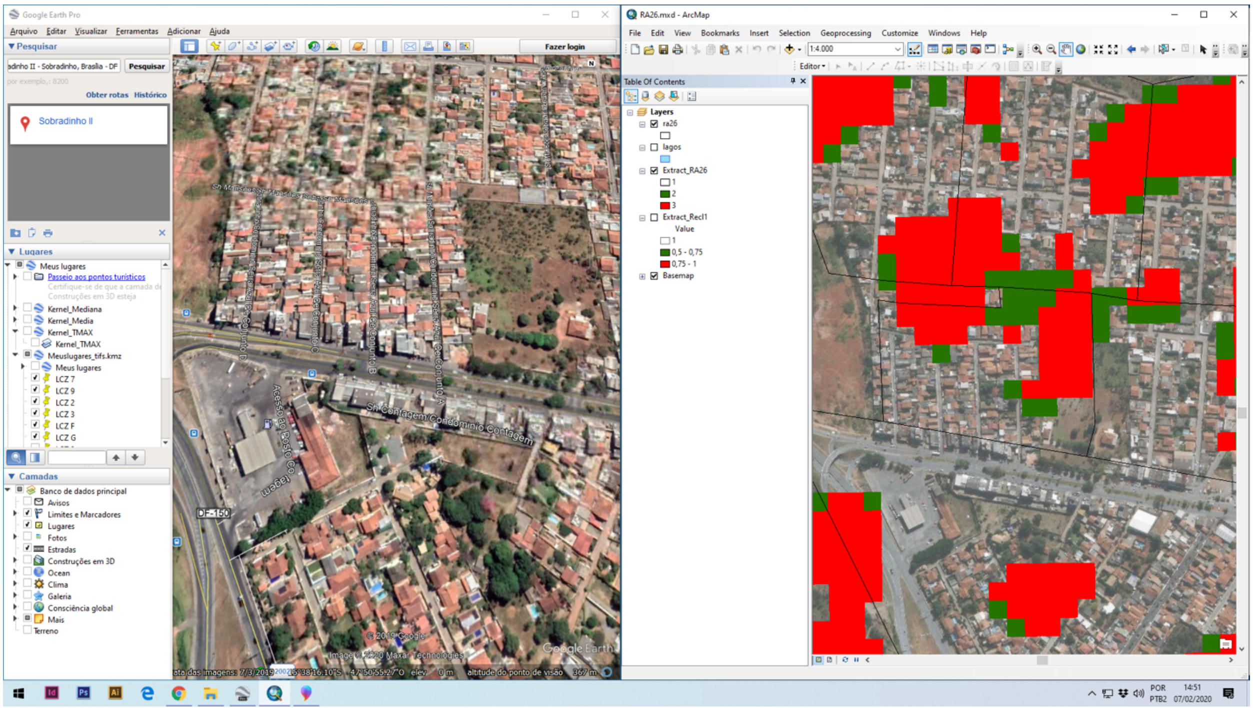

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Scia, Brasília - DF
Pesquisar
Obter rotas Histórico
SCIA
Lugares
Meus lugares
Passeio aos pontos turísticos
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Avisos
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
DF-010
DF-095
© 2019 Google
RA25.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:10.000
Table Of Contents
Layers
ra25
lagos
Extract_RA25
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
180528,335 8252109,109 Meters
POR PTB2
13:06 07/02/2020

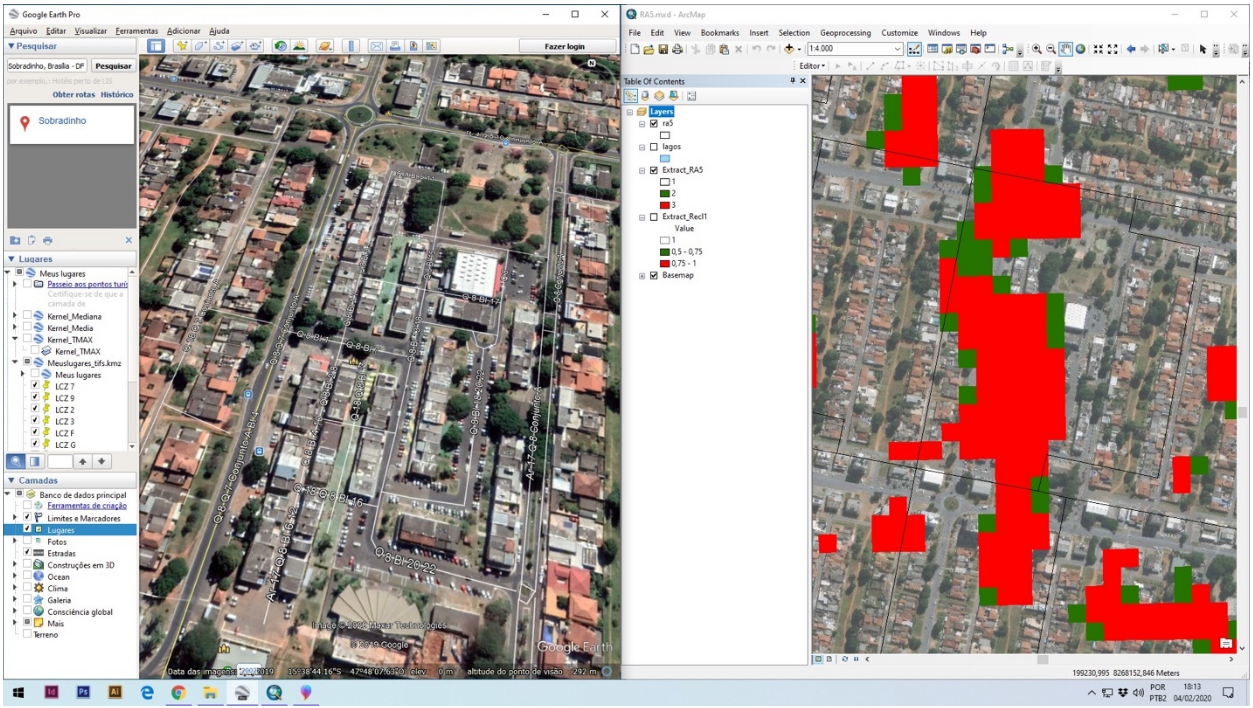
Appendix 26 RA XXVI - Sobradinho II



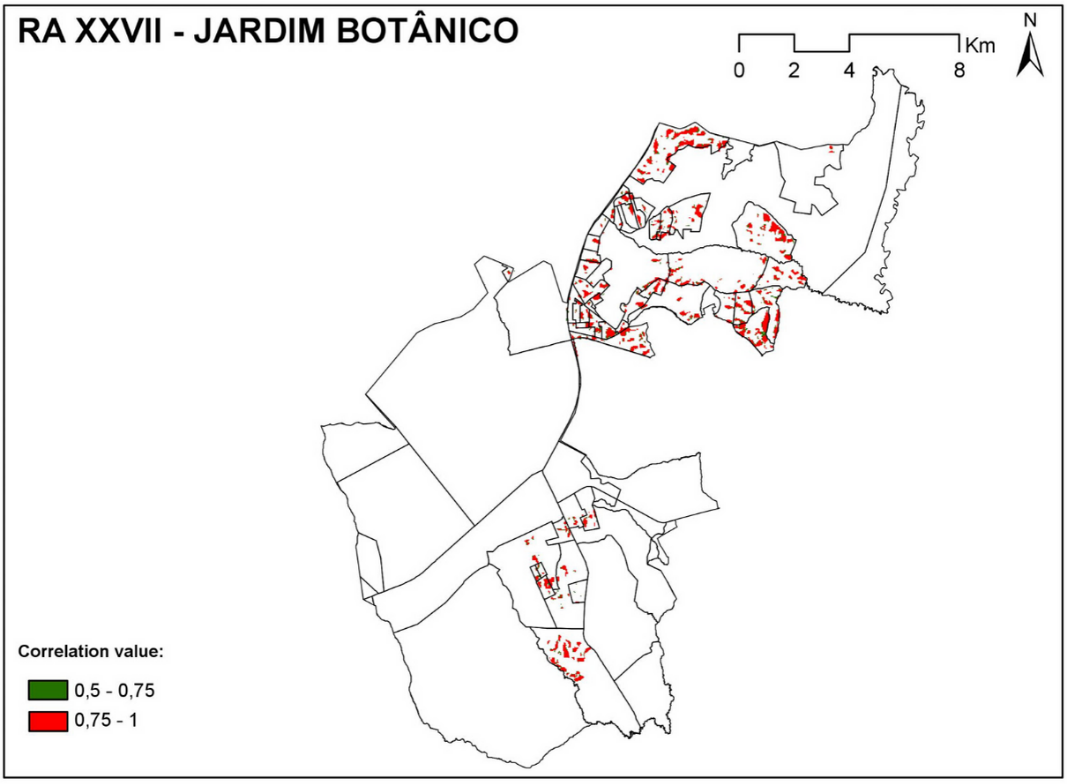


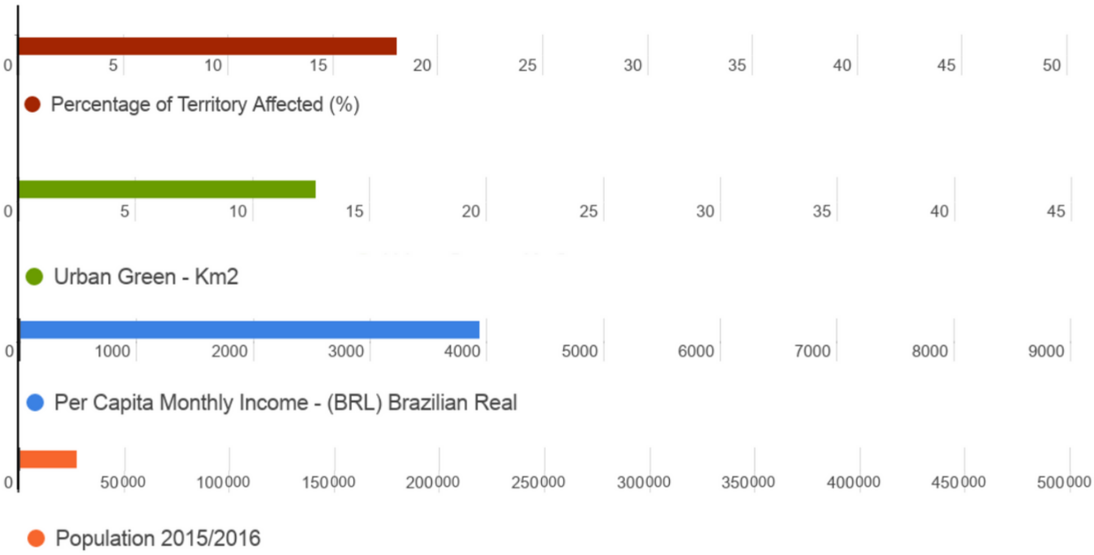

Google Earth Pro
RA26.mxd - ArcMap
Sobradinho II
Table Of Contents
Layers
Extract_RA26
Extract_Recl1
Basemap
AR 20 Conjunto 7
Google Earth

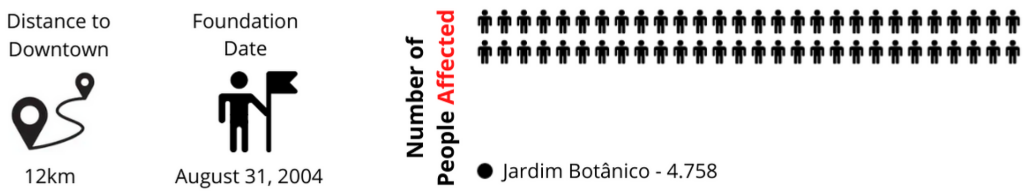

Google Earth Pro
RA26.mxd - ArcMap
Sobradinho II
Table Of Contents
Layers
Extract_RA26
Extract_Recl1
Basemap
DF-150
Google Earth

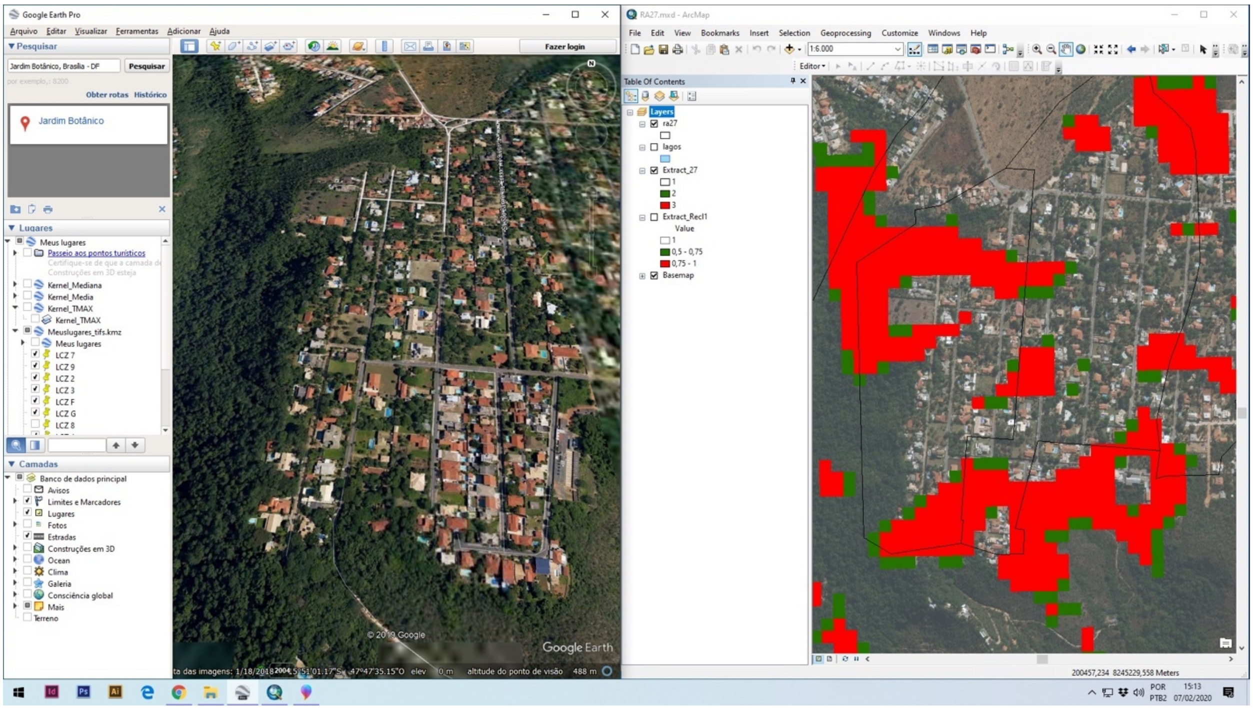

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Sobradinho
Lugares
Camadas
RA5.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
ra5
lagos
Extract_RA5
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap

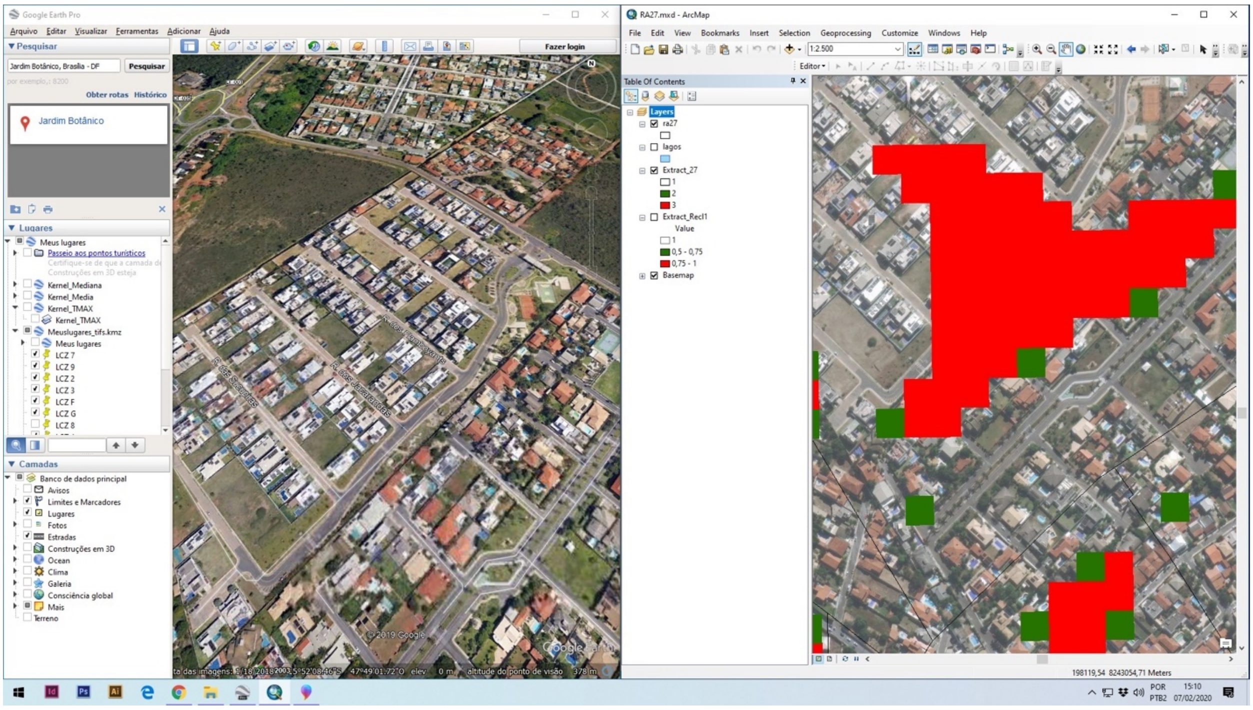
Appendix 27 RA XXVII - Jardim Botânico



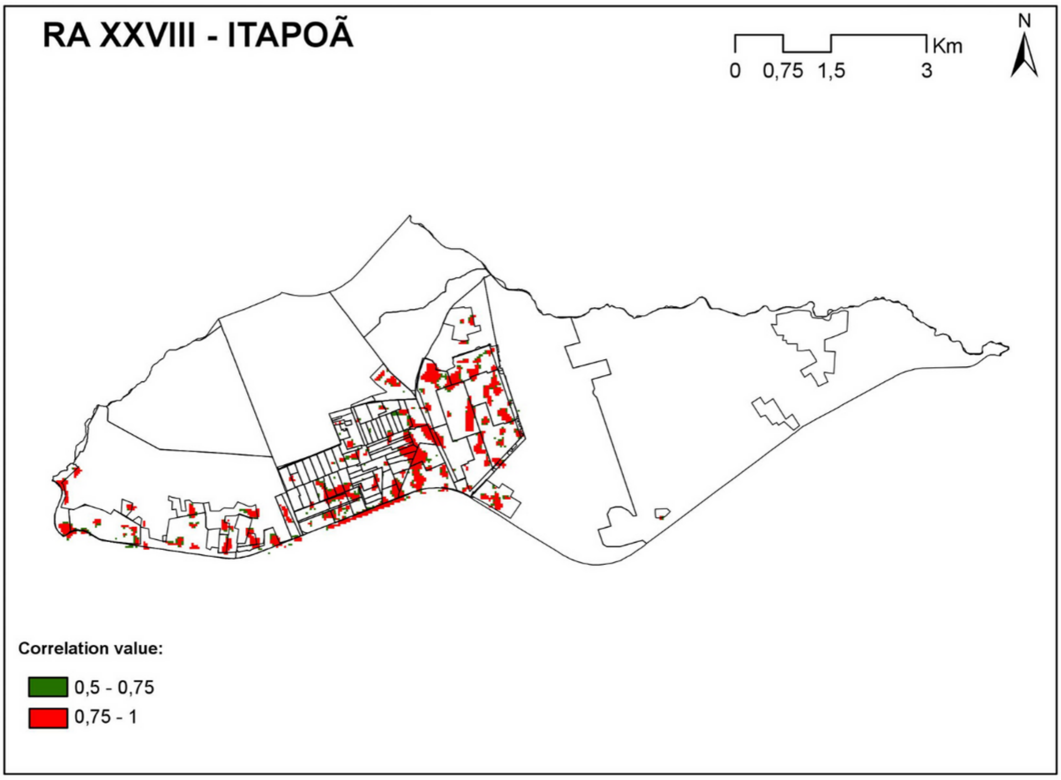


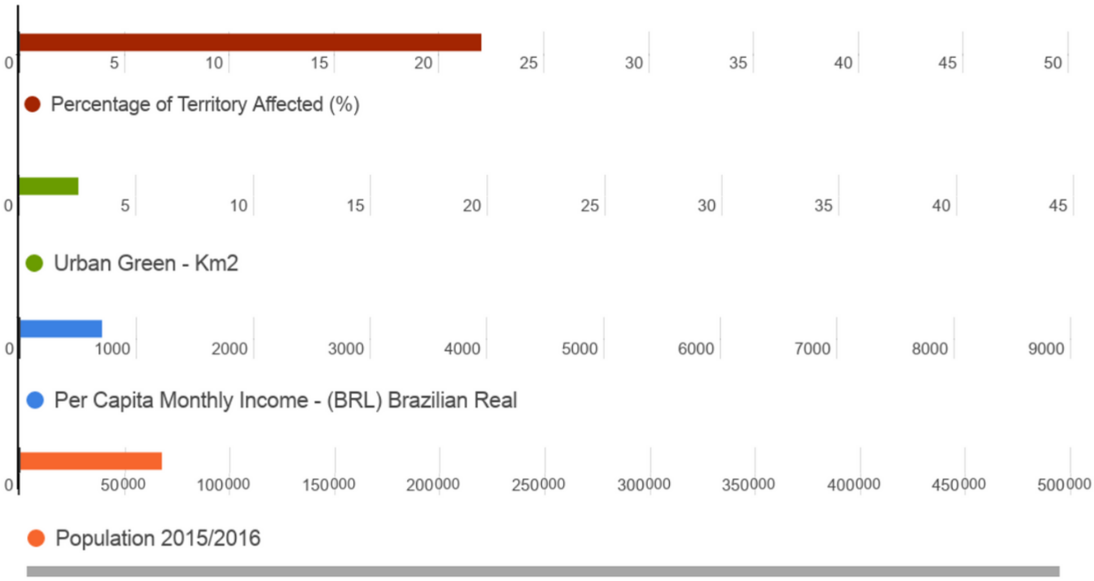


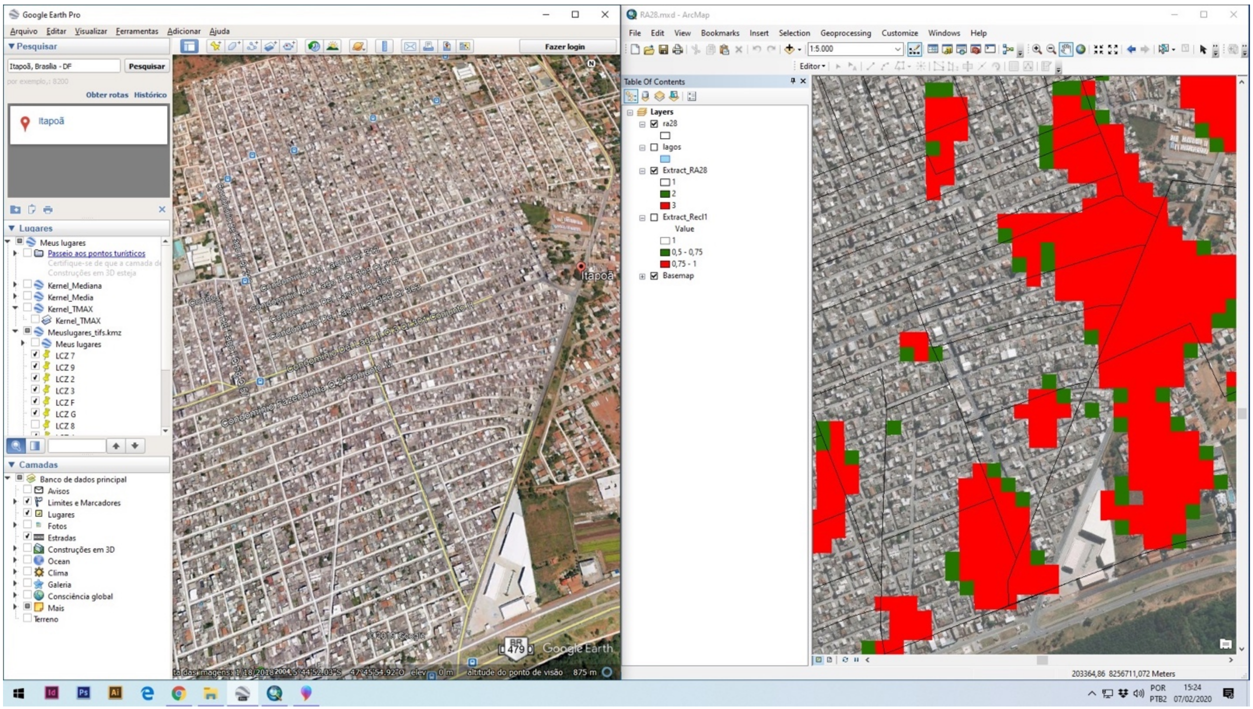

Google Earth Pro
RA27.mxd - ArcMap
Table Of Contents
Layers
ra27
lagos
Extract_27
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Jardim Botânico

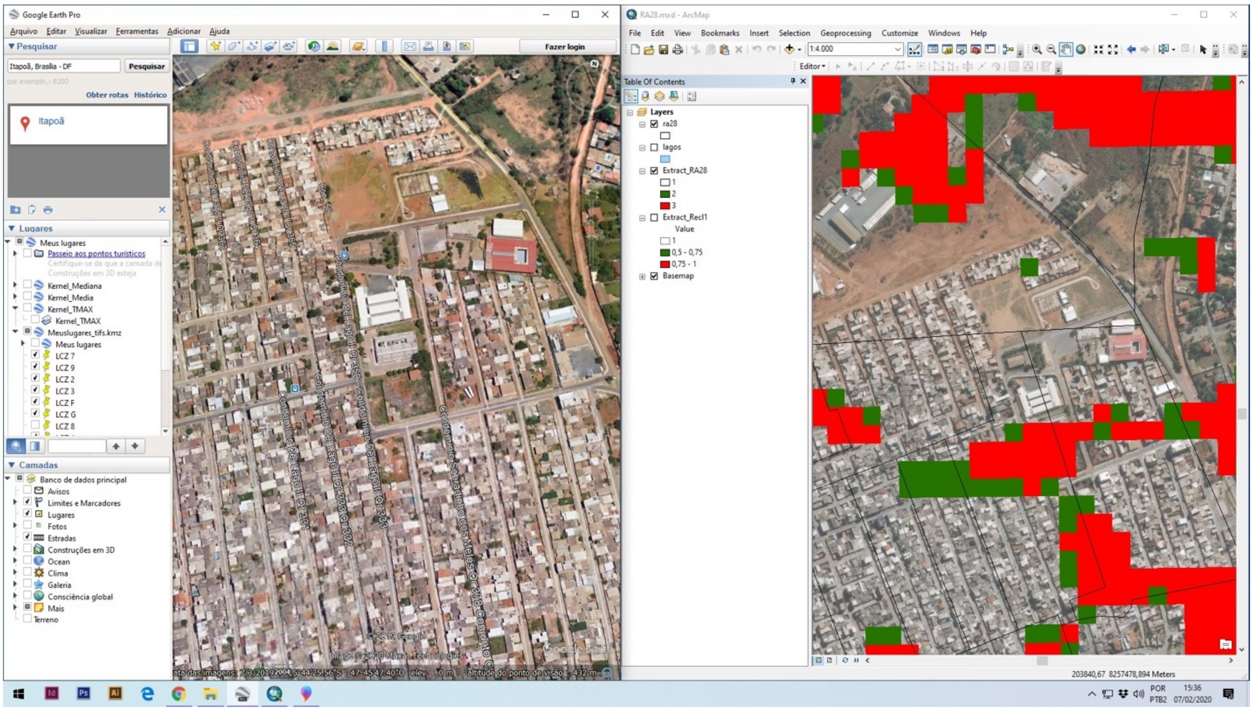

Google Earth Pro
RA27.mxd - ArcMap
Table Of Contents
Layers
ra27
lagos
Extract_27
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Jardim Botânico

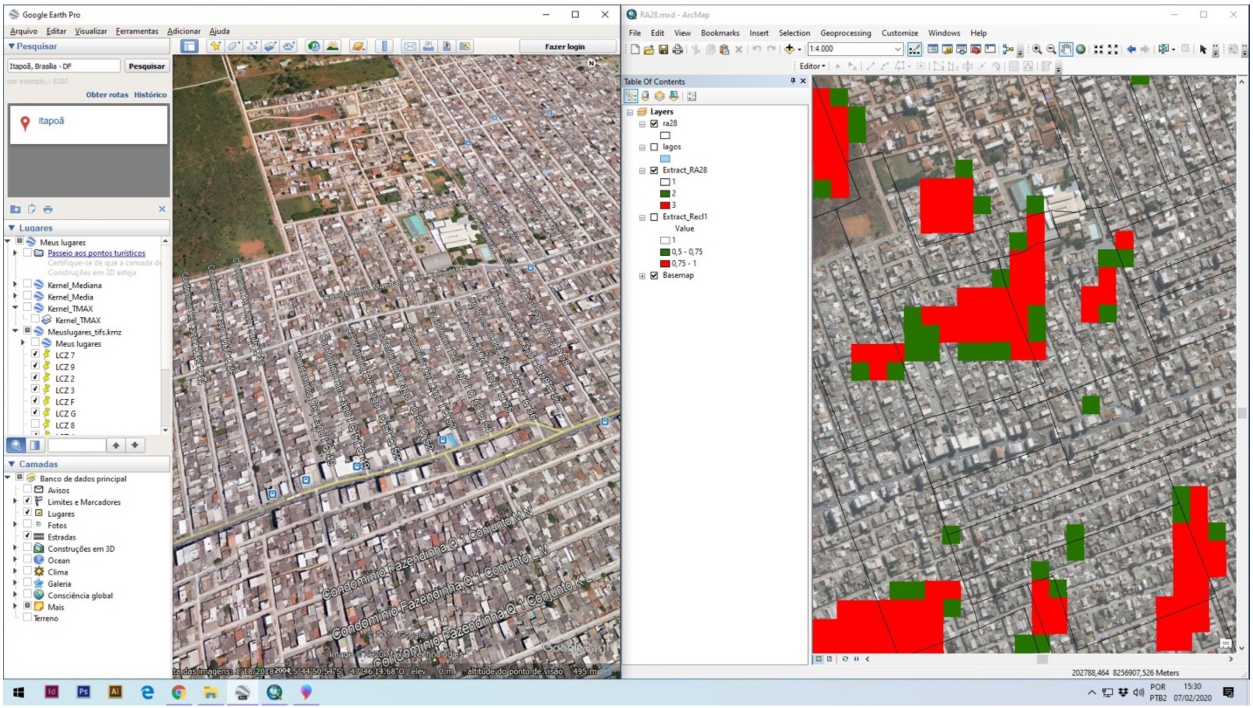
Appendix 28 RA XXVIII - Itapoã



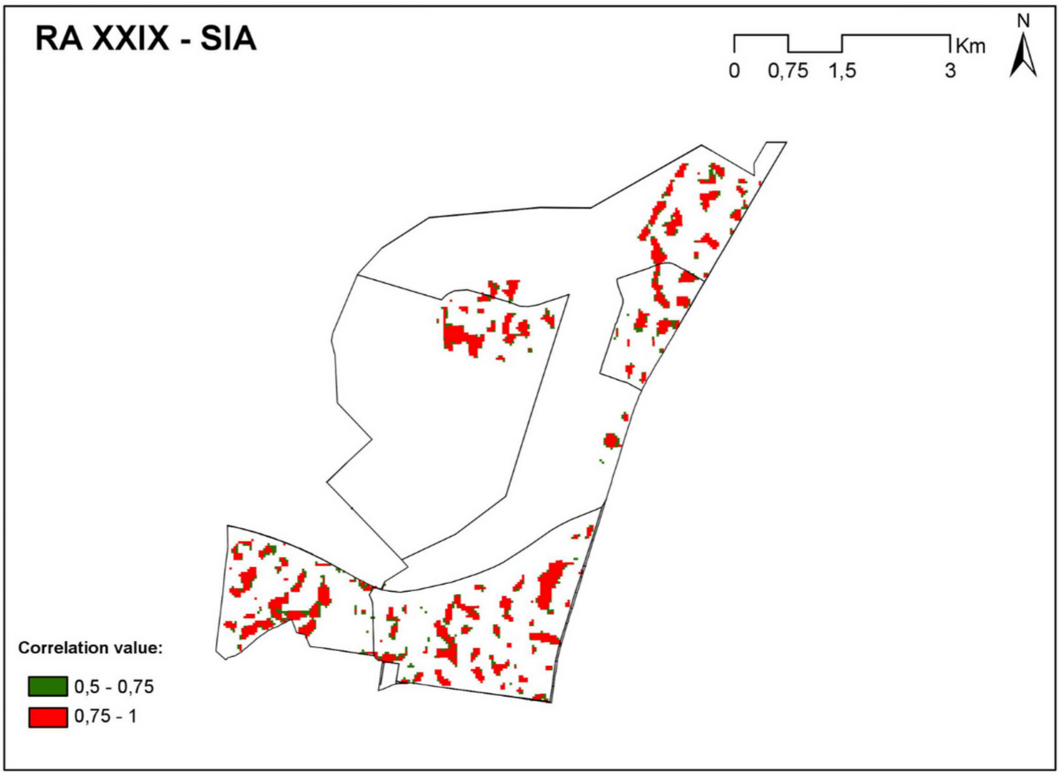


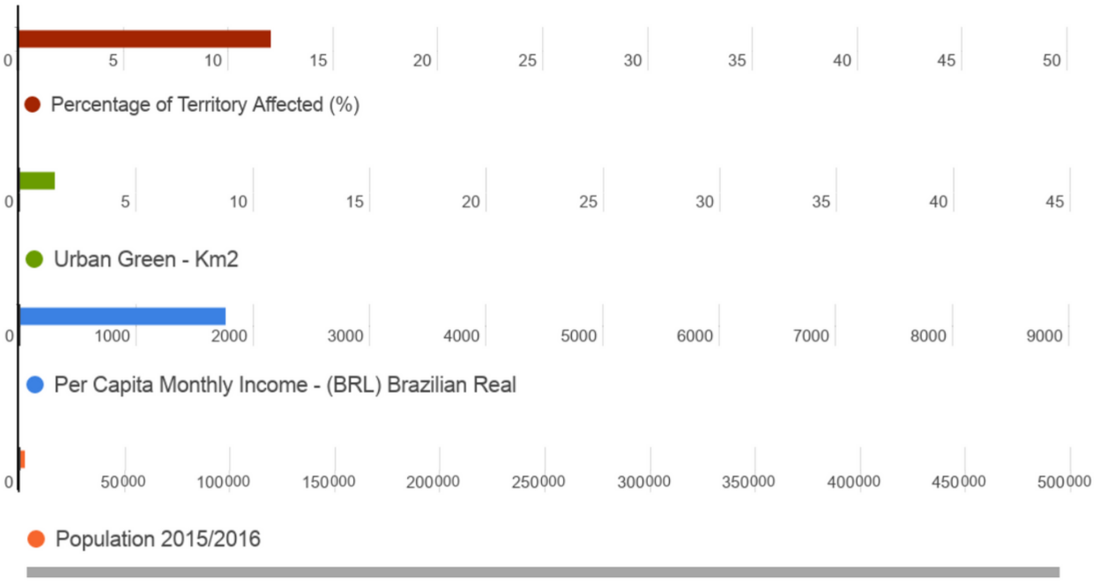

Google Earth Pro
RA28.mxd - ArcMap
Table Of Contents
Layers
ra28
lagos
Extract_RA28
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
203364,86 8256711,072 Meters

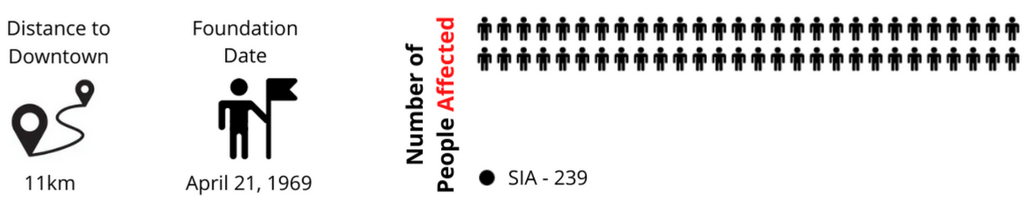

Google Earth Pro
RA28.mxd - ArcMap
Table Of Contents
Layers
ra28
lagos
Extract_RA28
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
203840,67 8257478,894 Meters

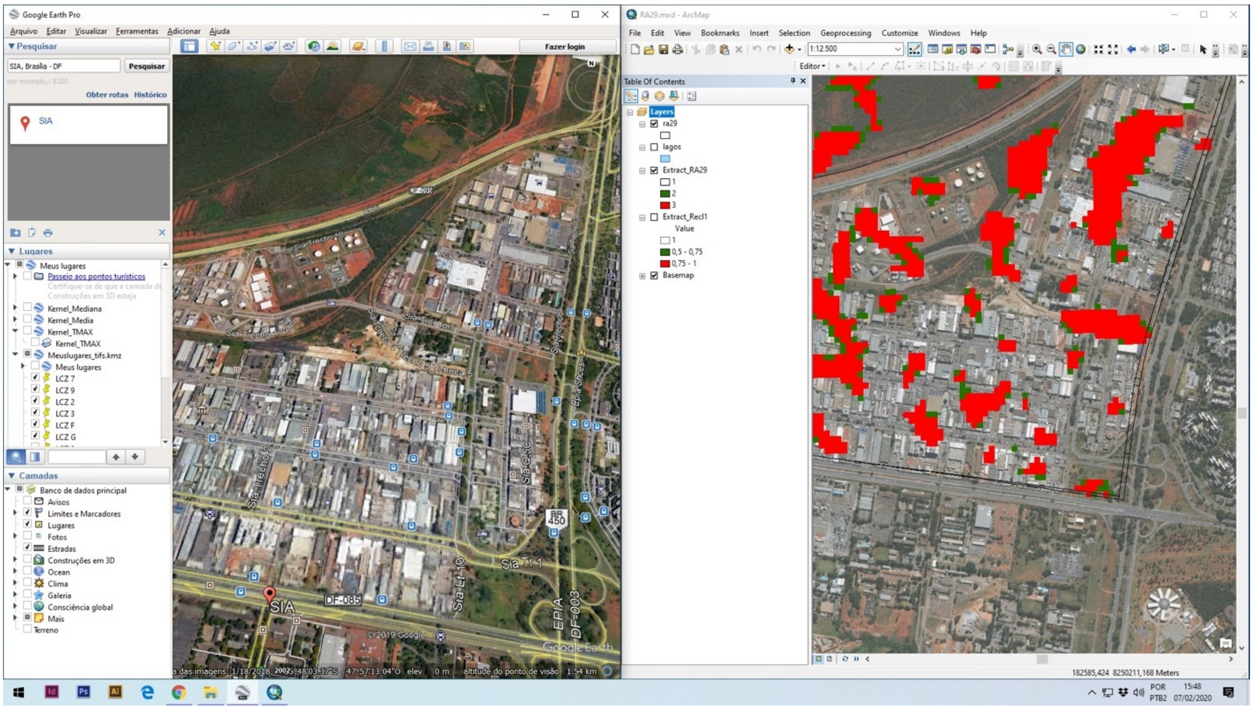

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Itapoã, Brasília - DF
Pesquisar
Obter rotas Histórico
Itapoã
Fazer login
Lugares
Meus lugares
Passeio aos pontos turísticos
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Avisos
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
RA28.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4.000
Table Of Contents
Layers
ra28
lagos
Extract_RA28
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
202788,464 8256907,526 Meters
POR PTB2
15:30
07/02/2020

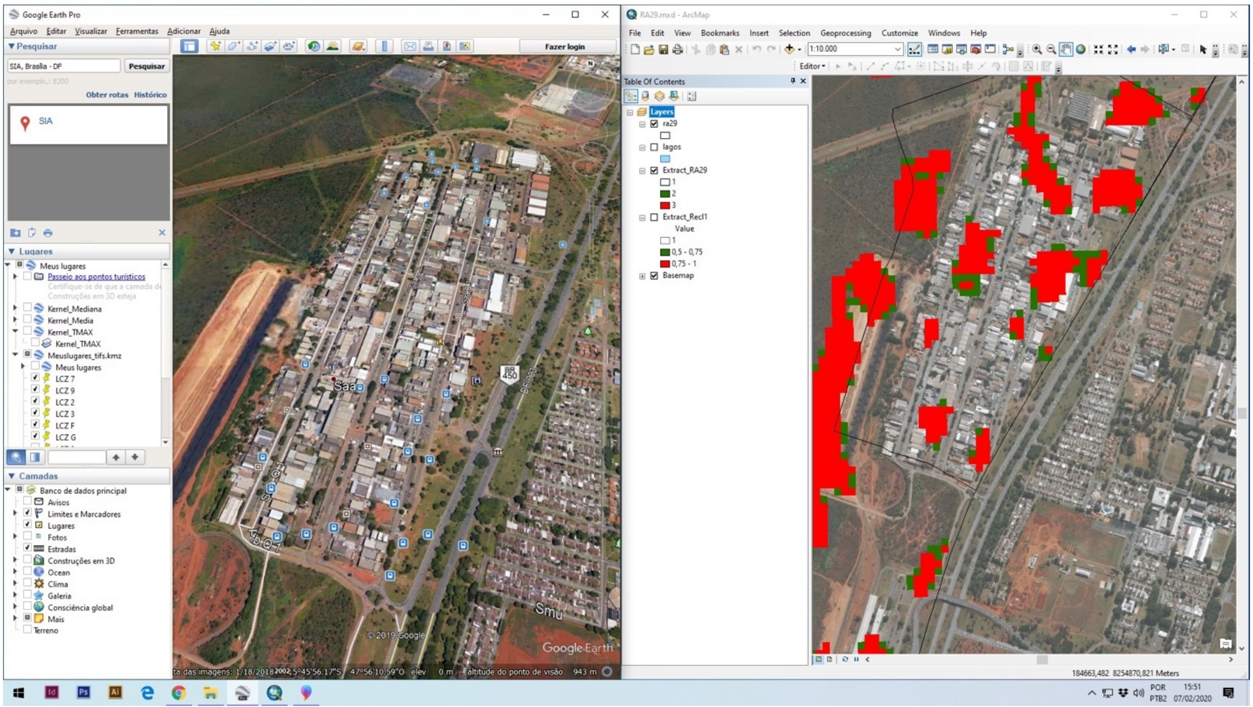
Appendix 29 RA XXIX - SIA



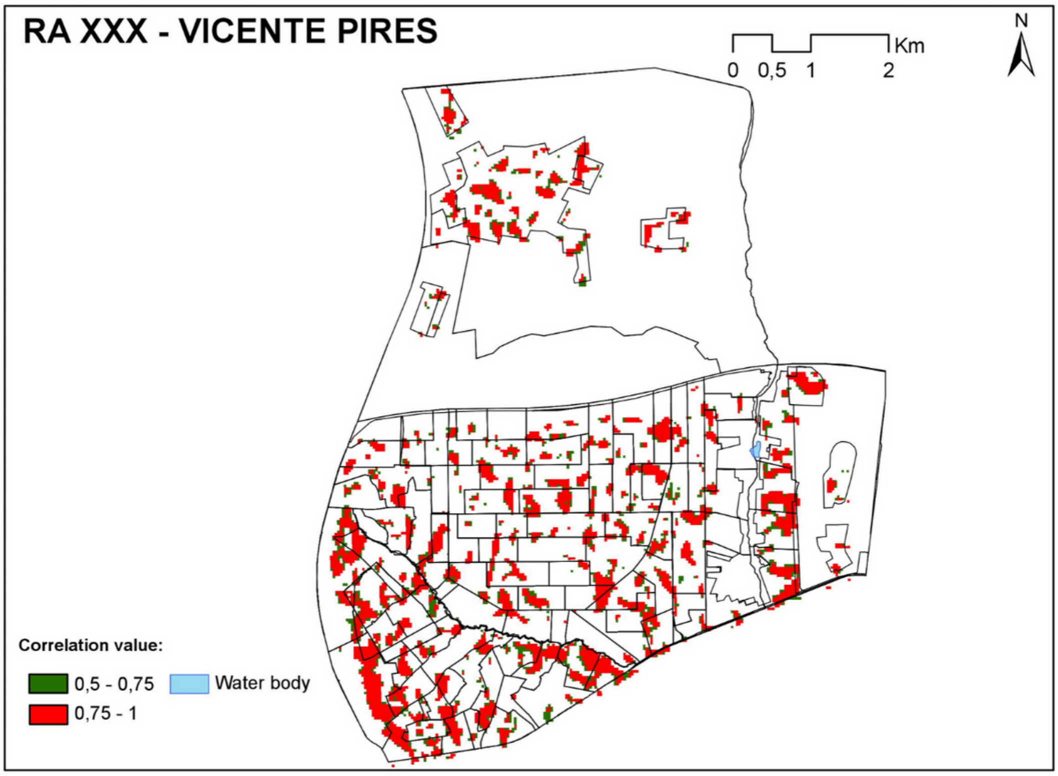


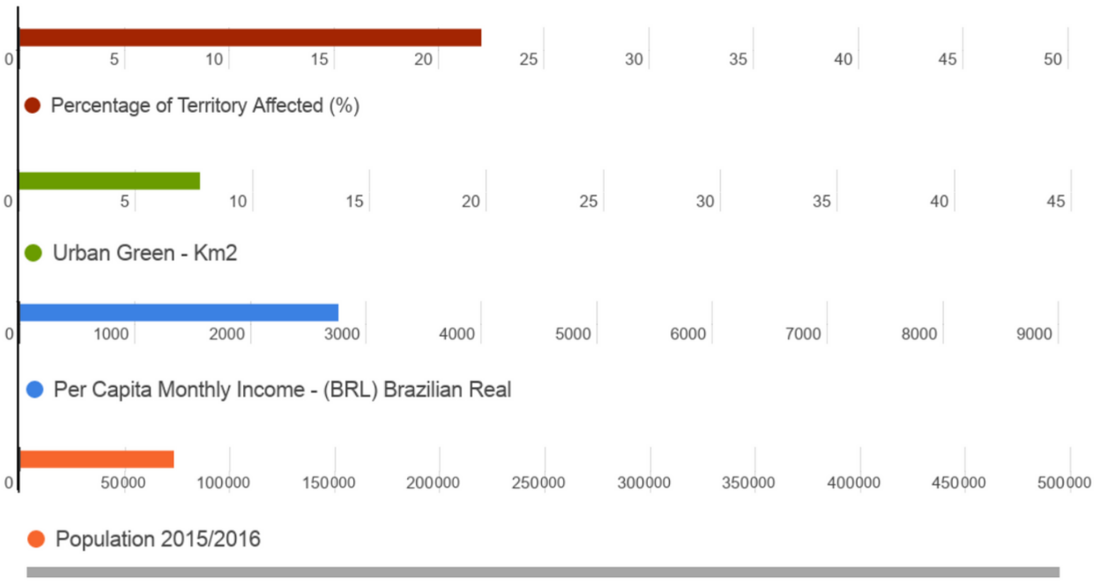


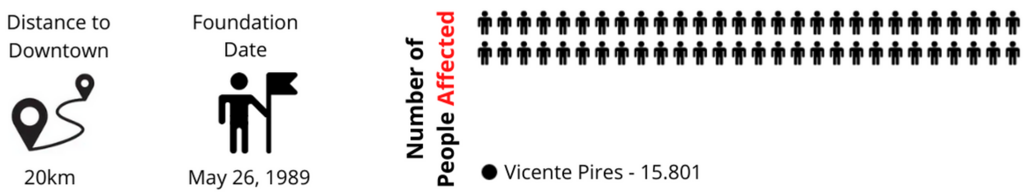

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
SIA, Brasília - DF
Pesquisar
SIA
Lugares
Camadas
RA29.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:12.500
Table Of Contents
Layers
ra29
lagos
Extract_RA29
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
182585,424 8250211,168 Meters

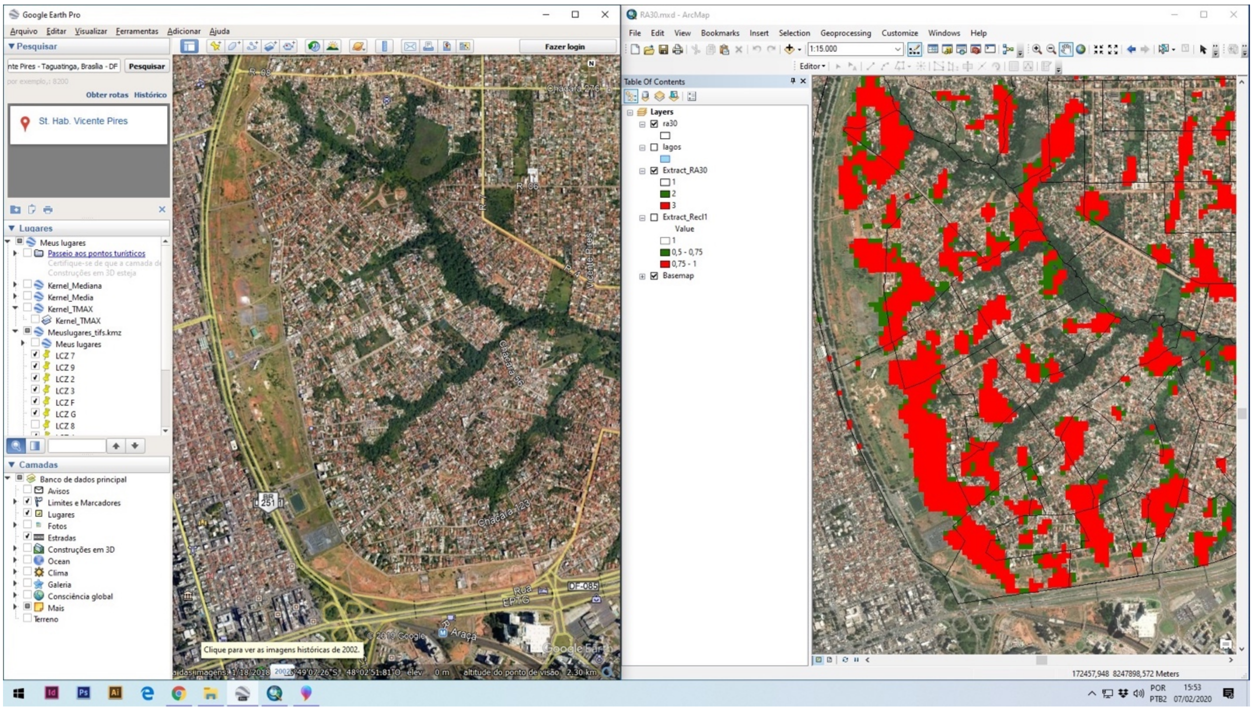

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
SIA, Brasília - DF
Pesquisar
SIA
Lugares
Camadas
RA29.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:10.000
Table Of Contents
Layers
ra29
lagos
Extract_RA29
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
184663,482 8254870,821 Meters

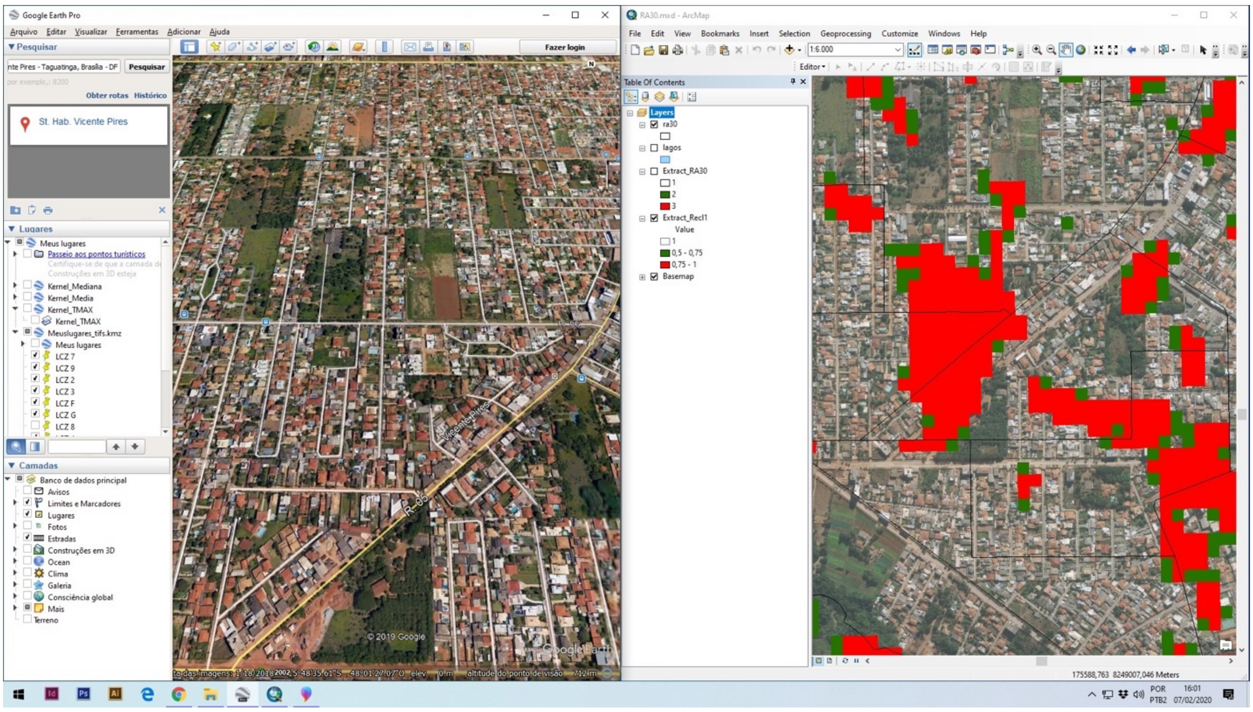
Appendix 30 RA XXX - Vicente Pires

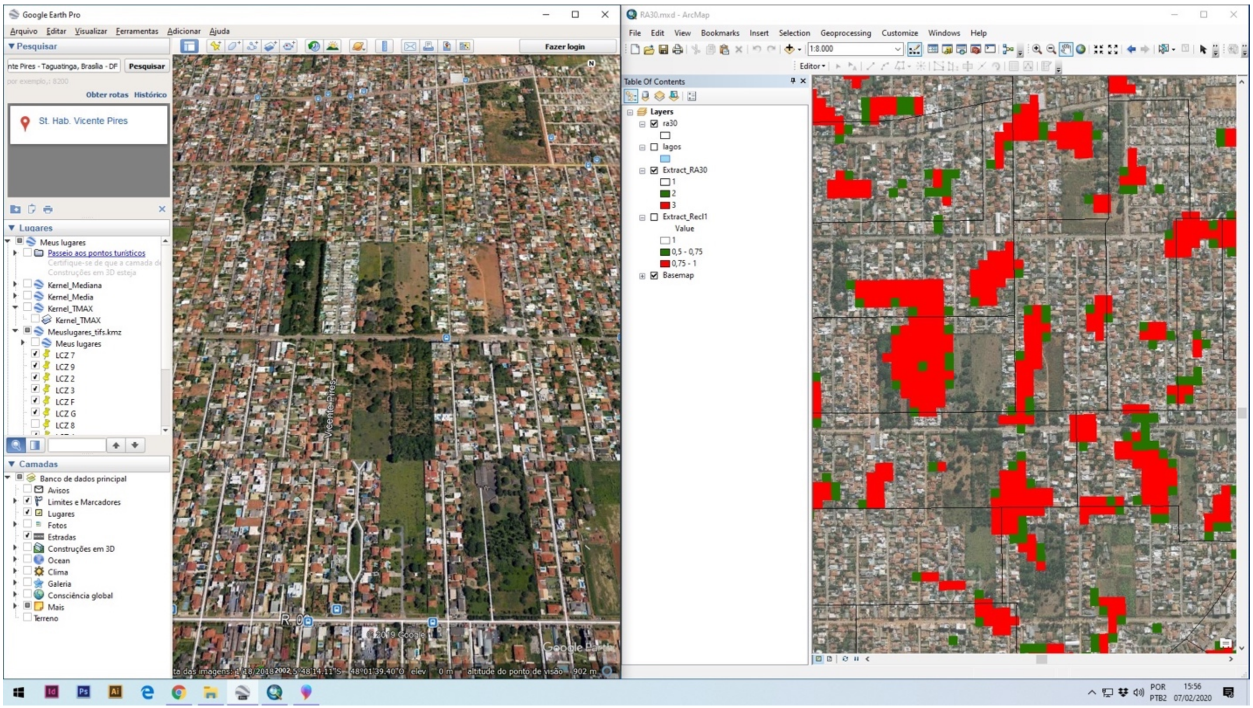




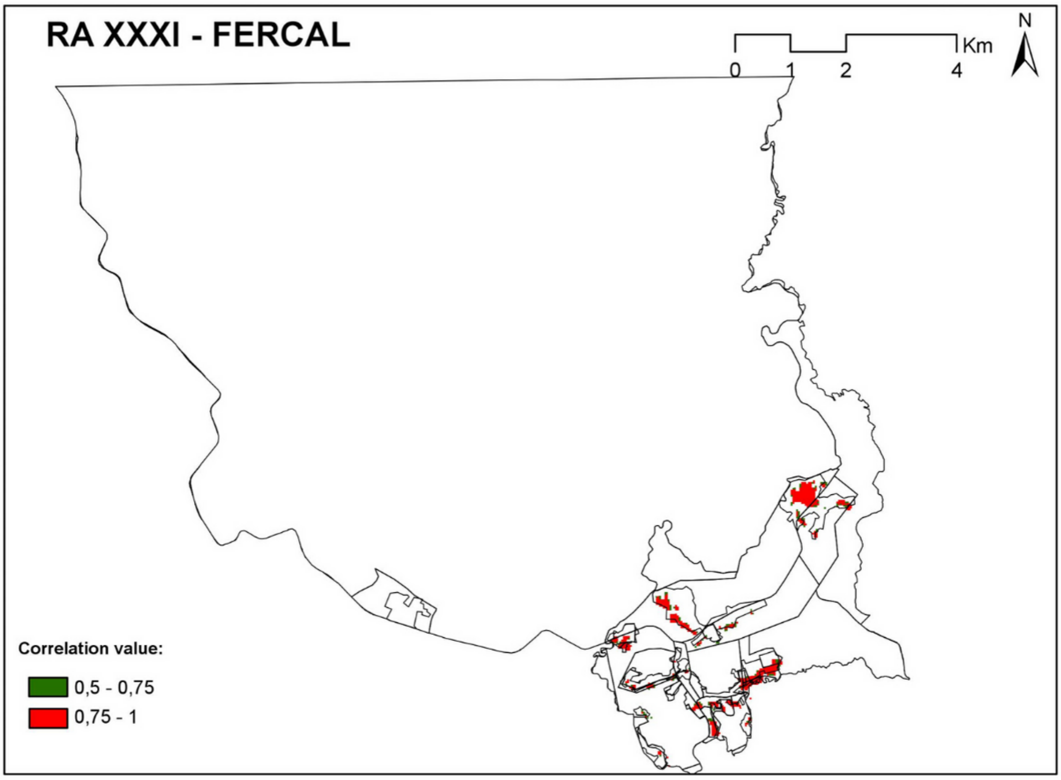


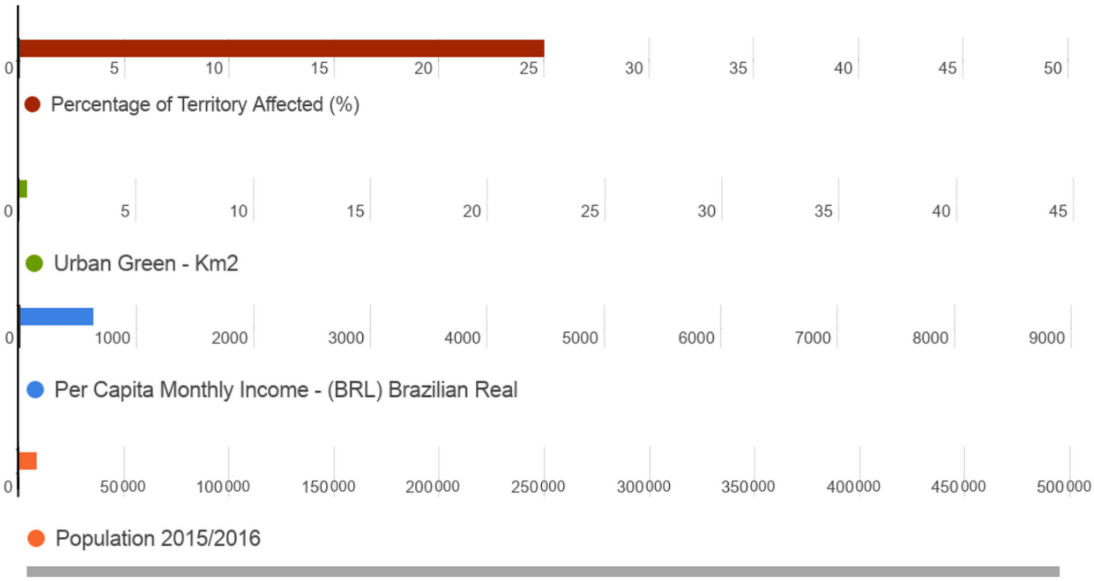

Google Earth Pro
RA30.mxd - ArcMap
St. Hab. Vicente Pires
Lugares
Camadas
Table Of Contents
Layers
ra30
lagos
Extract_RA30
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Clique para ver as imagens históricas de 2002.
172457,948 8247898,572 Meters

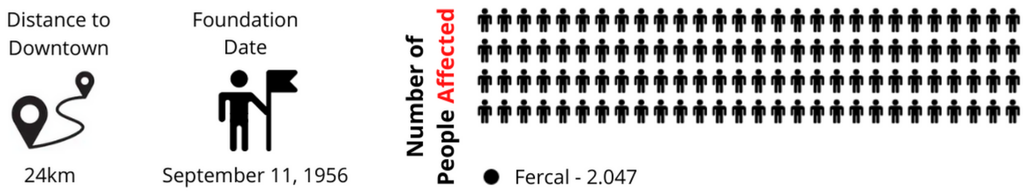

Google Earth Pro
RA30.mxd - ArcMap
St. Hab. Vicente Pires
Lugares
Camadas
Table Of Contents
Layers
ra30
lagos
Extract_RA30
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
© 2019 Google
175588,763 8249007,046 Meters

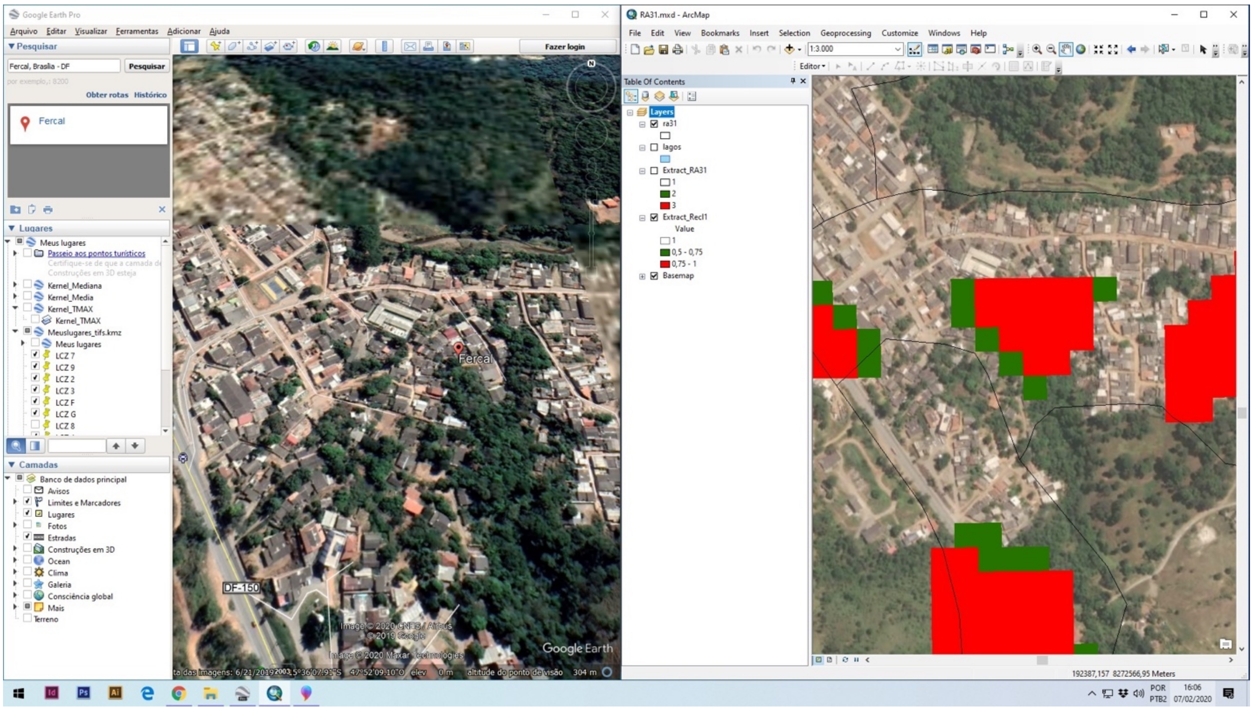

Google Earth Pro
Arquivo Editar Visualizar Ferramentas Adicionar Ajuda
Pesquisar
Pesquisar
Obter rotas Histórico
St. Hab. Vicente Pires
Lugares
Meus lugares
Passeio aos pontos turísticos
Kernel_Mediana
Kernel_Media
Kernel_TMAX
Kernel_TMAX
Meuslugares_tifs.kmz
Meus lugares
LCZ 7
LCZ 9
LCZ 2
LCZ 3
LCZ F
LCZ G
LCZ 8
Camadas
Banco de dados principal
Avisos
Limites e Marcadores
Lugares
Fotos
Estradas
Construções em 3D
Ocean
Clima
Galeria
Consciência global
Mais
Terreno
Fazer login
RA30.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:8.000
Table Of Contents
Layers
ra30
lagos
Extract_RA30
1
2
3
Extract_Recl1
Value
1
0,5 - 0,75
0,75 - 1
Basemap
POR PTB2
15:56
07/02/2020

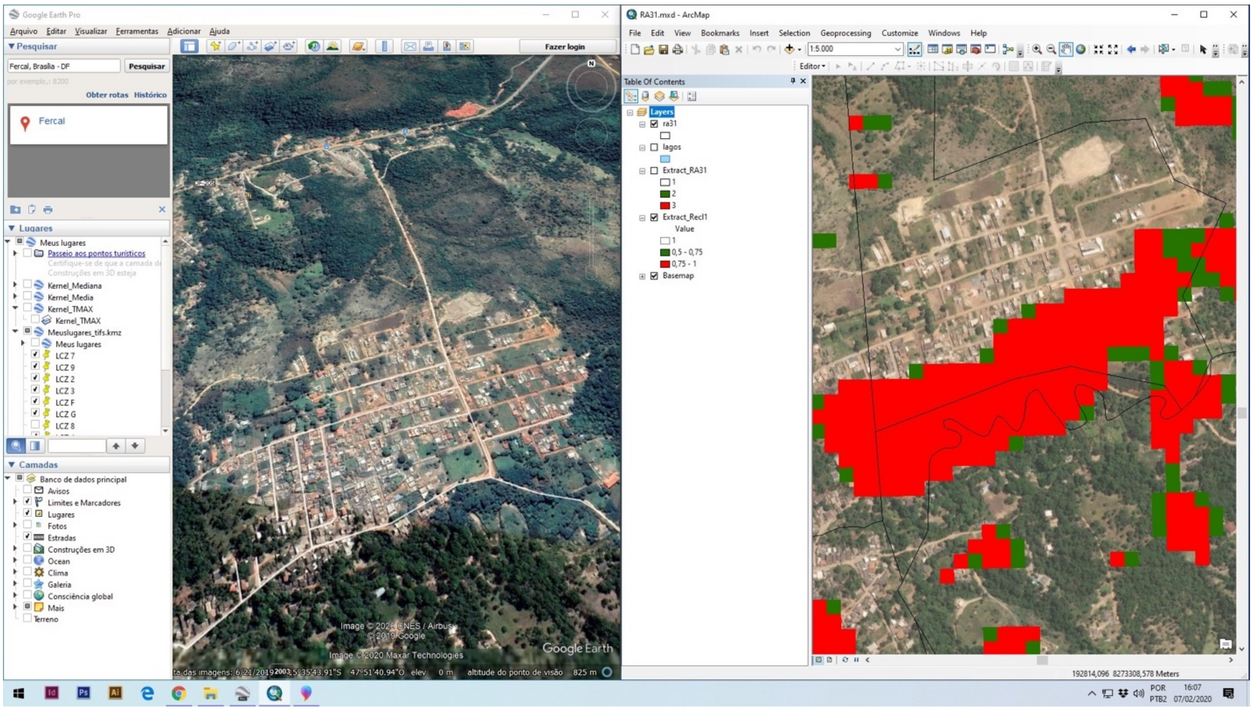
Appendix 31 RA XXXI - Fercal








Google Earth Pro
RA31.mxd - ArcMap
Fercal
Table Of Contents
Layers
ra31
lagos
Extract_RA31
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Google Earth


Google Earth Pro
RA31.mxd - ArcMap
Fercal
Table Of Contents
Layers
ra31
lagos
Extract_RA31
Extract_Recl1
Value
0,5 - 0,75
0,75 - 1
Basemap
Google Earth