Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 17, número 2, 2021

Using UAV for Land Management during the COVID-19 Pandemic and its Post-Pandemic Potential

Tatiane Ferreira Olivatto
Master Student, UFSCar, Brazil
tatianeolivatto@yahoo.com.br

Fábio Noel Stanganini
PhD Professor, UFSCar, Brazil
fnsgeo@gmail.com

ABSTRACT

After more than a year since the first case of COVID-19 in Brazil, some public sectors are still looking for tools to adapt their activities to epidemiological recommendations that require social distancing. Urban planning and territorial management are indispensable activities to the dynamics of cities and, therefore, cannot be interrupted. In this context, this article aims to investigate the use of Unmanned Aerial Vehicles (UAVs) as a territorial management tool, focusing on the Urban Technical Registration and Urban Land Regularization. From the case study methodology, it was verified in the experiences and current legislations that features related to property (such as constructions and vertical typology), urban infrastructure (e.g., manholes, sidewalks, lighting poles, hydrants, etc) and environmental aspects (mainly related to vegetation and water resources) need to be mapped for such purposes. We also considered the possibility of acquiring georeferenced and altimetric data. Finally, the use of orthophotos from UAVs has proved feasible for application in public territorial management in the context of epidemiological restrictions of isolation and social distancing imposed by the COVID-19 pandemic. This tool was also promising in the post-pandemic scenario, as it presents itself as a less invasive solution for property mapping.

PALAVRAS-CHAVE: Urban Technical Registration. Urban Land Regularization. Drone.

1 INTRODUCTION

The emergence of the novel coronavirus (COVID-19) in December 2019 has raised questions regarding the use of different technologies to monitor the advance of the virus around the world, including geotechnologies (BOULOS and GERAGHTY, 2020). These technologies have already proven to be effective in supporting the management of other pandemics, especially with regard to monitoring the epidemiological situation and the progress of vaccination campaigns (BEZERRA et al., 2018; OLIVEIRA et al., 2013).

Despite the focus on pandemic management and measures of social distancing, other processes that make up the dynamics of municipalities cannot be interrupted, such as urban planning and land management as a whole. Villaça (2001) emphasizes that these processes are indispensable, as they deal with essential issues such as urban infrastructure and basic sanitation, for whose articulation public authorities are responsible. Among the fields that constitute urban planning, the urban cadastre and Urban Land Regularization stand out, which, if left unarticulated, can negatively interfere with the collection of municipal taxes (PESSOA et al., 2019; RAMIRES, 2020).

According to Gripp Júnior et al. (2011), the urban cadastre had greater visibility after the Fiscal Responsibility Law, in which it was established that all municipalities should update the mapping of the features of their urban area, for a fair tax collection and better land management, as the space to be monitored would be better known (GARCIA, 2008). This led repercussions in Urban Land Regularization, as irregular properties were not charged taxes since they were not included in the records.

According to Law 13,465 of Urban Land Regularization (BRASIL, 2017), urban land regularization process requires a complete geo-referenced planialtimetric survey, including buildings and property boundaries, road system (sidewalk and carriageway), indication of public areas, landforms and other elements that characterize the urban nucleus in question.

The urban cadastre, in turn, does not have specific regulations, and the National System of Territorial Information Management (SINTER) was recently instituted as a:

> [...] public management tool that will integrate, in a spatial database, the dynamic flow of legal data produced by public registry services to

> the flow of fiscal, cadastral and geospatial data of urban and rural properties produced by the Union, by the States, the Federal District and the municipalities (BRASIL, 2016).

However, it has not yet been implemented, with each municipality managing its own urban cadastre. One of the consequences of this decentralization is the lack of a standard, as there is no single guideline of minimum requirements for this cadastre. According to Blatchut and Vilasana (1974), a Multipurpose Cadastre should be understood as a system of property registration, made in a geometric and descriptive way.

In addition, the City Statute (BRASIL, 2001), in Article 50, established the obligation of some municipalities to develop and approve participatory master plans. According to Cunha et al. (2019), the guidelines provided for in the master plan, as well as other instruments relating to urban policy provided for in the City Statute, require data that can only be made available through the organization of the municipality's territorial registry.

According to the Brazilian Institute of Geography and Statistics (IBGE), 95% of Brazilian municipalities and 100% of municipalities with over 500 thousand inhabitants had a Land Registration in 2015 (IBGE, 2017). But these data do not reveal the fragility and lack of technology in these records, especially the fact that most of them do not comprise georeferenced information (PEREIRA, 2009; CUNHA et al., 2019).

Traditionally, in small and medium-sized municipalities where the availability of financial resources is limited, land management is carried out based on extensive fieldwork or, alternatively, with the use of low-resolution satellite images (such as Landsat or Bing) (PINTO FILHO et al., 2020). However, for local planning, large scales are needed (1:500, 1:1000 or 1:2000, depending on the purpose), making the use of these low-resolution satellite images technically unfeasible. The possibility of acquiring satellite images or aerophotos (from airplanes, for example), which have acceptable scale and positional accuracy, becomes financially unfeasible (KLEMAS, 2015; TOPOUZELIS et al., 2018).

Despite that, as the pandemic progressed, remote sensing techniques proved to be more adequate in the face of extensive fieldwork involving contact between people, becoming an epidemiological risk for both professionals and residents. These techniques, with products with high spatial resolution and low cost, are an emerging demand for urban and land management solutions during the pandemic and, considering its promising use, after the pandemic as well. Unmanned Aerial Vehicles (UAVs), or Remotely Piloted Aircraft (RPAs), also popularly called drones, meet these demands (CURETON, 2020).

This is confirmed by the increase in the number of drone registrations in Brazil during quarantine months, which grew 13% from January to June 2020. According to the National Civil Aviation Agency (ANAC), the greatest growth was in the number of equipment registrations for professional use, with an increase of 15% (MATSUI, 2020). In addition, within the scope of public municipal administration, it is already possible to observe examples of the adoption of land management strategies in times of pandemic based on images resulting from UAV, for example, for updating the Land Registration (SANTOS et al., 2020), urban land regularization (PEDERNEIRAS, 2020) and continuity in the development of the master plan (PINTO FILHO et al., 2020). The technology is also being used in the territorial management of indigenous lands, thus avoiding research that requires field presence and increases the epidemiological risk of COVID-19 (TNC, 2021).

Thus, considering all these aspects, this work proposes to investigate the use of Unmanned Aerial Vehicle (UAV) orthophotos to support public land management in the context of the pandemic and evaluate its post-pandemic potential based on its pros and cons.

2 METHODOLOGY

In order to verify the feasibility of using UAVs for purposes of public land management in the epidemiological context of the novel coronavirus, the Case Study method of analysis was used, as it allows relating theoretical aspects to experimental issues (YIN, 2015).

Therefore, a survey of the main features to be mapped was carried out in order to update the urban technical register and urban land regularization, based on the main legislation in force, especially the Urban Land Regularization Law (BRASIL, 2017). The following features were then analyzed:

- Spatial resolution and positional accuracy;
- Delimitation of properties and buildings;
- Identification of the number of floors;
- Identification of land use;
- Identification of urban infrastructure;
- Environmental feature mappings.

Considering these selected features, the possibilities of identifying them by means of orthophotos resulting from UAV surveys were studied in comparison with other methodologies such as traditional topography, field research or low-resolution satellite images (free of charge). In addition, a debate was raised about the characteristics of the use of this tool considering epidemiological restrictions imposed by the COVID-19 pandemic.

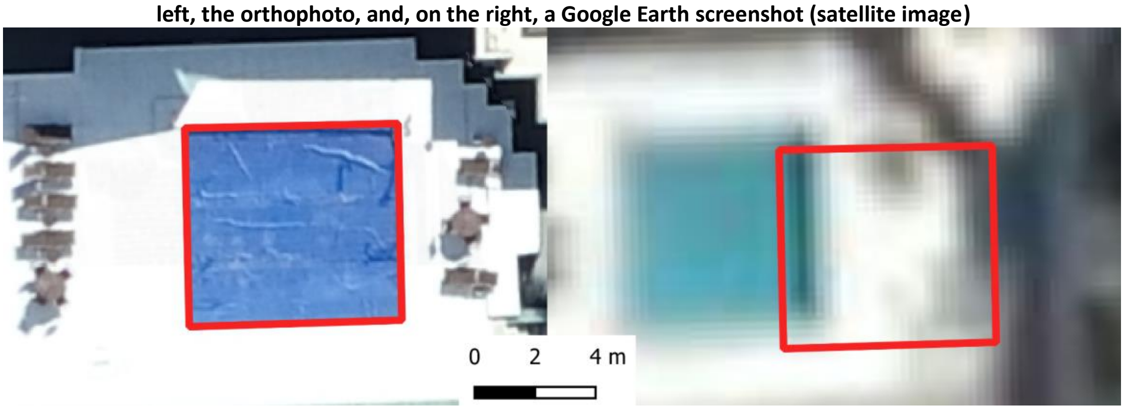
3 RESULTS AND DISCUSSION

The orthophoto utilized in this study has a pixel size of 6 cm^2. When georeferencing is performed with support points on the ground, the positional accuracy of the orthophotos resulting from UAVs is framed according to the Technical Norms of National Cartography (BRASIL, 1984).

In Figure 1, it is possible to observe two aspects related to the quality of orthophotos resulting from UAVs: spatial resolution and positional accuracy. On the left, an orthophoto fragment is shown and, on the right, a Google Earth screenshot (satellite image); it is possible to notice the displacement of the vectorized polygon in the orthophoto, as well as how imprecise it would be to vectorize any feature in the low resolution satellite image.

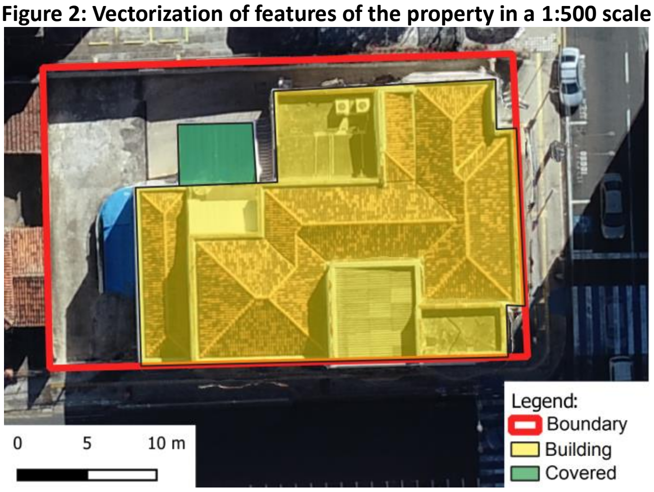
Figure 2 depicts an example that applies to both Urban Cadastre and Urban Land Regularization and deals with the vectorization of features related to property: boundaries, buildings and covered locations. From the vectorization of these features, it is possible to extract and calculate relevant information such as built-up area, coverage area, percentage of built-up area. In municipalities where the green municipal property tax is applied, for example, it is also possible to extract the necessary information for its calculation.

Figure 1: Perception of positional accuracy by the displacement of a vectorized feature on a 1:250 scale. On the left, the orthophoto, and, on the right, a Google Earth screenshot (satellite image)



Source: The authors, 2021.

Figure 2: Vectorization of features of the property in a 1:500 scale



Source: The authors, 2021.

In addition to the vectorization of features, other relevant information for supplying a spatial database referring to urban properties deals with the vertical typology. In this case, as illustrated in Figure 3, although the orthophoto (top of Figure 3) provides a general notion, the most suitable product is the Digital Surface Model (DSM) (lower part of Figure 3). From the MDS, it is also possible to extract the Digital Terrain Model (DTM) and the terrain contour lines.

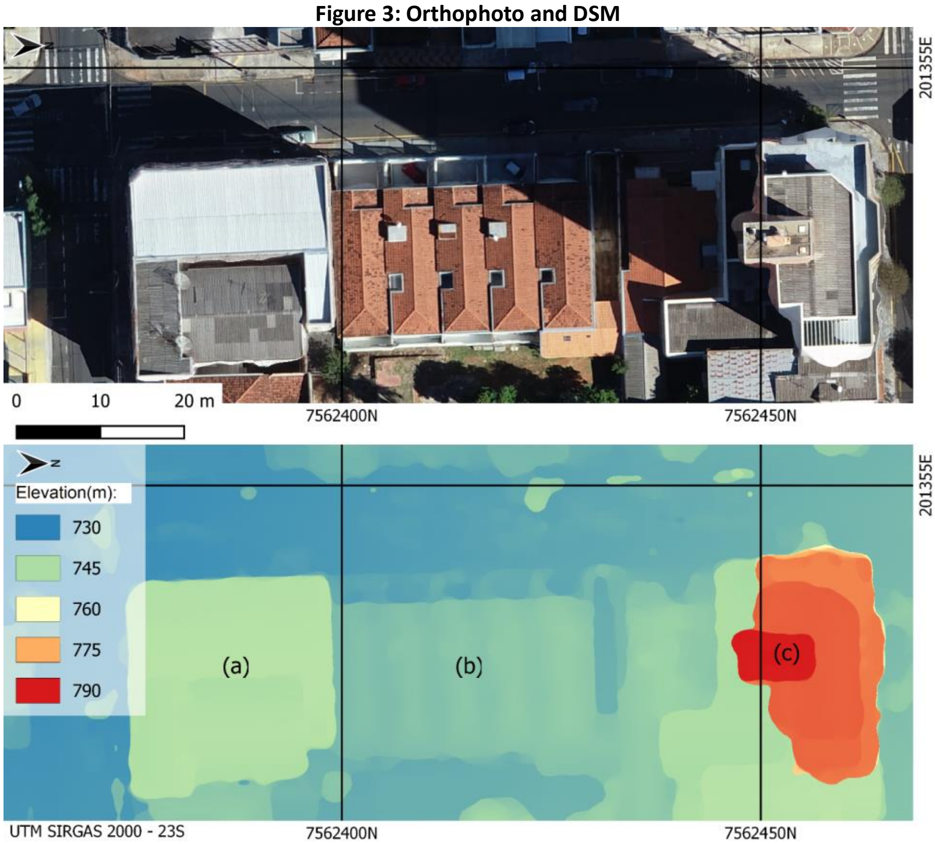
In Figure 3, the elevations of the road system vary between 730 and 742 meters: in (a), it is approximately 745 meters; in (b), 741 meters; and, in (c), it varies between 779 and 790 meters. Comparatively, (b) has fewer pavements in relation to (a), which has fewer pavements in relation to (c), so that: (a) varies 14.5 meters in relation to the road system; (b) varies 7 meters and (c) 52 meters. A limitation on the use of this methodology is found in the calculation of the exact amount of floors, as the height of the floor varies depending on the use (for example, a shed, which differs from a residence).

In the case of land use, the orthophoto can be used as a basis for delimitation (see Figure 4), however, fieldwork is still essential for the exact verification of uses, especially in the case of mixed uses and institutional uses. Another step that cannot be carried out using orthophoto, but that can be carried concurrently with field work to verify uses, is the collection

ISSN 1980-0827 – Volume 17, número 2, 2021

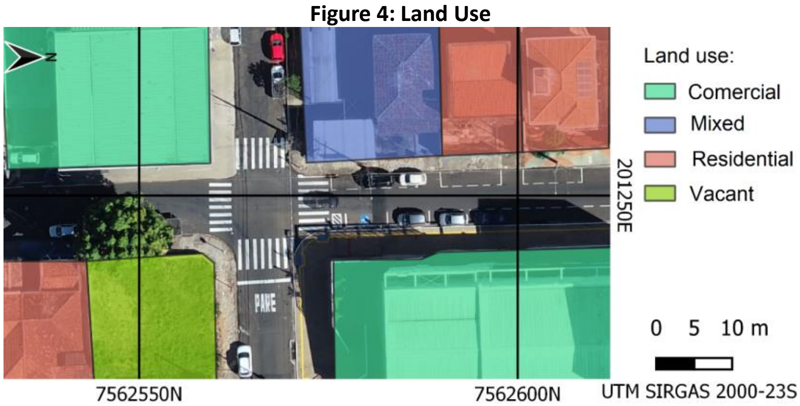
of data referring to the identification number of the properties. It should be noted that these processes do not require contact between service providers and residents.

Figure 3: Orthophoto and DSM



Source: The authors, 2021.

Figure 4: Land Use



Source: The authors, 2021.

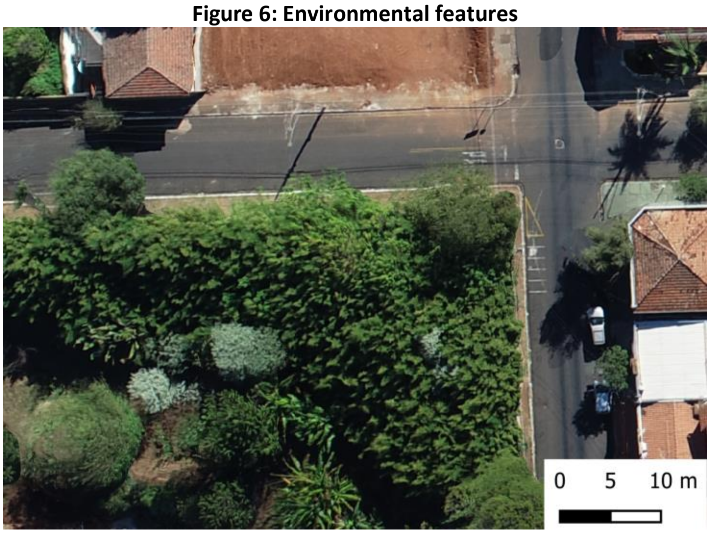
The mapping of basic urban infrastructure is shown in Figure 5. In this figure, the features related to afforestation of the roads, hydrant, poles, manholes, ramps for wheelchair users and traffic lights were mapped. Some data can be more detailed, as in the case of manholes, which, based on a field visit or a map of the service provider, can be identified as water wells, sewage or gallery wells. In addition to the features identified in Figure 5, public sidewalks, carriageways, bicycle paths/cycle lanes, pedestrian crossings, storm drains, parks, water supply lifts can also be mapped from orthophotos, among others.

Figure 5: Urban Infrastructre Mapping

Source: The authors, 2021.

Additionally, the mapping of the environmental characteristics of a location, required by the Land Regularization Law (Brasil, 2017), can be considered as another advantage in using orthophotos, as shown in Figure 6, which shows a fragment of vegetation inserted in an urban area.

Figure 6: Environmental features



Source: The authors, 2021.

Generally speaking, through orthophotos it is possible to identify water resources, extensive strips of vegetation and isolated fragments of vegetation, even allowing the diagnosis of environmental impacts such as areas with no permanent preservation area, erosion and risk of landslides. The identification of springs is also feasible through orthophotos; however, it requires further field verification.

The results indicated that the products obtained from UAV are promising for purposes of public land management in the epidemiological context of the novel coronavirus, in which entering the properties to carry out the measurement of constructions could cause contact between service providers and residents and, eventually, spread of the virus. Extensive field surveys on public roads could also expose workers to greater risk due to the longer exposure time.

From the acquisition of data in the field, the rest of the processes take place in the office, even allowing the professionals to work remotely (home-office). Considering these aspects, the possibility of the growing demand for the use of UAVs in recent months becoming permanent is considered. This is due to several advantages that have been highlighted, to which reduced cost and time for data acquisition and product quality can be added. Another advantage is that there is no need to physically enter properties, which facilitates the information collection procedure.

4 CONCLUSION

The use of orthophotos from UAVs proved to be a viable tool to support public land management in the context of the epidemiological restrictions of isolation and social distance imposed by the COVID-19 pandemic. Furthermore, the resulting high spatial resolution and positional accuracy and the diverse possibilities within photointerpretation developed in this study show that this tool could also be promising even after the pandemic.

When compared to solutions available for free, such as Google Earth, orthophotos were more effective both in vectoring features and in locating them. It is also possible to add advantages associated with fast data collection and processing of products, adaptation to areas of difficult access and low acquisition cost.

Orthophotos, when combined with fieldwork that preserves the social distance between workers and residents, allowed to map the minimum characteristics to comply with the Land Regularization Law and to identify the desired features of the Urban Cadastre, even allowing the achievement of results in a reduced time when compared exclusively to field and topography surveys. The resulting scales also meet the needs, allowing the general mapping at the 1:1000 scale and the detailing of buildings, infrastructure and environmental features at the 1:250 and 1:500 scales. In addition, altimetric products can also be highlighted as advantages of the UAV experience, as they are also required by law.

Although data acquisition requires field presence, execution time is reduced compared to traditional field surveys (topography), in addition to the possibility of carrying out the steps that follow it (processing and vectoring) in the home-office format. The main feature that made the use of UAV viable in the pandemic is the possibility of no contact between residents and service providers, which makes this alternative viable also in the post-pandemic scenario, as it consists of as a less invasive solution to mapping of the property.

Considering that the fields of Urban Land Regularization and Urban Cadastre in Brazil still have a long way to go and that these tasks are extremely relevant to the management of territorial dynamics, it is concluded that data acquisition through UAV is a demand that has emerged during the pandemic and has the potential to become permanent after it is over.

6 BIBLIOGRAPHICAL REFERENCES

BEZERRA, Luciana C. Albuquerque; FELISBERTO, Eronildo; DA COSTA, Juliana M. Barbosa; ABATH, Marcella de Brito; HARTZ, Zulmira. A gestão do conhecimento no contexto de uma emergência em Saúde Pública: O caso da síndrome congênita do Zikavírus, em Pernambuco, Brasil. **Anais do Instituto de Higiene e Medicina Tropical**, Universidade Nova de Lisboa, Lisboa, v.16, p.47-56, 2018.

BLACHUT, Theodor J.; VILASANA, J. Alberto. Cadastre: Various function characteristics, techniques and the planning of land records systems. Canada: National Coucil Canada, 1974.

BOULOS, Maged N. Kamel; GERAGHTY, Estella M. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. **International Journal of Health Geographics**, v.19, n.8, 2020.

BRASIL. Decreto nº 89.817, de 20 de junho de 1984. Estabelece as Instruções Reguladoras das Normas Técnicas da Cartografia Nacional. **Diário Oficial da União**: seção 1, Brasília, DF, p. 8884, 22 jul. 1984.

BRASIL. Lei nº 10.257, de 10 de julho de 2001. Regulamenta os arts. 182 e 183 da Constituição Federal, estabelece diretrizes gerais da política urbana e dá outras providências. **Diário Oficial da União**: seção 1, Brasília, DF, ano 133, p. 1, 11 jul. 2001. PL 181/1979.

BRASIL. Decreto nº 8.764, de 10 de maio de 2016. Institui o Sistema Nacional de Gestão de Informações Territoriais e regulamenta o disposto no art. 41 da Lei nº 11.977, de 7 de julho de 2009. **Diário Oficial da União**: seção 1, Brasília, DF, ano 89, p. 12, 11 mai. 2016.

BRASIL. Lei nº 13.465, de 11 de julho de 2017. Dispõe sobre a regularização fundiária rural e urbana [...] e dá outras providências. **Diário Oficial da União**: seção 1, Brasília, DF, ano 132, p. 1, 12 jul. 2017. MPV 759/2016.

CUNHA, Eglaisa; OLIVEIRA, Francisco; JULIAO, Rui; CARNEIRO, Andrea. O cadastro urbano no Brasil: histórico e evolução. **Revista de Geografia e Ordenamento do Território**, n.17, p.55-74, 2019.

CURETON, Paul. Digital Twins, smart cities and drones**.** In: CURETON, Paul (org.) **Drone Futures**. Londres: Routledge, 2020, p. 34.

GARCIA, Romay C. **O que é preciso saber sobre Cadastro Técnico Multifinalitário**. Brasília: Caixa Econômica Federal, 2007. Disponível em: <http://downloads.caixa.gov.br/_arquivos/desenvolvimento_urbano/gestao/CARTILHA_DE_CADASTRO_TECNICO_MULTIFINALITARIO_2007.pdf> Acesso em: 02 fev. 2021.

GRIPP JUNIOR, Joel; SILVA; Antonio Simões; VIEIRA, Carlos Antônio Oliveira. **Cadastro Técnico Municipal de Cidades de Pequeno Porte**. Universidade Federal de Viçosa, Viçosa, 2011. Disponível em: <https://intranet.ifs.ifsuldeminas.edu.br/joao.tavares/Material_Cadastro_e_Loteamento/CadastroTecnicoMultifinalitario%20-%209EAC/Material%20auxiliar/Cadastro%20T%C3%A9cnico%20Municipal%20de%20Cidades%20de%20Pequeno%20Porte%20.pdf > Acesso em: 10 fev. 2021.

IBGE. **Perfil dos municípios brasileiros**. Rio de Janeiro: IBGE, 2017. Disponível em: <https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101595> Acesso em: 10 fev. 2021.

KLEMAS, V. Coastal and Environmental Remote Sensing from Unmanned Aerial Vehicles: An Overview. **Journal of Coastal Research**, v. 31, n. 5, p. 1260–1267, 2015.

MATSUI, Naomi. Registro de drones manteve ritmo de 2019 mesmo na pandemia. Época, Rio de Janeiro, 17 jul. 2020. Disponível em: < https://epoca.globo.com/guilherme-amado/registro-de-drones-manteve-ritmo-de-2019-mesmo-na-pandemia-1-24538648> Acesso em: 12 fev. 2021.

OLIVEIRA, Juliana Silva; NERY, Adriana Alves; VILELA, Alba B. Alves; SANTOS, Charles Souza; BISPO, Karla C. de Albuquerque; BISPO, Luciene Dias. Os instrumentos de gestão e a epidemiologia: ferramentas do controle social. **Revista de Enfermagem UFPE Online**, UFPE, Recife, v. 7, n. 1, p.192-198, 2013.

PEDERNEIRAS. **Prefeitura utiliza drones para mapear e regularizar distritos industriais em Pederneiras**. Pederneiras: Prefeitura Municipal, 2020. Disponível em: < http://pederneiras.sp.gov.br/portal/noticias/0/3/2376/Prefeitura-utiliza-drones-para-mapear-e-regularizar-distritos-industriais-em-Pederneiras> Acesso em: 10 fev. 2021.

PEREIRA, Camilo Cesário. **A Importância do Cadastro Técnico Multifinalitário para Elaboração de Planos Diretores**. Dissertação (Mestrado em Engenharia Civil). Programa de Pós-Graduação em Engenharia Civil da Universidade Federal de Santa Catarina, 2009.

PESSOA, Lorayne Costa, REIS FILHO, Antônio Aderson, ROCHA, João Victor Vieira. O Cadastro Multifinalitário como ferramenta no Planejamento Urbano. **Brazilian Journal of Development**, Curitiba, v. 5, n. 1, p. 915-926, 2019.

PINTO FILHO, J. L. de O.; LIMA, M. L. de A.; OLIVEIRA JUNIOR, H. S. de. Mapeamento aéreo com drone para planejamento urbano. **Revista Políticas Públicas & Cidades**, v. 9, n. 4, p. 1-20, 2020.

RAMIRES, Júlio. C. de Lima. Avaliação da Produção Acadêmica sobre Ocupações Irregulares: Contribuições da Geografia Urbana. **Revista Eletrônica Da Associação Dos Geógrafos Brasileiros Seção Três Lagoas**, v. 1, n. 31, p. 225-259, 2020.

SANTOS, J. G. V.; DE SOUZA, J. E. A. N.; DOS PASSOS, J. B., CARNEIRO, A. F. T. Aquisição de dados utilizando fotogrametria com VANT's para apoio ao Cadastro Territorial. *In*: CONGRESSO DE CADASTRO MULTIFINALITÁRIO E GESTÃO TERRITORIAL, 14., 2020, Florianópolis. **Anais** [...]. Florianópolis: UFSC, 2020. p. 1-11.

TNC, 2021. **Novas tecnologias para contribuir com a gestão territorial em Terras Indígenas**. São Paulo: The Nature Conservancy Brasil, 2021. Disponível em: <https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101595> Acesso em: 10 fev. 2021.

TOPOUZELIS, Konstantinos, MAKRI, Despina, STOUPAS, Nikolaos, PAPAKONSTANTINOU, Apostolos; KATSANEVAKIS, Stelios. Seagrass mapping in Greek Territorial waters using Landsat-8 satellite images. **International Journal of Applied Earth Observation and Geoinformation**, v. 67, p. 98–113, 2018.

VILLAÇA, Flávio**. Espaço intra-urbano no Brasil**. São Paulo: Studio Nobel: FAPESP: Lincoln Institute, 2001.
YIN, Robert K. **Estudo de Caso: Planejamento e Métodos**. Porto Alegre: Bookman Editora, 2015.