# Potentialities and challenges of land regularization in favelas and informal settlements: Exploring the use of unmanned aerial vehicles (UAVS)

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**ABSTRACT**
Land regularization in favelas is a challenging and complex issue in the Brazilian context, involving legal, social, economic and urban aspects. In this scenario, the use of unmanned aerial vehicles (UAVs), popularly known as drones, emerges as a promising tool with the potential to significantly assist in land regularization activities in informal settlements. This article aims to explore and highlight the potential of UAVs in the regularization of informal settlements, evidencing their ability to provide accurate, up-to-date and detailed geospatial information. UAVs can perform aerial photogrammetric surveys, capturing high-resolution images and generating georeferenced orthomosaics and 3d models of the areas of interest. However, the effective implementation of UAVs in land regularization faces several obstacles and challenges. One of the main challenges is the need for adequate standardization for the use of these technologies in slum areas, considering the particularities and specific demands of these settlements. In addition, issues related to privacy, security, access to the data collected and training of the professionals involved also require attention. Another relevant aspect is the gap between the scientific and technological research developed so far and the discussions on the right to housing. The research has been directed, for the most part, to meet the demands of financial capital, with emphasis on the agribusiness sector, leaving aside the needs of communities in situations of housing vulnerability. Therefore, it is essential to promote a closer integration between scientific research, legislation and public policies aimed at land regularization in favelas, in order to ensure that the use of UAVs is guided by ethical, inclusive and socially just principles. Only in this way will it be possible to fully harness the potential of these technologies to promote decent housing and access to fundamental rights in informal urban areas.

**Keywords:** Photogrammetry, Informal settlements, Unmanned aerial vehicle, Land regularization.

# 1 INTRODUCTION

The process of urbanization in Brazil, driven by industrialization, combined with low wages and the high cost of urbanized land, resulted in a reality in which many workers ended up building their homes in favelas. These informal communities are predominantly located in at-risk areas such as hillsides, areas subject to landslides, and also in peripheral and poorly equipped regions of cities. This phenomenon is the result of a series of socioeconomic and political factors, which have contributed to the exclusion of these vulnerable population groups from adequate access to decent housing and basic urban infrastructure services.

In Brazil, in 2010, 6,329 favelas were registered, housing approximately 11.4 million residents. This amount represents about 6% of the total population of the country, showing a significant growth compared to the 3.1% recorded in 1991. During this 19-year period, the Brazilian population as a whole increased by around 20%, while the number of people living in subnormal agglomerations, also known as favelas, had a significant increase of approximately 61% (IBGE, 1991; IBGE, 2010).

This substantial increase in favelas reflects the social inequalities and difficulties faced by a significant portion of the Brazilian population in finding adequate housing. Accelerated urbanization, coupled with the lack of effective housing policies, has contributed to the disorderly growth of these communities, often located in risk areas such as steep slopes or river banks, exposing residents to precarious conditions of security and infrastructure.

The phenomenon of favelas in Brazil is complex and multifaceted, involving issues of poverty, social exclusion, limited access to basic services such as drinking water, sanitation and electricity, and the lack of land regularization. These challenges demand the implementation of integrated public policies, aimed at improving living conditions in these communities, guaranteeing the right to adequate housing, basic infrastructure and social inclusion actions, in order to promote a fairer and more sustainable urban development throughout the country.

This phenomenon of favelas is more representative in the metropolitan regions of Brazil, where the concentration of population is more intense. A striking example is the Metropolitan Region of São Paulo (RMSP), which is home to one of the largest metropolises in the world. In this region, about 18.9% of the population resides in favelas, reflecting the challenging socioeconomic conditions faced by a significant portion of the inhabitants.

However, it is not only in the MRSP that the presence of favelas is striking. In other metropolitan regions of the country, the proportion of the population residing in these communities is even higher. For example, in Belém, the percentage of residents in favelas reaches an impressive 53.9%, indicating a reality marked by the lack of adequate housing and the absence of effective policies for social inclusion and urban development.

Other metropolitan areas also face similar challenges. In Salvador, the population living in favelas represents 26.1% of the total, while in São Luís this proportion is 24.5%. In Recife, the presence of favelas reaches 23.2% of the population (IBGE, 2010). These alarming figures underscore the urgency of government actions and social initiatives to address the housing and infrastructure demands in these metropolitan areas, aiming to provide decent housing conditions and a better quality of life for the residents of these communities.

This perverse logic imposes a context of profound injustice, in which fundamental constitutional rights, such as the right to decent housing and access to essential public services, are systematically denied, depriving millions of people of a dignified life. This alarming reality also highlights the historical and complex challenge involved in implementing the necessary measures for the land and urban regularization of favelas.

Land and urban regularization is one of the greatest challenges faced by urban planning practices today. Its objective is to ensure the security of property ownership and access to urbanized land, through interventions that seek to improve urban, housing, social and environmental conditions. In this context, the predominant paradigm in favela urbanization projects is to comprehensively improve the living conditions of these communities. This implies the implementation of actions that go beyond the simple regularization of the property, covering the improvement of the existing physical infrastructure, such as sanitation, water supply, electricity and access to paved roads.

In addition to physical improvements, the effective participation of the population is considered a fundamental aspect in this process. The engagement and active contribution of residents is valued, seeking a participatory approach that takes into account the specific demands and needs of each community. This participation includes from the initial phase of diagnosis to the implementation and monitoring of interventions, promoting a sense of belonging and shared responsibility.

Housing and urban improvements require a detailed design that relies on comprehensive geospatial information. This includes data on the topography of the land, such as the location of buildings, roads, drainage network, power lines, water supply systems, classification of land use and occupation, administrative boundaries, as well as information on areas of geotechnical risk and susceptible to flooding.

However, favelas lack adequate and up-to-date geospatial information, as they are often excluded from official data collections. Traditional sources of remote sensing are not sufficient to deal with the complexity of favelas, such as the identification of individual residential units, the detailed mapping of internal infrastructures, or the precise analysis of local environmental conditions (Gevaert et al., 2018).

Therefore, we face a significant challenge in obtaining reliable geospatial information to guide improvements in these areas. It is necessary to develop innovative approaches adapted to the specific

characteristics of favelas. This may involve the use of advanced remote sensing techniques, such as high-resolution images and 3D mapping technologies, coupled with participatory methods that involve the residents themselves in data collection.

By overcoming existing limitations and obtaining accurate and up-to-date geospatial information for favelas, we will be able to promote more effective and sustainable planning, directing resources appropriately and implementing interventions that meet the specific needs of each community. This approach based on reliable data and active participation will contribute to improving the quality of life, promoting social inclusion and achieving more equitable urban development.

The use of aerial survey embarked on UAVs (Unmanned Aerial Vehicles), popularly known as drones and defined in Brazilian legislation as RPA (Remotely-Piloted Aircraft), presents a significant contribution to the activities of land regularization and urbanization of favelas. This approach has several advantages over other tools, such as satellite imagery or aerophotogrammetry embedded in manned aircraft, which is worth mentioning.

One of the main advantages is the favorable cost/benefit ratio, since the use of drones for aerial survey tends to be more affordable financially, making it a viable option even with limited budgets. In addition, the speed of execution is a relevant aspect, since drones allow the rapid acquisition of updated geospatial data, streamlining the mapping and analysis process.

Another positive point is the accuracy and level of detail of the information collected through georeferenced orthomosaics and 3D modeling. Drones can capture high-resolution images, allowing for a more thorough analysis of site characteristics, existing buildings, infrastructure and environmental conditions. This provides a solid basis for regularization activities, contributing to more informed decision-making. In addition, the use of drones offers flexibility and adaptability to the specific needs of each favela. Drones can access hard-to-reach areas and capture data in precise detail, even in complex and congested urban spaces. This versatility enables a more comprehensive and accurate mapping of the physical and socioeconomic characteristics of favelas, helping to identify problems and plan appropriate solutions.

However, the adoption of this technology requires a standardization appropriate to the specific needs of survey in favelas, as well as the continuous development of scientific and technological research to ensure the effectiveness of mapping. It is essential to establish clear and up-to-date guidelines for the use of drones in favelas, considering the peculiarities of these complex urban environments. This involves issues such as airspace regulation, safety procedures, licensing and certification of operators, as well as ethical and legal guidelines for the collection, processing and storage of the data obtained.

At the same time, it is necessary to invest in scientific and technological research that can improve mapping techniques using drones. This includes the development of advanced image

processing algorithms, geospatial data analysis and 3D modeling in order to obtain more accurate and reliable results. In addition, the research may also explore new approaches, such as the integration of additional sensors, such as multispectral cameras or laser sensing systems, to enrich the information captured by the drones.

This article aims to address the potentialities, obstacles and challenges of the use of aerial survey technology in UAVs (Unmanned Aerial Vehicles) in the land regularization and urban planning of favelas. To achieve this goal, three distinct steps will be presented, which aim to offer a comprehensive understanding and identify the various approaches adopted in the application of this technology in favelas. In addition, the article will include two information boards, addressing the ethical and normative aspects related to this application, as well as a quantitative overview of scientific research on remote sensing with UAVs.

The potential of this technology will be explored, highlighting its specific benefits and advantages for land regularization and urban planning. Practical examples of projects that have successfully used drones in this context will be presented, demonstrating how the aerial survey embarked on UAVs can contribute to the obtaining of accurate and updated geospatial data, allowing a more efficient and informed analysis for the planning of interventions. Next, the main obstacles faced in the application of this technology in favelas will be discussed. Issues such as the lack of adequate standardization, the difficulty of access and mapping in hard-to-reach areas, as well as the ethical and privacy challenges related to the collection and use of data will be addressed. Examples of practical challenges and the strategies adopted to overcome them will be presented, offering insights on how to deal with these difficulties effectively. Finally, a quantitative overview of scientific research related to the use of UAVs in remote sensing applied to land regularization and urban planning of favelas will be presented. The evolution of scientific publications in this area will be analyzed, identifying the main trends, methodological approaches and knowledge gaps that deserve greater attention.

By addressing the potentialities, obstacles and challenges of the use of aerial survey in UAVs for the land regularization and urban planning of favelas, this article seeks to contribute to the advancement of practices in this field, offering subsidies for informed decision-making and the development of more efficient strategies. Through the understanding of the different paths adopted and the critical analysis of the scientific panorama, it is expected to promote the responsible and ethical use of this technology, aiming at improving living conditions in favelas and promoting fairer and more inclusive cities.

## 2 METHODOLOGY

This article is divided into three stages, in which different aspects related to the use of UAVs (Unmanned Aerial Vehicles) in the mapping of favelas will be addressed, focusing on land

regularization and urban planning. In the first stage, real situations will be presented in which UAVs were used in the mapping of favelas, encompassing approaches such as participatory mapping, urbanization projects and struggles and resistances.

The goal is to provide a panoramic view of these experiences, highlighting the potentialities and technical challenges associated with the use of this tool. The necessary technical requirements and specific considerations for carrying out effective mapping in favela environments will be discussed.

The second stage consists of analyzing the normative and ethical aspects related to mapping with UAVs in favelas. The standards of the Department of Airspace Control (DCEA) and the National Civil Aviation Agency (ANAC) that regulate the use of these devices will be addressed. In addition, the associated ethical assumptions will be discussed, considering the collection of sensitive data and the privacy of the communities involved. The goal is to understand the legal and ethical guidelines that must be followed to ensure a responsible and safe approach to the use of UAVs.

The third stage takes a predominantly quantitative approach. The analysis is based on the hypothesis that research related to aerophotogrammetry with UAVs in Brazil has been directed mainly to conservation areas related to the environment and to market trends, such as agribusiness, while the theme of land regularization and urban planning of favelas has received less attention. At this stage, a survey of scientific publications on the subject will be carried out, using the Scopus journal database, which covers 16,500 peer-reviewed journals, and the articles published in the Brazilian Symposium on Remote Sensing (SBSR). These sources were chosen for their accessibility, relevance, and volume of content related to the research in question. The time frame adopted for the SBSR covers the last five events (2013, 2015 and 2017, 2019 and 2023), in which exclusive thematic sessions on the theme were held.

By adopting this methodology, it is expected to provide a comprehensive view of the potentialities, challenges, normative and ethical aspects, as well as the quantitative panorama of research related to the use of UAVs in the mapping of favelas for land and urban regularization. This information is essential to guide more efficient, responsible and sustainable practices in this field, aiming at improving the living conditions of favela communities and building more inclusive cities.

## 3 RESULTS

### 3.1 UAVS AND FAVELAS: WHAT IS REALLY POSSIBLE, WHAT ARE THE POTENTIALITIES OF THIS TOOL?

Unmanned Aerial Vehicles (UAVs) go beyond the scope of academic research and have the potential to establish connections between the university, the community and society at large. In countries with high rates of inequality and poverty, these devices can play an especially significant role as they face more complex and urgent urban challenges. This technology has the capacity to offer

concrete and impactful benefits, contributing to the promotion of equality, the improvement of living conditions and the strengthening of local communities. By bringing innovative solutions to urban problems, UAVs can drive social transformation and promote greater socio-spatial inclusion.

It is not a coincidence that in countries like Brazil favelas are practically invisible on official maps, and this lack of information reflects, in most cases, a deliberate political and ideological stance. In this perspective, there is a resistance to officialize, through data collection, the existence of these communities. Therefore, from the outset, the mapping of favelas with the use of UAVs carries an evident ideological impact and also has the power to promote the empowerment and identity construction of communities. This approach challenges the narrative of marginalization and stigmatization of favelas, allowing these spaces to be recognized, represented and valued in a more just and inclusive way. Through precise and detailed mapping, communities can claim their existence, their rights and their importance within the urban context, strengthening their sense of belonging and enhancing their active participation in the search for social, urban and political improvements.

We can identify three levels of essential data for favela improvement projects, and it is possible to correlate these data with the possibilities of acquisition, whether by direct, indirect or non-obtainable through drone imaging (Gevaert et al., 2018) (as presented in Table 1). This distinction is critical to understanding the scope and effectiveness of using drones to provide this crucial information.

Table 1: Examples of information obtained through mapping with UAVs. Source: Adapted from Gevaert et al., 2018.

| **Direct acquisition by images obtained through UAVs** | | **Needs other sources** |
|---|---|---|
| Way | Land use | Population counts and other census information |
| Building boundaries | Garbage dump sites | Income, etc. |
| Vegetation | Urban infrastructure | Administrative limits |
| Elevation models | Contextual information | |
| Terrain models | Attributes of the features, such as: type of roof, number of floors, construction material, etc | |

The characteristics of the data generated by UAVs have increasingly driven their use in mapping favelas around the world. This trend is especially observed in developing and underdeveloped countries, where informal land use is more prevalent. In these contexts, UAV technology plays a key role in the development of solutions to issues such as land regularization, cadastre, control of risk areas,

sanitation, among others. The use of these technologies enables a more precise, efficient and affordable approach to address the urban and social challenges present in these communities.

Slum Rehabilitation Authority, the body responsible for the control and management of slums in India, has launched a pioneering project in the city of Mumbai that uses UAVs to map all slum housing. The objective of this project is to promote urban rehabilitation and land regularization of these areas (THE TIMES OF INDIA, 2018). Other examples show the collaboration between local governments, third sector and universities, as in the cases of the mapping with UAVs carried out by the University of Twenty/ITC, in the Netherlands, in the slums of Kigali in Rwanda (Africa), as well as initiatives in Maldonado (Uruguay) and Tandale in Tanzania (Africa).

Gevaert et al. (2017) conducted a study investigating the integration of 2D radiometric and textural aspects, 2.5D topographic features, and 3D geometric features derived from UAV-embedded aerial surveys, with the aim of obtaining a highly accurate automated classification for favelas. The study was conducted using datasets from settlements in Kigali (Rwanda) and Maldonado (Uruguay). The results revealed that the integration of 2D and 3D characteristics resulted in an overall accuracy of 91.6% and 95.2%, respectively, in the identification of features in informal settlements. These findings highlight the potential of using UAVs and integrated analysis of different geospatial features to improve the accuracy and efficiency of mapping and classification processes in favelas.

Koeva et al. (2016) conducted a study aimed at demonstrating the potential of using UAVs in creating and updating maps in a slum located in the city of Kigali, Rwanda. For this, 954 images were collected using a DJI Phantom 2 Vision Plus quadcopter. As a result, an orthophoto covering an area of 0.095 km2 was generated, with a spatial resolution of 3.3 cm. This orthophoto was used for the extraction of features with a sub-decimetric precision, including the cadastral update. Quantitative and qualitative controls of the products were performed, which indicated that the accuracies obtained are in accordance with international standards. The collection of high-precision control points in the field allowed the generation of planimetric data with vertical accuracies of less than 8 cm, thus satisfying the requirements for the production of maps at the 1:1000 scale. These results highlight the effectiveness of using UAVs to create and update accurate and up-to-date maps in favela environments.

Gevaert et al. (2015), in their research conducted in the city of Kigali, Rwanda, highlight the benefits of aerial survey with UAVs, which make it possible to obtain more accurate and complementary information, previously inaccessible. This approach significantly reduces the need for fieldwork and provides a solid foundation for communication between the stakeholders involved in the process. These results show the capacity of the use of UAVs as an effective tool for data collection and improvement of available information, promoting a better understanding and collaboration on issues related to favelas.

Birriel et al. (2016) conducted a study in Maldonado, Uruguay, focusing on a high-density irregular settlement. The aim of the research was to map existing elements including houses, fences, passageways, streets and surface runoff. For this, they used Microdone's md4-1000 quadcopter, equipped with a 24MP SONY Nex7 camera and a 16mm focal length lens. The flights were programmed using the mdCockpit software, with a flight altitude set at 80 meters above the ground. Before the flights, footholds were established, being marked with white crosses spray-painted. The collection of these points was performed with a dual-frequency Rtk GPS. The results showed planimetric accuracies between 1.7 and 2.5 centimeters and altimetric accuracies between 5 and 5.6 centimeters, evidencing the accuracy achieved in obtaining the data.

In Tandale, one of the largest slums in Dar es Salaam, Tanzania, municipal authorities have adopted the use of UAVs to develop plans to protect and assist communities at risk of flooding. Called Ramani Huria (Open Mapping), the project aims to create accurate maps that can be used to mitigate flood risks and improve disaster response. The use of UAVs in mapping allowed the creation of flood risk models and a community resilience plan, including the identification of evacuation routes. In addition, this initiative has empowered university students and community members to identify and map the areas most susceptible to flooding, allowing local authorities to act in real time. The resulting maps are user-friendly and accessible to people with varying levels of education (Makoye, 2017).

In order to illustrate these practices in Brazil, we highlight the work carried out by Langoni et al. (2018) in the favela of Banhado, located in the municipality of São José dos Campos - SP. For the aerial survey, a DJI Phantom 4 Pro UAV equipped with a 20 MP camera and lens with f/2.8 aperture was used, along with the PIX4D Capture application for the definition of the flight plan. The Agisoft PhotoScan 1.2.4 software was used to generate the three-dimensional (3D) model, orthophoto and level curves with equidistance of 1 m. The total coverage area was 144,968 m², with 251 images acquired. The flight was performed at an average height of 100 meters, with a lateral and longitudinal overlap of 80% in the photos. After image acquisition, the data were processed by applying transformations based on the SIFT (Scale Invariant Feature Transform) method. The results, combined with field surveys, made it possible to obtain the precise location of the residences and to vectorize the boundaries of the lots, including in areas of restricted access. In addition, it was possible to delimit ditches, sewage ditches and identify regions with solid waste concentration (Figure 1), using photointerpretation techniques.

A group formed by professionals and students of architecture, engineering and law, which operates in the area of Technical Advisory in Housing of Social Interest (ATHIS) in the city of São Carlos and in the interior of São Paulo, Maitá ATHIS, was the first organization to develop a technical and political protocol for the use of drones in the scope of land regularization in Brazil. The group uses drones as an important tool in its activities, mainly for the application of geotechnologies, such as the

Geographic Information System (GIS) and photogrammetry. The technical and political foundations defined for the use of drones by Maitá ATHIS are related to the strengthening of communities and social movements in the struggle for decent housing and access to land, the development and appropriation of technical-scientific knowledge and technologies for action with communities, the facilitation of participatory and pedagogical processes for planning by the communities of their territories, the execution of housing and urban improvement projects in partnership with residents, the contribution to the sustainability and dynamics of the construction of cities and rural settlements, and the creation of healthy and safe habitats (SANTOS et. al, 2022).

Maitá ATHIS has experiences of acting in different communities, such as Em Busca de Um Sonho (EBUS) in São Carlos, where they participated since the beginning of the occupation process and worked in the construction of proposals for architectural and urban projects, using drones for aerial surveys. They also participated in the Banhado Popular Plan, in São José dos Campos, developing studies of urbanization and land regularization, and worked in aerial surveys in rural settlements in partnership with Peabiru TCA and the Rural Workers Movement (MST).

The use of drones by Maitá ATHIS provides field work savings, technical precision and autonomy in the survey and identification of demands. Drone technology is used to generate orthophotos and assist in the analysis and discussion of projects, division of lots, identification of infrastructure needs, among other aspects related to social housing. Maitá ATHIS seeks to promote the participation of communities, value their knowledge and contribute to the creation of decent and sustainable housing spaces, both in urban and rural areas. The group works in partnership with different institutions and social movements, aiming to strengthen the struggle for housing and the guarantee of the right to the city (SANTOS et. al, 2022).

Figure 1: Example of the detailed level of information obtained through the aerial survey in the Banhado favela (São José dos Campos - SP). Source: Adapted from Langoni et al., 2018.

## 3.2 ETHICAL AND NORMATIVE ASPECTS

The use of UAVs is subject to a number of rules, regulations and authorizations established by regulatory bodies. The National Civil Aviation Agency (ANAC) is responsible for regulating and supervising activities related to civil aviation, including the certification of equipment used in UAVs. The Department of Airspace Control (DECEA) is in charge of controlling Brazilian airspace, establishing guidelines for the safe operation of UAVs. In addition, the National Telecommunications Agency (ANATEL) is responsible for the approval of the radio frequency transmitters used by these devices. These standards and regulations are essential to ensure security, privacy, and compliance in UAV operations (see Table 2).

Table 2: Rules and regulations for the registration and operation of UAVs. Source: Ministry of Defense, 2018.

| | |
|---|---|
| RBAC E No. 94, dated May 2, 2017 | General requirements for unmanned aircraft for civil use; |
| ANAC Resolution No. 419, of May 2, 2017 | Approves the Brazilian Special Civil Aviation Regulation No. 94; |
| ICA 100-40, dated December 22, 2016 | Remotely Piloted Aircraft Systems and Access to Brazilian Airspace; |
| ANAC Resolution No. 377, of March 15, 2016 | Regulates the granting of public air services to Brazilian companies and provides other measures; |
| Normative Ordinance No. 953/MD, April 16, 2014 | Provides for the adoption of procedures for the activity of aerial survey in the National Territory; |
| ICA 63-13, of November 11, 2013 | Procedures of the Organs of SISCEAB Related to AVOEM, AVANAC and AVOMD; |

| | |
|---|---|
| Decree No. 7,845, of November 14, 2012 | Regulates procedures for security accreditation and treatment of classified information in any degree of secrecy, and provides for the Security and Accreditation Center; |
| Law No. 11,182, of September 27, 2005 | Creates the National Civil Aviation Agency, ANAC, and gives other measures; |
| Decree No. 2,278, of July 17, 1997 | Regulates the Aerosurvey Activities in the National Territory; |
| Law No. 7,565, of December 19, 1986 | Brazilian Aeronautical Code; |
| Decree-Law No. 1,177, of June 21, 1971 | It provides for aerial surveys in the national territory, and gives other measures. |
| Decree-Law No. 89,817, of June 20, 1984 | Regulatory Instructions of the Technical Standards of National Cartography |

The Brazilian Regulation of Special Civil Aviation 94/2017 (RBAC-E) of ANAC establishes clear guidelines for the operation of UAVs, classifying them into two main categories: model airplane, used for recreational purposes, and Remotely-Piloted Aircraft (RPA), intended for experimental, commercial or institutional flights. According to the regulations, the operation of RPAs is restricted to areas with a minimum horizontal distance of 30 meters from unauthorized third parties. Model airplanes with a maximum takeoff weight of up to 250 grams, including equipment, battery and cargo, are exempt from registration with ANAC. In the context of slum lifting, it is common to use model airplanes with a maximum takeoff weight of more than 250 grams and up to 25 kg (class 3), operated in visual line of sight at heights of up to 400 feet (about 120 meters) above ground level. In these circumstances, it is necessary to register the UAV with ANAC. In addition, the remote pilot must be legally an adult and have an appropriate license and license for the activity. A series of documents must also be carried by the remote pilot, including Certificate of Registration, Certificate of Registration, flight manual, insurance policy with proof of payment and proof of risk assessment (Brasil, 2017a).

These rules and regulations aim to ensure safety and accountability in the operation of UAVs while protecting the integrity of the people and property involved. Compliance with these guidelines is essential to ensure that UAVs are used ethically and legally, minimizing risks and promoting safety in air activities. The use of airspace by RPA (Unmanned Aerial Vehicle - UAV) is a strictly regulated activity in Brazil, subject to specific guidelines established by the competent authorities. These guidelines are fundamental to ensure the safety of air operations, the integrity of airspace and compliance with the standards established in the civil aviation sector.

The regulation of the use of UAVs is addressed through ICA (Instruction of the Aeronautics Command) 100-40, issued by DECEA (Department of Airspace Control), the body responsible for the control and management of Brazilian airspace. This instruction establishes clear guidelines for the safe and responsible operation of UAVs, covering aspects such as registration requirements, flight

authorization, operational limitations, restricted areas, and communication procedures with air traffic control. In addition to DECEA's ICA 100-40, the Brazilian Aeronautics Code (CBA), established in 1986, also defines the general rules and regulations that apply to civil aviation in the country. These standards cover several aspects related to the operation of aircraft, including remotely piloted aircraft. The CBA establishes the fundamental principles and rules that must be followed by UAV operators, ensuring compliance with legal requirements and the safety of air operations.

Thus, compliance with the regulations established by ICA 100-40 of DECEA and the Brazilian Aeronautics Code is essential for conducting air operations with UAVs in a safe, responsible and legally acceptable manner. Compliance with these standards contributes to the smooth integration of UAVs into the airspace and promotes the safety of operations for both manned and unmanned aircraft.

In the context of commercial access to Brazilian airspace, it is important to note that Remotely Piloted Aircraft (RPA), also known as UAVs, are considered regulated aircraft and are subject to specific procedures for legal and safe operations. The pilot responsible for the operation of an RPA must follow the guidelines established by the aeronautical authorities and meet the requirements necessary to ensure compliance with air traffic regulations. To carry out commercial operations with an RPA in Brazilian airspace, it is necessary for the pilot to register and request flight authorization through the SARPAS system (Request for Authorization to Use RPAS). This process allows for prior air traffic analysis and ensures proper coordination between manned and unmanned aircraft. The time required to evaluate the flight authorization application may vary depending on the specific characteristics of the intended operation. The deadlines can vary from 45 minutes to 18 days, counted from the submission of the request. This variation occurs due to the complexity of air traffic in certain areas and the volume of requests received by the competent authorities.

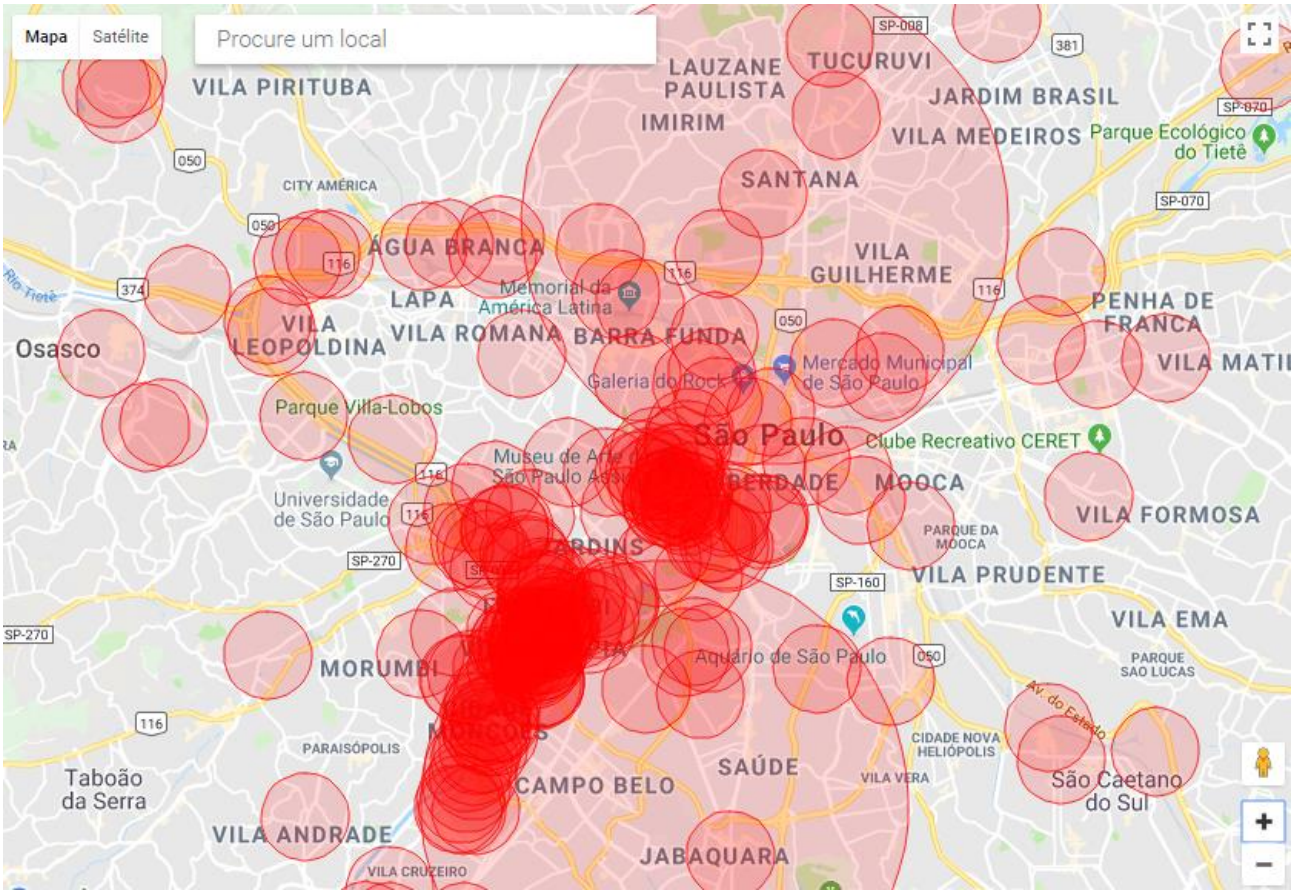
It is critical that RPA pilots are aware of these procedures and are prepared to comply with regulatory requirements, ensuring the safety of air operations and compliance with established standards. By correctly following the protocols for registering and requesting flight authorization, pilots contribute to the smooth integration of RPAs into the airspace and to the sustainable development of commercial activities involving these aircraft.

It is essential to note that, especially in metropolitan areas, where most of the Brazilian favelas are concentrated, the restrictions on RPA operation cover extensive urban areas. As a result, air traffic analyses have generated considerable delays in the process of obtaining authorization for aerial surveying, which is the most time-consuming among the three existing process models in SARPAS.

In addition, doubts and questions have arisen regarding the criteria used to determine certain flight restricted zones, especially when these are not located near established aerodromes and air routes (as illustrated in Figure 2). These uncertainties increase the difficulty of making successful requests, often resulting in unfavorable opinions for these requests. These restrictions, established by the

Ministry of Defense, cover areas of high concentration of Brazilian favelas. Importantly, such restrictions have a significant impact on air traffic analyses and the process of obtaining authorization for aerial survey, resulting in a longer process and often associated with negative opinions for these requests. There are also questions about the criteria adopted in the definition of these restricted zones, especially when they are not located near aerodromes and aircraft routes.

Figure 2: Flight restricted zones (marked in red) for Remotely Piloted Aircraft (RPA) in the Metropolitan Region of São Paulo.




The legalization of low-cost aerial surveys in favelas faces another challenge related to current legislation. Decree-Law No. 1,177/1971, which is still in force, does not distinguish between the types of aircraft to be used for the execution of these activities. This legislation was created at a time when Unmanned Aerial Vehicles (UAVs) were rudimentary and experimental, and strict control of aerial surveys was considered necessary for strategic issues of national security and sovereignty. However, with technological evolution and the popularization of high-resolution satellite imagery, these strategic issues have been overcome. Currently, UAVs are able to perform aerial surveys with precision and quality, at a significantly lower cost than traditional methods. The lack of flexibility in the current legislation is also reflected in the absence of provisions that allow air operations with special objectives of social interest, as is the case of urban land regularization in favelas. These operations have a

differentiated character, aiming to promote social inclusion, guarantee fundamental rights and improve the living conditions of the population in informal settlements.

Given this scenario, it is necessary to update the legislation so that it considers the specificities of low-cost aerial surveys in favelas and establishes guidelines that facilitate and encourage the use of UAVs for purposes of social interest. It is essential that legislation provides a more flexible approach, allowing the responsible use of these technologies to promote land regularization and contribute to the sustainable urban development of communities in situations of vulnerability.

The actuality of Decree-Law 1.177/1971 brings significant restrictions for the execution of aerial surveys in the national territory. According to this decree, only specialized organizations of the Federal Government, state governments and private organizations (legal entities) registered and accredited by the Ministry of Defense (MD) are allowed to carry out aerial surveys.

This limitation prevents companies not registered in the MD from participating in public bids or entering into contracts with private individuals for the execution of these activities. As a result, there is an exclusion of a wide range of companies and professionals who possess the technical knowledge and the ability to offer quality aerial survey services.

The question of the legality of aerial survey with UAVs for cartographic purposes is the subject of debate and concern on the part of the National Association of Aerosurvey Companies (ANEA), which represents the main players in the sector. According to ANEA, the lack of specific regulation makes these aerial surveys illegal.

The absence of a clear and specific regulation for aerial surveys carried out by UAVs generates legal uncertainties as to the validity and acceptance of these derived products. ANEA warns that these products may be challenged in court, which may have negative consequences for companies that carry out these aerial surveys without the proper licenses and authorizations.

In addition to the possible legal consequences, it is important to note that companies that act irregularly in the aerolift sector are subject to various administrative, civil and criminal sanctions. Federal Decree 2.278/1997 establishes the applicable penalties, in articles 24 to 26, for companies that operate irregularly, including fines and other punitive measures.

Current registration procedures are characterized by their bureaucracy and high costs, which results in significant restrictions on the number of companies able to provide aerial survey services. In this sense, it is crucial to identify the need for more flexible regulation in the sector as a key issue to democratize access to spatial information.

The legal uncertainties and high costs associated with the aerial survey services offered by large companies have negative impacts on the access of these services by small municipalities, technical advisories in social housing and low-income communities. These limitations not only hinder access to

essential space information, but also inhibit the emergence of companies specializing in low-cost aerial surveying.

A more flexible regulation in the sector would allow the reduction of unnecessary barriers and obstacles, enabling the participation of a greater number of companies in the aerial lifting market. This would enable the emergence of companies specializing in low-cost aerial surveying, which could meet the specific demands of small municipalities, technical advisories and low-income communities.

In addition, more flexible regulation would encourage healthy competition in the market, contributing to the reduction of the costs of aerial lift services. This would result in greater economic accessibility for entities and communities seeking to use these services for project development, decision-making, and urban planning.

The democratization of access to spatial information is of paramount importance to promote equal opportunities and sustainable development. By facilitating access to low-cost aerial survey services, ensuring the quality and reliability of these services through proper regulation, it is possible to strengthen the capacity of communities and institutions to make informed decisions, properly plan urban development and address socio-environmental challenges.

Therefore, it is essential to rethink the registration procedures and adopt a more flexible approach in the regulation of the aerial survey sector. This will expand access to spatial information, foster innovation and boost sustainable development, benefiting both low-income entities and communities and the overall progress of the country.

In addition, it is essential that the Ministry of Cities establishes clear criteria for the application and evaluation of products generated from aerial surveys with UAVs, especially in the context of land regularization of informal urban centers occupied by low-income population (Reurb - S). This initiative must comply with Federal Law 13,465/2017, known as the Land Regularization Law.

A relevant example in this regard is the work of INCRA (National Institute of Colonization and Agrarian Reform), which has already announced specific rules for the use of UAVs in the process of georeferencing rural properties, through the Execution Norm Incra/DF/02. This standard establishes standards of precision appropriate to the different types of property limits and emphasizes the importance of complying with the other requirements established by Incra's Technical Manual of Positioning.

Thus, it is essential that the Ministry of Cities follow this example and develop similar criteria to guide the use of aerial surveys with UAVs in the process of land regularization of informal urban centers. These criteria should cover aspects such as the precision necessary for the delimitation of the areas, the reliability of the products generated, the interoperability with other geographic information systems and the observance of the legal requirements established by the Land Regularization Law.

By establishing these criteria, the Ministry of Cities will contribute to the standardization and quality of aerial surveys conducted with UAVs in the context of land regularization, ensuring the reliability of the information generated and social justice in the process of regularization of areas occupied by low-income population.

Thus, the definition of clear criteria and the alignment with current legislation will be fundamental to ensure that aerial surveys with UAVs are effective and reliable as tools for land regularization, promoting the legal security of the occupants, the reduction of conflicts and the promotion of social inclusion.

Another issue of extreme importance is the observance of civil, criminal and administrative sanctions related to the irregular operation of Unmanned Aerial Vehicles (UAVs). The Brazilian Aeronautics Code (Law No. 7,565/1986) establishes the administrative sanctions in article 289, providing for fines for aircraft pilots who disregard the guidelines contained in this regulation and other regulations of access to airspace.

In addition to administrative sanctions, UAV operators are subject to criminal and civil sanctions when they endanger the life or health of third parties, as well as when they threaten the integrity of vessels or aircraft, as provided for in articles 132 and 261 of the Brazilian Penal Code. In addition, the Law on Criminal Misdemeanors (art. 33) establishes sanctions for those who drive an aircraft without the proper license, while article 35 of that same law deals with offenses committed by those who perform aerobatics or flybys outside the legally permitted areas, or who perform the descent of the aircraft in places not intended for this purpose.

These sanctions are intended to ensure safety in the airspace and curb inappropriate practices that may pose risks to the integrity of people, other aircraft or vessels. It is critical that UAV operators are fully aware of these legal responsibilities and strictly comply with established rules and regulations.

The supervision and compliance with the aforementioned sanctions are the responsibility of the competent bodies, such as the National Civil Aviation Agency (ANAC), the Brazilian Air Force (FAB) and the police authorities. Awareness of the legal consequences of irregular operation of UAVs is crucial to promote air safety and preserve the integrity of aerospace operations in the country.

With regard to civil sanctions, it is important to note that the Civil Code establishes the responsibilities and consequences for those who, through action, voluntary omission, negligence or recklessness, infringe rights and cause damage to third parties, even if they are exclusively moral damages, thus characterizing an unlawful act, as provided for in article 186 of the aforementioned code (Brasil, 2002).

This legal provision aims to protect the rights and integrity of people, establishing the obligation of reparation on the part of those who, in any way, cause harm to others. Therefore, those who, in the context of the operation of Unmanned Aerial Vehicles (UAVs), violate the rights of third

parties and cause damages, including of a moral nature, will be subject to the sanctions provided for in the Brazilian legal system.

It is essential that UAV operators are aware of their legal responsibilities and act diligently, observing the applicable rules and regulations, in order to prevent the occurrence of unlawful acts and minimize the risks of causing harm to third parties. Strict observance of legal provisions is essential to ensure safety, the protection of individual rights and the preservation of social welfare in the context of UAV operations.

It is essential to emphasize the relevance of privacy in the context of Brazilian legislation. In this sense, it is in article 5, item X, of the Federal Constitution of 1988, that we find the consecration of the principles of the inviolability of intimacy, private life, honor and image of people. As established in this constitutional provision, these fundamental rights are guaranteed and safeguarded, and those who suffer violation of these rights have the legal protection to seek compensation for the material or moral damages that arise.

The protection of privacy is one of the pillars of democracy and individual rights, ensuring the dignity and autonomy of citizens. In this context, it is essential that activities related to the use of technologies, such as Unmanned Aerial Vehicles (UAVs), are carried out in accordance with legal standards, respecting the rights and intimacy of people.

Therefore, the Federal Constitution of Brazil, by establishing the inviolability of intimacy, private life, honor and image, as well as the right to compensation for damages arising from its violation, guarantees a solid basis for the protection of the privacy of individuals, reinforcing the importance of respecting these fundamental rights in all activities involving the use of technologies and the collection of personal information.

Considering the vast potential of Unmanned Aerial Vehicles (UAVs) in providing geospatial information, it is essential to address the issue of the risks associated with the exposure of people's privacy, honor and image, especially in the face of the possible inappropriate use of the data collected. In this context, it is imperative to deepen the discussion on ethics in the use of this equipment.

UAVs have advanced technological capabilities that enable the capture of accurate images and data, providing valuable information about the environment and society. However, this indiscriminate collection of information can also pose a threat to people's privacy and individual rights.

Therefore, it is crucial to establish ethical considerations to guide the responsible use of UAVs. This implies the definition of clear guidelines on the collection, storage and sharing of data, as well as the adoption of appropriate security measures to ensure the protection of personal information.

In addition, it is essential that there is transparency and informed consent on the part of the people involved in order to ensure that their privacy and dignity are respected. Enforcement and regulatory mechanisms also play a key role in ensuring that the use of UAVs is guided by ethical

principles, preventing abuses and ensuring accountability in cases of violations. Thus, the discussion on the ethical use of UAVs becomes indispensable, as it allows reconciling the use of their technological potential with the preservation of people's fundamental rights, providing a balance between innovation and protection.

In order to address the operation of Unmanned Aerial Vehicles (UAVs) in precarious settlements, such as favelas, it is crucial to adopt measures that ensure the necessary care, even in the absence of specific regulations in Brazil regarding the use of this equipment and privacy issues. In this context, it is essential to involve the participation and social control of the activity, as well as to promote a broad notification to the residents about the activities to be developed. Residents' associations play a key role in this process. Through them, it is possible to obtain the approval of the aerial survey, establishing a kind of "social license" for the operation. In addition, the associations ensure the wide dissemination of the period in which the activities will be carried out and the type of information that will be captured. To facilitate this dissemination, it is possible to use various means, such as the collage of posters, the distribution of newsletters and the use of social networks.

Importantly, the active participation of residents' associations not only allows residents to be informed about the operation of UAVs, but also promotes community engagement, ensuring that their interests are taken into account. In this way, it is possible to establish a transparent and constructive dialogue between UAV operators and residents, aiming to mitigate privacy concerns and ensure that activities are conducted in a responsible manner. Therefore, it is essential to promote a collaborative approach, which involves the participation of residents' associations and the wide dissemination of pertinent information, in order to ensure a transparent operation of UAVs, respecting the rights and interests of the community involved.

The considerations raised by Gevaert et al. (2018) emphasize the importance of overflight with Unmanned Aerial Vehicles (UAVs) in relation to the identification of people in private spaces. Given this context, it is essential to inform citizens about their rights to access, process and distribute photographs, as well as to establish measures to mitigate privacy concerns. Therefore, it is necessary to define guidelines that determine the level of abstraction and distribution of the information collected. First, it is crucial that this type of aerial survey is based on social participation, responsibility, transparency, empowerment and equity, which are fundamental values for urbanization policies and projects. This approach allows residents the power to move or cover moving objects they don't want to be photographed. In addition, it helps to establish which non-removable objects will be blurred before distribution to the public, respecting people's privacy. Second, it is important to point out that the concept of sensitive information or privacy can vary between people, groups, and cultures. Therefore, it is essential to take into account the perspective of local communities in relation to private objects and spaces. Different communities may have different perceptions about what is considered

private and should have their particularities respected. Thus, when considering the guidelines presented by Gevaert et al. (2018), it is possible to establish a balance between the use of UAVs for aerial surveys and the protection of people's privacy. The active participation of local communities, combined with clear and transparent guidelines, allows to mitigate concerns, respect cultural specificities and ensure an ethical and responsible approach in the use of these technologies.

## 3.3 THE PATHS OF SCIENTIFIC PRODUCTION AND THE CHALLENGES FOR STIMULATING RESEARCH WITH UAVS IN FAVELAS AND PRECARIOUS SETTLEMENTS

The report by renowned consultancy Pricewaterhouse Coopers & Associates (PwC) reveals an emerging global UAV market, estimated at €112 billion, driven by recent advancements such as improved flight speed, increased payload capacity and real-time data collection solutions. In this context, sectors such as infrastructure (inspection, aerophotogrammetry, monitoring of works, transport of materials and equipment) represent 39.7 billion euros, followed by the agricultural sector (collection and analysis of data on properties, crops and precision spraying) with 28.5 billion euros. In addition, the transport sector, security industry and media and entertainment industry also present significant numbers, with 11.4 billion, 8.8 billion and 7.7 billion euros, respectively (PwC, 2017).

A detailed analysis of keywords in the renowned Scopus journal database reveals a remarkable exponential growth in UAV-related research over the past five years, pointing to a clear and solid correlation between global scientific production and the market niches identified in the renowned PwC report. As shown in Table 3.

Table 3: Publications on the use of drones in specific application areas. Source: Scopus. Own elaboration.

| | **ARTICLES PUBLISHED / YEAR** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR** | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | TOTAL |
| **Engineering** | 88 | 77 | 119 | 138 | 178 | 206 | 234 | 343 | 357 | 502 | 2242 |
| **Computer Science** | 16 | 30 | 35 | 45 | 73 | 90 | 174 | 228 | 254 | 358 | 1303 |
| **Earth and Planetary Sciences** | 10 | 15 | 20 | 29 | 55 | 78 | 101 | 116 | 182 | 182 | 788 |
| **Environmental Sciences** | 8 | 9 | 17 | 17 | 27 | 59 | 78 | 98 | 172 | 193 | 678 |
| **Physics and Astronomy** | 5 | 6 | 14 | 17 | 17 | 28 | 32 | 30 | 28 | 60 | 237 |
| **Agricultural and Biological Sciences** | 4 | 8 | 18 | 17 | 27 | 42 | 70 | 108 | 146 | 184 | 624 |
| **Energy** | 3 | 14 | 16 | 20 | 27 | 27 | 28 | 28 | 46 | 63 | 272 |
| **Decision Sciences** | 4 | 0 | 13 | 0 | 0 | 13 | 0 | 28 | 40 | 37 | 135 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Social sciences** | 0 | 13 | 0 | 17 | 21 | 27 | 24 | 63 | 49 | 64 | 278 |
| **Materials Science** | 2 | 11 | 6 | 12 | 18 | 20 | 16 | 0 | 0 | 0 | 85 |
| **Total articles focusing on favelas and precarious settlements** | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 2 | 0 | 1 | 0 |

In the survey conducted in the annals of SBRS, the Brazilian Symposium on Remote Sensing, there was a significant concentration of research in the field of environmental monitoring and conservation, as well as in the agribusiness sectors, with emphasis on forestry and sugarcane production. In addition, it is worth mentioning the presence of studies related to topography and digital cartography, covering the ground support for aerophotogrammetric surveys, data filtering and generation of digital terrain models (table 4).

Table 4: Publications on the use of drones in specific application areas. Source: Brazilian Symposium on Remote Sensing. Own elaboration.

| SECTOR | 2013 | 2015 | 2017 | 2019 | 2023 | TOTAL |
|---|---|---|---|---|---|---|
| **Conservation and environmental monitoring** | 2 | 6 | 10 | 12 | 8 | 38 |
| **Agriculture and forestry** | 1 | 7 | 5 | 5 | 5 | 23 |
| **Topography, digital cartography, cartographic accuracy and comparative tests between image classifiers for various purposes** | 1 | 7 | 5 | 19 | 5 | 37 |
| **Construction** | 0 | 1 | 0 | 1 | 2 | 4 |
| **Mining** | 1 | 0 | 1 | 1 | 1 | 4 |
| **Multi-finalitary registration** | 0 | 1 | 0 | 1 | 0 | 2 |
| **Education** | 0 | 0 | 0 | 0 | 1 | 1 |
| **Energy** | 0 | 0 | 0 | 0 | 2 | 2 |
| **Cultural heritage** | 0 | 0 | 0 | 0 | 1 | 1 |
| **Precarious settlements (favelas)** | 0 | 0 | 0 | 0 | 0 | 0 |

The scarcity of scientific production related to the use of UAVs in precarious settlements, such as favelas, given the possibilities and challenges that this tool offers for low-cost planialtimetric and cadastral surveys, highlights the need to establish a solid strategy to train and train teachers and university students in this field. To meet this demand, it is essential to build and strengthen a collaborative network of teaching, research and extension in architecture and urbanism courses, as well as in related areas, which is dedicated to enabling the political-scientific articulations necessary to boost the advancement of this theme. This collaborative network should seek the integration of

teachers, researchers, professionals and local communities, fostering the exchange of knowledge, experiences and resources.

It is essential to promote the training and qualification of faculty and students, through courses, workshops and practical activities that explore the potential of UAVs in obtaining accurate data and spatial analysis of precarious settlements. In addition, it is important to encourage interdisciplinary research, involving areas such as geography, sociology, engineering and social sciences, to understand the complexity of precarious settlements and identify innovative and sustainable solutions for urban development. By establishing this training and qualification strategy, it will be possible to train future professionals to deal with the challenges and demands related to the use of UAVs in precarious settlements, contributing to the promotion of social inclusion, adequate urban planning and the improvement of the quality of life of marginalized communities.

Thus, the construction of this collaborative network and the implementation of training and qualification programs are essential steps to boost scientific research, technological innovation and sustainable development in the context of precarious settlements.

In the field of teaching, there is significant potential to take advantage of the research developed and incorporate it effectively in the classes of topography, remote sensing and geoprocessing. This integration would enrich the educational experience of students by providing them with up-to-date and practical knowledge about the use of UAVs. The introduction of these studies in the related disciplines would provide students with the opportunity to learn about the latest technologies and methodologies applied in the field of geospatial analysis. They could explore real cases of UAV use, understand their applications in planialtimetric and cadastral surveys, and acquire practical skills in processing and interpreting data collected by these unmanned aircraft.

In addition, the dissemination of this research through academic extension programs would be of great value to the community at large. The results and findings obtained by the research could be shared in events, workshops and courses aimed at professionals, public managers and residents of precarious settlements. In this way, UAV technology and its practical applications could be disseminated, raising awareness and promoting the responsible and beneficial use of these tools in communities. In addition, student participation in outreach programs would offer them the opportunity to apply their academic knowledge in real-world situations. They could engage in mapping and monitoring projects of precarious settlements, working side-by-side with local communities to identify their needs and provide solutions based on the data collected by UAVs.

This interdisciplinary and practical approach in teaching and academic extension would contribute to the formation of qualified professionals who are aware of the challenges faced by precarious settlements. In addition, it would promote a culture of innovation and entrepreneurship among students, encouraging them to seek creative and sustainable solutions to urban problems.

Therefore, by incorporating research on the use of UAVs in the relevant disciplines and disseminating them through extension programs, we will be creating a bridge between academia and practice, empowering future professionals and promoting the effective application of these technologies in the context of precarious settlements.

University extension programs play a key role in strengthening the aforementioned strategy. They provide a valuable opportunity to establish a two-way connection between universities, social movements, technical advisories and communities fighting for the land regularization of their neighborhoods. This collaborative approach allows not only society to take ownership of the innovations and solutions developed in the academic environment, but also establishes a meaningful dialogue between teachers, students and the struggles and resistances in favor of decent housing.

On the one hand, university extension programs allow the transfer of knowledge and technology to the community. The solutions and innovations developed in the academic sphere can be applied directly to the challenges faced by communities, contributing to the development of more effective and sustainable land regularization projects. This promotes social inclusion and strengthens the capacity of communities to address housing-related obstacles. On the other hand, the participation of teachers and students in extension programs provides an opportunity for direct involvement with the struggles and resistances for housing. By working side by side with social movements and technical advisors, they have the chance to understand the needs and demands of communities in precarious settlements. This immersion in the real context of social struggles allows academics to become sensitized to social issues and acquire a broader and more critical perspective on urban challenges.

In addition, the dialogue between teachers, students and communities promotes an exchange of experiences and knowledge. Students have the opportunity to learn from experience and popular wisdom, incorporating these perspectives into their academic training. In turn, the residents of the communities can benefit from the technical-scientific knowledge brought by the academics, helping in the search for more efficient and contextualized solutions. In this way, university extension programs play an essential role in building a bridge between academia and society, driving concrete actions towards land regularization and the improvement of housing conditions. By promoting collaboration, dialogue and the exchange of knowledge, they contribute to a more comprehensive and committed approach to the demands and needs of communities. It is thus considered to contribute to the challenges of Brazilian universities delimited by Fiuza et al. (2009), comprising the search for a quality standard compatible with the state of evolution and dynamization of scientific knowledge in the contemporary world and also the development of social programs that use geotechnologies to overcome national problems that cannot be postponed, focusing on exclusion and socially structural need, including the subject of housing.

Thus, associate research and teaching with UAVs, especially in the field of architecture and urbanism, to the organic links between the university and civil society, as defined by Fiuza et. al (2009, p. 300-301), will allow to commit the scientific and pedagogical projects with the national socioeconomic reality in order to clarify that "society includes the business sector and its values, but also the working classes, organizations and social movements, as well as their values".

This expanded perspective will allow us to build a technological appropriation that goes beyond a mere instrumental use of geotechnologies in general and remote sensing embedded in UAVs in particular. It is essential to train students and researchers who are sensitive, responsible and aware of the social problems that affect the country.

By promoting a critical and reflective approach in teaching and research, it is possible to develop a deeper awareness of the importance of considering social issues and existing inequalities. Students and researchers will be encouraged to reflect on the role of geotechnologies and remote sensing in relation to the social problems faced by communities.

This perspective goes beyond the technical and instrumental aspect, seeking to explore the potential of geotechnologies as tools for social transformation. Students will be encouraged to think critically about how these technologies can be applied ethically and responsibly, taking into account the needs and realities of the most vulnerable communities.

In this way, academic training will include not only technical and scientific knowledge, but also a social and ethical conscience. Students will be trained to use geotechnologies and remote sensing as tools to address and solve social problems, contributing to the construction of a fairer and more inclusive country.

In addition, sensitive and responsible training will also involve an understanding of the limitations and ethical implications of using UAVs and geotechnologies. Students will be encouraged to reflect on issues such as privacy, data security, inclusion and community participation. This will empower them to make informed and ethical decisions when employing these technologies in their future projects and research.

Therefore, by adopting this expanded and conscious perspective, it will be possible to train students and researchers committed to the responsible and transformative application of geotechnologies and remote sensing embedded in UAVs. This integral training will contribute to the construction of a more engaged academic body prepared to face the country's social challenges, bringing real and lasting benefits to the most vulnerable communities.

## 4 CONCLUSIONS

The areas of irregular settlements, in their majority, present challenging characteristics, such as housing density, precarious constructions and environmental problems, such as flooding and risks of

landslides. In addition, the roads in these areas often have irregular layouts and dimensions that hinder the movement of vehicles. In this context, planialtimetric and cadastral surveys play a fundamental role in the development of projects aimed at the legal and urban adequacy of these settlements.

With a solid base of collected data, it is possible to obtain better results in the projects, with more appropriate and economically viable solutions. According to Federal Law 13,465/2017, it is necessary a precise survey of the areas occupied by the buildings, delimitation of the lots, in addition to the characterization of the topography and materiality of the occupied place for the purposes of land regularization. Likewise, for the development of urban projects aimed at improving access to drainage and sanitation services, a precise survey of road layouts and topography is necessary to identify areas of flooding and environmental conflicts.

However, conducting a "traditional" planialtimetric and cadastral survey can be extremely challenging in areas of precarious settlements. The difficulty of access to certain locations, including flooded areas and the interior of the lots, as well as the complexity in characterizing various aspects during the field survey, makes the aerial survey by UAVs the most appropriate option.

It is important to emphasize that the work of technical advisors with housing movements can advance both in technical and political aspects with the use of technologies that allow a better understanding of the territory and the effective participation of communities. The use of low-cost survey technologies allows obtaining accurate data that serve as a basis for the development of discussions related to political strategies of permanence in areas at risk of removal, as well as for discussions and monitoring of self-managed works.

These technological tools also provide greater autonomy to architects and residents, allowing greater participation in the process of constitution of the project and in the reversal of the role of technology in society. The development of scientific research in universities on technologies that can contribute to this process is fundamental to advance in actions that promote greater autonomy and solidity to technical advisories and social movements, resulting in political actions that seek to modify reality.

In addition, the use of UAVs to collect more accurate and up-to-date territorial information can be a powerful tool to counter the arguments presented by the government in processes of removal of favela residents. Environmental or risk justifications are often presented, when in fact these communities are victims of real estate speculation. With reliable territorial information, professionals and communities can discuss the importance of the permanence of communities and present more precise technical arguments in defense of their rights.

In summary, the option for aerial survey with UAVs may represent a technical and political advance in the development of works aimed at the land regularization and urbanization of precarious settlements. It is essential that this advance be accompanied by other actions that promote the

participation and awareness of residents, as well as the reversal of the modes of housing production and the production of spatial information about these territories. Only in this way will it be possible to achieve the emancipation of political consciousness and seek significant transformations in the reality of marginalized communities.

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