


GEOGRAPHY

The Challenge of Pricing Georeferencing Services for Rural Properties: A Critical Review

A Dificuldade na Precificação de Trabalhos de Georreferenciamento de Imóveis Rurais: Uma Revisão Crítica

Rodrigo Fantin Xavier da Silveira¹ , Caio dos Anjos Paiva¹  & Adriano Ávila Goulart² 

¹ Universidade Federal do Paraná, Departamento de Geomática, Curitiba, PR, Brasil

² Universidade Federal do Paraná, Laboratório de Geoprocessamento e Estudos Ambientais, Curitiba, PR, Brasil

E-mails: rodrigofantin@ufpr.br; anjospaiva@ufpr.br; adriano.goulart@ufpr.br

Abstract

This article reflects on the barriers faced in determining prices for georeferencing services for rural properties in Brazil. The lack of widely accepted objective criteria creates difficulties for both professionals in the field and landowners. Throughout the text, a review of the Georeferencing of Rural Properties and its evolution over the years is conducted, analyzing conventional pricing methodologies and their limitations. It highlights that the time required for service execution is a fundamental element in defining fair values to be charged or paid. The research suggests that the predictability of work time should be the primary factor in formulating more accurate prices, recommending the viability of a geospatial model, which will be addressed in a future article.

Keywords: Surveying Services; Price Determination; Execution Time

Resumo

Este artigo apresenta uma reflexão sobre as barreiras enfrentadas na determinação de preços para serviços de georreferenciamento de propriedades rurais no Brasil. A falta de critérios objetivos amplamente aceitos gera dificuldades tanto para os profissionais da área quanto para os contratantes e proprietários das terras. Ao longo do texto é realizada uma revisão sobre o Georreferenciamento de Imóveis Rurais e sua evolução com o passar dos anos, são analisadas as metodologias convencionais de precificação e suas limitações, destacando que o tempo necessário para a execução do serviço é um elemento fundamental na definição de valores justos a serem cobrados ou pagos. A pesquisa indica que a previsibilidade do tempo de trabalho deve ser o principal elemento na formulação de preços mais acurados, sugerindo a viabilidade de um modelo geoespacial, que será abordado em um artigo futuro.

Palavras-chave: Serviços de Topografia; Determinação de Preço; Tempo de Execução

1 Introduction

Georeferencing of Rural Properties (GIR), created with the aim of land organization, is fundamental for land regularization in Brazil, as presented by Law 10,267/2001, known as the “Rural Properties Georeferencing Law” (Brazil 2002). This legislation established the need for georeferencing as a requirement for the registration of rural properties in the National Register of Rural Properties (CNIR). The main objective of this regulation is to ensure accuracy in defining the boundaries of rural properties, preventing overlaps and providing greater legal security for both owners and the State.

According to Toledo and Bertotti (2014), National Institute of Colonization and Agrarian Reform (INCRA) established new rules for land regularization aiming to unify and ensure the precision of the CNIR. The basis for these guidelines is the 3rd Technical Norm for Georeferencing (3rd NTGIR), which defines the technical standards and the new concept of ‘rural property’ to be followed. To detail the procedures, the norm is supplemented by two technical manuals: one focused on geographic positioning and the other on defining the property’s boundaries and confrontations.

The tool that operates this entire system is the Land Management System (SIGEF), an online platform that

automates data validation and property certification in an agile and efficient manner (Toledo & Bertotti 2014).

According to Santos (2022), the collaboration between INCRA and the Real Estate Registry Office (CRI) is crucial because it involves the supervision of a qualified and trained professional to carry out the measurement of rural properties.

According to Duarte et al. (2022), GIR is vital for complementing legal security and effective management of rural areas, directly contributing to the agrarian and territorial progress of the country. However, the evaluation of the costs of these services still presents gaps due to the lack of uniform criteria and the complexity of the variables involved in the process, which, in turn, influence the prices throughout the process (Duarte et al. 2022).

Also, Felipetto et al. (2023), emphasize that from the perspective of Surveying and Cartography, Georeferencing is the process of determining the positions of points on the earth's surface based on their three-dimensional coordinates (X, Y, Z) or through geodetic coordinates, such as latitude, longitude, and altitude, within a specific Reference System, in this case, SIRGAS 2000 used in Brazil. Based on this principle, it is feasible to establish the shape, size, and location of areas using various methods of geodetic and topographic survey.

According to Borges Júnior et al. (2017), the Local Geodetic System (SGL) is a unique reference system for each property, defined by a local cartesian plane with its origin at the centroid of the property's polygon. This plane is tangent to the Earth's surface at its origin, a characteristic that minimizes the area distortions commonly found in more extensive cartographic projections. The area calculation process is automated by SIGEF, the system first converts the geodetic coordinates of the property's vertices into the SGL and subsequently applies Gauss's Formula to determine the final area.

The obstacles encountered in pricing evaluation include the characteristics of the terrain, the logistics required to reach the measurement points, the expenses with appropriate equipment and technologies (Ok 2025). As well as the deadlines and requirements defined by INCRA. The lack of predictability in costs affects both the professionals responsible for carrying out the services and the clients, potentially also impacting bidding processes.

Thus, this article aims to conduct a literature review on the pricing of GIR services, highlighting the importance of forecasting execution time as a fundamental criterion in cost definition. Subsequently, the legal aspects supporting the GIR technique will be discussed, along with a brief history of GIR in the country and existing pricing methods and their challenges.

Some of these variables constitute real obstacles to those executing the GIR, consequently leading to variations in service pricing. Some common obstacles encountered in GIR include: landscape characteristics (steep slopes, wet areas, dense vegetation, to name a few), the logistics necessary to reach the measurement points, the expenses with appropriate equipment and technologies, as well as the deadlines and requirements set by INCRA. The lack of cost predictability affects both the professionals responsible for performing the services and the clients, which can also impact on the final pricing of bidding processes.

2 Georeferencing Importance and Regulation in Brazil

According to Figueiredo Filho, Disperati & Watzlawick (2003), the configuration of rural property in Brazil has undergone substantial changes with the growth of agribusiness, leading to a greater demand for effective management of rural areas. Law No. 10,267/2001 (Brazil 2002) introduced georeferencing and certification of rural properties, creating the CNIR, which, according to Fontes (2018), is a unified database of INCRA and the Federal Revenue Secretariat, allowing for the identification and sharing of rural property information. INCRA is the entity responsible for validating these certifications, ensuring that property boundaries comply with current legislation and prevent overlaps of these properties. Georeferencing not only provides a clear visualization of property boundaries but also enables the prevention of land conflicts, overlaps, and territorial disputes, especially in areas with a high concentration of rural properties (Fontes 2018; Felipetto et al. 2023).

According to Fontes (2018), the process of transcribing georeferenced data into property records serves as a subsidy for updating land bases and for the effectiveness of public policies aimed at land distribution and access to land.

Thus, according to Fontes (2018), when carried out properly, GIR can ensure the legality of rural properties and have economic and social relevance, serving as a subsidy for land regularization and territorial management. Land regularization, in turn, facilitates access to rural financing, promotes local economic growth, and helps minimize conflicts related to land ownership. However, for the process to be effective, it is vital that these services are performed with adequate technical precision, involving reputable professionals, avoiding overlaps of areas, and ensuring that costs are consistent with the reality of each service based on the region in which they are carried out.

In addition to the “Rural Properties Georeferencing Law”, it is worth noting that other laws, decrees, and regulations complement and highlight GIR, such as Law No. 6,015 (Brazil 1973), which provides for public records, and the Technical Standard NBR 13.133 (ABNT 1994), to name a few (Santos 2022).

Georeferencing goes beyond a normative technical procedure; it is the fundamental basis for the Rural Registry. In several countries, such as Germany, Netherlands, and Switzerland, this cadastral base is used to keep reference mappings updated, providing support for public infrastructure projects. In Brazil, this practice becomes even more relevant, considering that only 5.5% of the national territory has mapping at a scale of 1:25,000 (Sluter et al. 2018). Furthermore, there is a divergence in this mapping process, as urban mapping is carried out by IBGE and DSG, while rural mapping is responsibility of INCRA and CNIR.

Georeferencing plays a crucial role in publicizing and guaranteeing the right to property, facilitating the identification of area overlaps and thereby preventing land conflicts, irregular occupations, and protecting conservation areas

3 Georeferencing Evolution and History

Topographic surveys have several purposes, such as verifying areas for buying and selling, opening land records, amicable divisions, reopening boundary lines, and land use surveys, among others (Figueiredo Filho, Disperati & Watzlawick 2003).

With the advancement of geotechnologies, the Global Positioning System (GPS) has become an essential tool in topographic surveys, complementing or even replacing traditional methods that use theodolites or total stations. This technology facilitates the acquisition of geographic coordinates and the creation of digital and georeferenced maps, providing greater efficiency in fieldwork. However, its performance can be affected by environmental factors, such as the presence of dense vegetation cover, which interferes with signal accuracy. The integration of Differential Global Positioning System (DGPS) receivers with total stations has significantly improved the reliability of surveys, ensuring greater accuracy in land management and contributing to the security and precision of geospatial information (Figueiredo Filho, Disperati & Watzlawick 2003).

According to Santos (2022), until 2001, as land records and/or transcriptions did not establish precision and were insufficient to determine the location of property vertices, property transactions were only registered in Notary Offices, with the possibility of judicial rectification of inconsistencies until 2003. According to the aforementioned

author, property owners were responsible for updating the registration with INCRA, while the surveyor was responsible for the positional quality and uncertainty of the measured vertices.

Thus, INCRA was unable to produce a mosaic of the set of properties due to the lack of standardization of existing surveys and data (Santos 2022).

According to Toledo and Bertotti (2014), the promulgation of Law 10.267/2001 (Brazil, 2002) represented a turning point, as it established norms for georeferencing and instituted the need for certification by the INCRA, instituting the georeferencing of rural properties and the integration of land data with other federal agencies. This process has undergone significant transformations over the years, utilizing new information technologies that have made the Georeferencing of Rural Properties (GIR) more automated and efficient. The implementation of the 3rd NTGIR (INCRA 2013) and SIGEF represents an important milestone in this scenario, facilitating the mapping of rural territory and increasing the technical responsibility of the professionals involved, who must constantly update their knowledge to ensure survey accuracy and the quality of the certification process.

According to Ballar (2021), until 2013, this procedure was done manually and consumed a considerable amount of time; after that date, with the creation of SIGEF, the process was digitalized, improving efficiency and reducing the certification timeframe. With the combination of INCRA and CNIR through SIGEF, more than 40 million hectares were certified in the first ten months of the tool's operation.

SIGEF is an electronic tool developed by INCRA to support land governance in Brazilian territory. Through it, the reception, validation, organization, regularization, and availability of georeferenced information on the boundaries of rural properties, both public and private, are carried out. Through SIGEF, the certification of data regarding the boundaries of rural properties and the management of georeferencing service contracts with public administration are performed (INCRA 2022).

Due to management by SIGEF and INCRA's regulation of GIR, it is feasible to associate the relevance of time in defining the vertices for property certification and its influence on service evaluations. The digitalization provided by SIGEF not only increased the effectiveness of certification, significantly reducing the necessary time and improving accuracy, but also established technical standards through INCRA manuals (Ballar 2021).

Toledo and Bertotti (2014) commented that the 3rd NTGIR represented an advance not only in automation but also in the specification of field procedures, noting that the norm was supplemented by specific technical manuals, such

as the Technical Manual for Positioning and the Technical Manual for Boundaries and Confrontations, which detail how property limits are to be characterized. Furthermore, strict precision criteria that professionals must meet were established.

As detailed by Borges Júnior et al. (2017), the required positional precision for vertices varies according to their type and location: 50 cm for artificial boundaries, 3.0 m for natural boundaries, and 7.5 m for points in locations that are difficult to access or inaccessible (INCRA 2013).

This technical standardization is fundamental for the quality of data inserted into SIGEF and for the legal security and reliability of the national land registry, ensuring that no property overlaps occur (Toledo and Bertotti 2014; Borges Júnior et al. 2017).

The update of the Technical Manual for Georeferencing Rural Properties (MTGIR), according to Felipetto et al. (2023), aimed primarily to integrate new technologies and procedures, enhancing the guidelines of the first edition of the manual. In this context, a variety of techniques that can be applied in specific situations were incorporated, such as positioning by remote sensing via aerial photogrammetry, utilizing remotely piloted aircraft, such as Remotely Piloted Aircraft (RPAs), as well as airborne radar, airborne laser scanning, and orbital sensors on satellites.

For each adopted positioning method, the absolute positional accuracy of the coordinates of the vertices that delimit the rural property must be assessed. For this evaluation, orthomosaics and orthophotocartoons can be used, in addition to combinations with Digital Terrain Models (DTM), Digital Surface Models (DSM), or contour lines (Felipetto et al. 2023).

4 Current Pricing Methods

According to Bomfim and Passareli (2011), it is necessary to understand the cost structure, even if it is already defined by the market, as it is only possible to expand or improve profit margins if costs are reduced. The lack of knowledge about costing methods and the absence of a structured plan hinders the achievement of sustainable profit margins. This makes managerial education and the development of data-driven strategies for efficient pricing important (Purificação et al. 2022).

Price setting is an essential factor for any company or self-employed professional, ensuring profit in service provision. It also demonstrates, through financial indicators, the health of the company (Pissinati & Dias, 2022). Although a cost structure is indeed very important for profitability, the process must be well-structured with the personnel involved. This means that the employees of a

company should apply and reinforce, however tedious and exhausting it may be, the recording of everything that comes in and out, thereby providing knowledge of profit, as mentioned by Bomfim and Passareli (2011), and the formation of a fair price, as noted by Pissinati and Dias (2022).

Seeking other pricing alternatives involving more than one variable, Malaman and Amorim (2017) indicated that the combination of traditional and innovative approaches results in better estimates, and the pricing methods used for real estate valuation were Fuzzy Logic and the traditional Linear Regression method present in ABNT standards. It was found that the second method, Linear Regression, showed superior results for the sample used. According to Duarte et al. (2022), to seek a fair price for a service, one must estimate fixed costs (independent of service execution), variable costs (dependent on analysis, progression, and complete execution of the service), and profit margin (remuneration for executing the service). That said, it is beneficial for any company, regardless of size, when it maintains knowledge and balance of these factors.

Pricing products and services is an extremely important factor for companies, directly impacting profitability and competitiveness in the market. Additionally, Araújo et al. (2023), demonstrate that, although the issue of pricing is old, academia produces relevant studies that assist in formulating strategies for defining more efficient prices, both for products and services. Algorithms and statistical methods are effective in supporting pricing decisions, making the process more precise and adaptable to market changes, which are more complex due to cost variability and the influence of the digital environment in the case of services (Araújo et al. 2023).

Thus, as highlighted by Malaman and Amorim (2017), Duarte et al. (2022), and Araújo et al. (2023), it is emphasized that, even though there is no best method or single method that justifies or defines the best possible pricing, it is healthy for a company to seek an existing method or create one that brings them closer to a price that is more competitive in the market, for both products and services.

5 Challenges and Variables that Impact Pricing

As discussed so far, the definition of prices for GIR services is relative, due to the variables that tend to influence the cost and, consequently, the duration of the service. These factors range from studying the physical characteristics of properties to the regions where they are registered, changing considerably from state to state.

5.1 Landscape Characteristics

The quality of georeferenced surveys is directly related to a series of variables, including the type of equipment used, the density of vegetation cover, atmospheric conditions, and the desired accuracy. In open areas, GPS can efficiently replace conventional topography, but in forest regions, for example, signals can be degraded, compromising the accuracy of measurements (Figueiredo Filho, Disperati & Watzlawick 2003).

According to Ok (2025), landscape characteristics are a determining factor in topographic surveying, as the terrain governs the selection of the most appropriate method. For example, while RPA are particularly effective for surveying rugged terrain, their utility diminishes in areas with dense vegetation. In such conditions, traditional surveying methods are advised due to their greater reliability and accuracy (Ok 2025).

The characteristics of the terrain might be one of the most influential variables in price formulation. Aspects such as topography (comparing flat areas and mountainous regions), the presence and density of vegetation, and access to points of interest should be studied if they directly influence the time required to carry out the service.

These characteristics, such as irregular relief and/or dense vegetation, lead the technical team to traverse long distances under challenging conditions, hindering the functionality of equipment and increasing the execution time and consequently financial expenditures.

5.2 Infrastructure and Logistics

The road network of the area, the scope of the work, and the frequency of measurements also influence the choice of surveying methods (Figueiredo Filho, Disperati & Watzlawick 2003). The infrastructure of the region where the property is located is also one of the factors that influence pricing. The lack of proper roads or the need to transport equipment to remote locations impacts transportation and accommodation costs for the team.

The logistics involved in moving equipment, such as Global Navigation Satellite System (GNSS) receivers, drones, total stations, among others (Oliveira et al. 2024). Those types of equipment consume a considerable portion of the budget (both in terms of equipment acquisition and rental).

That said, it is possible to assess the impact that a high-quality road network can have, not only on the safety of those involved but also on the estimation of the service period, thus affecting pricing.

5.3 Technology and Equipment

The evolution of cartography has brought more sophisticated equipment, such as total stations, GPS devices, and post-processing software, which allow for greater error control and precision in results. Although the decision on which tools to use should consider a balance between accuracy and operational costs, as well as the good sense and experience of the professional (Figueiredo Filho, Disperati & Watzlawick 2003).

Emphasizing the importance of Real Time Kinematic (RTK) GNSS, Rohr (2023) shows that this is the most reliable methodology for georeferencing, as it involves the determination of altimetric data in projects that require precision and encounter constant obstructions, such as in rural areas where there is dense vegetation, for example.

The selection of a topographic surveying methodology is a critical decision. As compared for by Ok (2025), conventional methods, such as Total Station and GNSS, offer superior precision and reduced initial equipment costs. These techniques are well-suited for projects requiring sub-centimeter accuracy in localized and accessible areas. Conversely, technologies like RPA demand higher initial investment in both equipment and software. However, they prove more economical for larger-scale projects and those in difficult-to-access terrains by significantly reducing time in the field (Ok 2025). Therefore, acquisition and maintenance costs are expenditures that must be considered in price formation. Furthermore, the choice of technology must also account for the project's complexity and specific requirements.

Technological progress has brought new options for georeferencing, if they are allowed by regulations and achieve the necessary precision, such as drones and image processing software, which offer greater effectiveness in data collection, impacting pricing.

5.4 Bureaucratic Requirements and Deadlines

The complexity of the process is due to the technical regulations of INCRA, which include the use of SIGEF for certification. The presentation of documents and the frequent need for adjustments to meet regulatory requirements can extend deadlines and incur unexpected expenses for all parties involved. Furthermore, adherence to deadlines required by contractors or regulatory institutions demands meticulous planning, especially in larger or more complex projects.

In this case, although it may seem to qualify as a fixed cost due to having a specific deadline or a possible

return for document reappropriation, it is considered a variable cost since, in some cases, it must account for an extrapolation of this date/deadline or the final return of documents.

5.5 Regional Variability

Brazilian territory helps to influence price variations between different regions. Aspects such as climate, population density, cost of living, and availability of specialized labor can make certain services considerably more expensive in some locations. According to Oliveira and Piccinini (2011), in the constitutional theory of the labor market, training and remuneration do not follow the logic of competence or market dynamics. Medium and large companies tend to set rules, such as preparing employees for specific positions, how to pay them, their roles, and promotions. Professions and trades are guided by institutional rules rather than supply and demand.

According to Veloso (1992), the state of Paraná is composed of two different biomes: tropical rain forest (Atlantic Forest) and savana (Cerrado).

The first biome is made up of different physical contexts, both in physical and economic, social, and cultural aspects. Climates shift from dry to rainy at different times of the year, as well as the high variation in altitudes throughout the state (Santos 2022).

These factors, combined with the lack of scientific literature addressing these challenges, highlight how complicated the process of setting prices is, where cost diversification makes it challenging to standardize prices and increases the demand for predictive models that take these regional disparities into account. Therefore, the price of a GIR service in the metropolitan area of Curitiba/PR will differ from that in Sorriso/MT, even if the size of the property and the number of markers are identical, for example.

These difficulties illustrate how complicated the process of price determination is and further emphasize the importance of methods that integrate technical, economic, logistical, and primarily physical factors. The application of models that treat time as a fundamental element can provide better forecasting and accuracy in expense evaluation, ensuring competitiveness and clarity in the georeferencing sector.

5.6 Level of Professional Experience

According to Silva et al. (2017), because a large portion of the professionals surveyed were unaware of the correct asepsis procedure, the outcome for the patients

could have been much more favorable. This factor, among others, led managers to plan improvement measures, such as training courses and health education.

The relationship between professional experience and self-perception of competence is related to the development of skills in the workplace, as practical experience not only enriches technical knowledge but also increases the professional's confidence and adaptability in the face of challenges. According to Batista, Matos, and Graça (2011), more experienced professionals tend to reflect critically on their experiences, which enables them to integrate new learnings into their daily practice. Competence should therefore be understood in a multidimensional way, encompassing not only formal knowledge but also the informal learnings that arises from daily interactions and practices.

Thus, it is possible to see that the level of experience, both professional, as addressed by Silva et al. (2017), and lived experiences, as highlighted by Batista, Matos, and Graça (2011), can positively influence and predict outcomes.

6 Existing Works of Topographic Services Prices Review

Research on price assessment for georeferencing services in Brazil is quite limited, especially regarding standardized and predictive models that take regional and technical particularities into account. In many cases, pricing is carried out empirically. However, some investigations present methods and approaches that help understand the variables at play and develop more efficient strategies.

6.1 Pricing Methodologies Studies

Gazola (2002) suggests the implementation of regression models to analyze costs, linking the variables involved in the methodology, from data collection to exploratory analysis and finally to model adjustment and applicability to new data. By defining a methodology, it is possible to anticipate costs based on controllable variables, such as logistics and physical characteristics of the terrain, allowing for a more accurate prediction of service execution.

The study by Lorenzi and Rosa (2007) addresses cost control in service-providing companies, emphasizing the complexity of pricing due to the different natures of the services, whether repetitive or specific. It highlights the importance of proper allocation of direct and indirect costs, considering factors such as labor, materials, and organizational structure, among others.

The proposal from Lorenzi and Rosa (2007) was the implementation of the Activity-Based Costing (ABC)

method in a surveying company, aimed at accurately assigning costs to each executed activity. The detailed inventory of direct and indirect costs, identification of cost drivers, and analysis of the relationship between activities and expense generation allowed for greater financial transparency and control.

The provision of surveying services requires a high level of precision and quality to ensure the efficiency of the surveys performed. However, companies operating in this sector face challenges related to rework, which directly impact productivity and pricing. Cunha, Nascimento and Parreira (2014) highlight that rework in small surveying companies may be caused by internal communication problems, failures in understanding the scope, and a lack of organizational meetings. These factors generate waste of time and resources, affecting project profitability and the company's competitiveness in the market.

Rework not only compromises the timely delivery of services but also elevates operational costs, as it requires repetition of previously executed stages. According to the Pareto analysis conducted in the study by Cunha, Nascimento, and Parreira (2014), 90.48% of the causes of rework are related to a lack of information between company sectors, communication failures with the client, and errors in technical documentation.

These problems directly impact service pricing, as the need to redo something compromises profit margins and hinders budget forecasting. The application of management methodologies, such as the Plan-Do-Check-Act (PDCA) cycle, is suggested as a strategy to minimize rework and enhance the organization of internal processes. This approach helps standardize activities, mitigate failures, and ensure compliance with surveying services. Moreover, implementing quality tools, such as checklists and control forms, proves to be effective in reducing operational inconsistencies without the need for large financial investments. Thus, adopting these practices can significantly contribute to the proper pricing of georeferencing services, ensuring greater cost predictability and competitiveness in the sector (Cunha, Nascimento & Parreira 2014).

Implementing a costing method, as done by Lorenzi and Rosa (2007), can be effective in determining the actual costs of services and assisting in specific decision-making. Differentiating between types of services influences price formulation and cost categorization, making the choice of an efficient costing system highly relevant. Similarly, as conducted by Cunha, Nascimento, and Parreira (2014), a methodology was applied to evaluate elements that were causing financial distortions from what was planned.

6.2 Comparative Analysis of RPA Methodologies

In the global context, the use of technologies such as RPA and satellite imagery is widely adopted to reduce expenses in topographic surveys. Barros and Silva (2019) examine the cost-benefit ratio of using RPAs in the georeferencing of rural properties in Brazil, showing that, although the initial investment is considerable, the reduction in execution time and the need for labor justifies the costs over time, reducing rework and providing services with higher quality and lower costs.

Another methodology followed by Chicati et al. (2019) utilizes images obtained through RPA (photogrammetric coverage) for surveying natural boundaries in hard-to-reach areas, comparing them with data from the same vertices surveyed using GNSS/RTK positioning. They found that the values obtained with the orthophoto are within the precision required by NTGIR for natural or inaccessible boundaries.

On the other hand, Ferreira (2019) emphasize the use of RPA instead of Total Stations when comparing the time difference in obtaining points on a desired surface. Due to this comparison, it was established that using images or point clouds is more advantageous for this type of survey.

The comparison between traditional and contemporary methods highlights the importance of models that adjust pricing to local conditions, which is especially significant in large nations like Brazil.

6.3 Main Gaps and Opportunities

Although the available studies provide relevant contributions, there are notable gaps in the literature, particularly regarding the integration of technical, economic, and logistical variables into pricing models. Additionally, few studies investigate the impact of aspects such as seasonality, climatic conditions, and local infrastructure on cost formation.

According to Fontes (2018), the current certification of rural properties has changed the way qualified professionals conduct these certifications, leading to different interpretations and increasing the need for research on the correct application of legislation.

A promising opportunity lies in the development of predictive models based on spatial statistics, as indicated by Pimenta (2021).

These models can incorporate factors such as terrain characteristics, the distance between vertices, and estimated execution time, providing greater accuracy in price

determination and consequently aiding the competitiveness of professionals and companies in the georeferencing sector.

7 Time as Pricing Main Factor

The duration of a georeferencing project is an influential aspect in calculating its costs. Estimating the time required for each phase of the work helps professionals establish more accurate prices, minimizing uncertainties and improving the allocation of human and technological resources.

7.1 Relationship Between Time and Cost

According to Alves, Varotto and Gonçalves (2012), a quantitative-descriptive approach was used to investigate the prices and pricing methods used by retailers in São Paulo. The research was conducted through a survey with a non-probabilistic and convenience sample, considering establishments in the region in 2011, involving 35 individuals.

The pricing methods were classified into three categories: cost-based methods of the provider, customer expectation-based methods, and market competition-based methods. The research found a predominance in the use of traditional cost methods rather than customer-oriented approaches (Alves, Varotto & Gonçalves 2012).

That said, it is possible to seek a pricing methodology for services and surveying aimed at maximizing profits, market competitiveness, and customer loyalty. The analysis of pricing methods should include approaches such as cost analysis (considering equipment and labor), competitive pricing (evaluating competitor rates), and value-based pricing (considering the perceived benefit to customers). According to Souza and Peixe (2019), the need for systematic mapping of costs associated with service provision is highlighted, which serves as a basis for constructing a pricing structure that reflects the economic reality of operations.

Implementing an efficient pricing methodology in the surveying sector can significantly benefit from the analysis of actual data from previous projects, like what was conducted in hospitality sector research. The meticulous collection and analysis of direct costs, such as materials and labor, and indirect costs, which encompass administrative and tax expenses, are fundamental to ensuring a comprehensive assessment of expenditures (Souza & Peixe 2019). Thus, adopting a descriptive method that combines theoretical analysis and empirical case studies allows for a detailed assessment of the variables impacting both the cost and the execution time of surveying services,

promoting a more precise understanding of the market dynamics and pricing.

Moreover, incorporating an adequate profit margin structure through the markup method is essential to ensure that the prices charged not only cover operational costs but also sustain the financial viability of the business. Effective management of costs and expenses becomes a strategic tool, with the recommendation to implement control and planning systems that facilitate the comparison between actual and projected costs (Souza & Peixe 2019). This integrated approach not only optimizes pricing setting but also contributes to the competitiveness and economic sustainability of the surveying sector, similar to what is observed in hospitality.

As suggested by Tinoco and Silva (2019), the methodology can be defined through the analysis of Electronic Consumer Invoices (NFC-e) as data sources. It is also suggested to identify categories and average prices for each category, a model that considers variables such as service demand, associated costs (transportation, for example), and competition.

Thus, it is possible to link with surveying expenses, controlling the expense invoices, as well as categorizing each type of service by area and location executed and the average price to be paid/received for them. Validating the methodology and model is important to verify their reality with market acceptance and what was actually spent, consequently adjusting values to be both competitive and fair (Tinoco & Silva 2019). Similarly, this evaluation model can be replicated for surveying and GIR services, where the final values of the model can be adjusted to the market reality, making them more competitive.

7.2 Time and Service Complexity

According to Fontes (2018), due to the hierarchy among regulations and the need to conduct registrations and notations in a manner that respects the laws involved in the certification process of rural properties. Furthermore, the complexity of services is affected by changes in existing laws.

The integration of technical documents into existing records, due to particularities and requirements, in addition to the need for information to be understood and accepted by the registries, each having its own requirements, increases the difficulty and delivery time of the necessary documents (Fontes 2018).

The complexity increases when considering the integration of these documents into existing registration systems, which may have their own particularities and requirements. Moreover, the need to ensure that this information is understood and accepted by various registries,

often differing in their practices, adds an additional element of difficulty.

In the state of Paraná alone, biomes such as the tropical rainforest (Atlantic Forest) and savana (Cerrado), which present very different physical and cultural characteristics, can be found (Veloso 1992). The predominant climate is subtropical and temperate, with the possibility of rain in the summer and undefined dry periods (Maack 2012).

There are high range in altitudes, as in Guarapuava/PR, for example (Santos 2022).

This complex scenario, presenting a diversity of conditions, may influence not only the time taken to conduct field surveys but also the necessary mobility in these regions.

Initially, Duarte et al. (2022) emphasize the necessity of conducting a survey on the legal registration status of the property, which involves obtaining an updated certificate from the competent Real Estate Registry Office (CRI). For land regularization, the CRI establishes a series of judicial or extrajudicial requirements, as per public registration legislation, that the owner or possessor of the property must follow. If the registration is regularized, the CRI will issue a document that outlines the steps to be followed and lists all necessary documentation for the process.

In developing the execution of the georeferencing of rural properties, based on the norms and legislation established by INCRA, compliance with various requirements is essential, including the submission of specific files and documents (Duarte et al. 2022).

7.3 Predictive Models Importance

According to Rêgo and Pena (2012), spatial regression is fundamental for understanding and representing spatial dependence, using observed data from nearby areas to predict or explain phenomena in regions that have not yet been analyzed. Spatial regression models, such as the Spatial Regressive Model (SAR), Spatial Error Model (SEM), and the General Spatial Model (SAC), are used for this representation.

The SAR model considers the dependence between variables, quantifying it concerning their neighbors and covariates, while the SEM derives information from the random error dependency of the model. The SAC is a generalization of the previous models, effective in contexts of high spatial dependence. The SAR is preferred in situations of spatial dependence, although the SEM is relevant when multiple parameters are considered. In a

study conducted by the authors, the SAR and SEM models were applied to evaluate the spatial dependence between vertices, with the possibility of incorporating the SAC for quality comparison if strong spatial dependence is identified in the variables analyzed (Rego & Pena 2012).

In a comparative analysis of three methods of spatial inference, Lombardi (2001) investigates the use of the Analytical Hierarchy Process (AHP), Boolean logic, and Fuzzy Gamma for generating maps of areas of interest. The integration of thematic and numerical maps through these methods resulted in the creation of a synthesis map, which provides a comprehensive and efficient view of the situation, essential for effective decision-making.

The AHP method stood out for its objectivity in spatializing areas, using the weighting of variables such as land use, slope, road network, and drainage. In contrast, the Boolean approach proved inadequate as it treated all variables with equal importance, without clarifying the individual contributions of each in identifying the areas of interest. Thus, Lombardi (2001) emphasizes the importance of choosing the appropriate method, highlighting the superiority of AHP in spatial analysis (Lombardi 2001).

Pimenta, Ribeiro and Junior (2021) discuss and evaluate the use of statistical methods, such as linear regression, to increase municipal revenue, for example. The comparison of different regression models to estimate dependent variables demonstrated the effectiveness of considering spatial autocorrelation through more advanced models. The statistical analysis, especially multiple linear regression, allowed the construction of a Conventional Linear Regression Model (CLRM), reducing variables based on significance tests and utilizing cartographic data and real estate registries. The model's accuracy was evaluated according to the recommendations of the NBR 14.653-2 standard, through statistical tests. Applying this same methodology to the realm of georeferencing, it is possible to determine the time required to materialize vertices, for instance, in the delimitation of rural properties.

Each model responds appropriately, where the CLRM is efficient in predicting prices due to the normality of residues and autocorrelation of errors, and the Geographically Weighted Regression (GWR) considers spatial autocorrelation and spatial heterogeneity, making predictions where the dependence on the spatial variable influences the outcome more accurately. Therefore, when considering the geographical component, it is inevitable that a spatial regression model is used, thus obtaining reliability in the results and evaluating the influence of independent variables (Pimenta, Ribeiro & Junior 2021).

8 Conclusion

The evolution of Georeferencing of Rural Properties (GIR), both in procedures and data acquisition, in Brazil has been a milestone for land regularization, promoting legal security and efficient land management. With the increasing demand for organized agrarian practices, the importance of GIR has become evident, facilitating the precise definition of property boundaries and preventing conflicts of interest.

However, despite its relevance, the lack of clear and well-established parameters and methodologies for pricing georeferencing services poses a challenge. Cost assessment is often conducted empirically, leading to significant variations in prices charged for similar services in different regions. This reality highlights the absence of a consistent pricing model that considers the numerous variables involved, including land characteristics, logistical requirements, and regulatory demands.

The time required to perform the georeferencing service is one of the most relevant factors in price determination. The predictability of execution time not only helps professionals estimate more accurate costs but also serves as a basis for resource allocation. Unfortunately, the lack of a modeling approach that incorporates this variable, along with others that influence the service, undermines the formulation of fair and coherent prices.

Given this scenario, it is essential to harmonize the pricing criteria in the sector of georeferencing of rural properties. The creation of a standardized model that integrates the various necessary variables for cost definition is fundamental to promoting transparency and competitiveness in this market. With a systematic and well-defined approach, it will be possible to ensure that GIR services are evaluated fairly, benefiting both professionals in the field and landowners, as well as society as a whole.

9 References

- ABNT - Associação Brasileira de Normas Técnicas. 1994, *NBR 13133: Execução de levantamentos topográficos*, Rio de Janeiro, 35 p.
- Alves, C.A., Varotto, L.F. & Gonçalves, M.N. 2012, 'Objetivos e métodos de preço no varejo: estudo na zona sul de São Paulo', *Revista de Administração de Empresas*, vol. 52, no. 6, DOI:10.1590/s0034-75902012000600003
- Araújo, G.C., Gomes, V.A.P., Batista, B.C. & de Freitas, R.R. 2023, 'Precificação de Produtos e Serviços: Uma Análise Bibliométrica', *Revista Científica Foz*, vol. 6, no. 1, pp. 16-16.
- Ballar, V.C.M. 2021, 'Georreferenciamento de imóvel rural e processo de certificação via SIGEF: estudo de caso do CECA-UFAL', Undergraduate Thesis, Universidade Federal de Alagoas.
- Batista, P., Matos, Z. & Graça, A. 2011, 'Auto-percepção das competências profissionais em profissionais do desporto: efeito da área de intervenção e da experiência profissional', *E-balonmano.com: Revista de Ciencias del Deporte*, vol. 7, no. 2, pp. 117-131.
- Bomfim, E.A. & Passarelli, J. 2011, *Custos e formação de preços*, (7th ed.), IOB Thomson, São Paulo.
- Borges Júnior, C.R., Brito, J.L.S. & Schmidt, M.A.R. 2017, 'Estimativa de Área no Sistema Geodésico Local para Parcelas Rurais com Cálculo de Área Referenciado ao Sistema UTM', *Revista Brasileira de Cartografia*, vol. 69, no. 7, pp. 1411-1425.
- Brazil, 1973, *Lei n. 6.015 de 31 de dezembro de 1973*, Dispõe sobre Registros Públicos e dá outras providências, viewed 1 Jul. 2025, <https://www.planalto.gov.br/ccivil_03/leis/l6015compilada.htm>.
- Brazil, 2001, *Lei n° 10.267, de 28 de agosto de 2001*, Altera dispositivos das Leis n: os 4.947, de 6 de abril de 1966, 5.868, de 12 de dezembro de 1972, 6.015, de 31 de dezembro de 1973, 6.739, de 5 de dezembro de 1979, 9.393, de 19 de dezembro de 1996, e dá outras providências, viewed 1 Jul. 2025, <https://www.planalto.gov.br/ccivil_03/leis/leis_2001/l10267.htm>.
- Chicati, M.L., Neto, O.T., Nanni, M.R., Oliveira, R.B.D., Cézar, E. & Chicat, M.S. 2019, 'Uso de drones no georreferenciamento de imóveis rurais para levantamento de vértices de difícil acesso', *Simpósio Brasileiro de Sensoriamento Remoto*, vol. 19, pp. 283-286.
- Cunha, G., Nascimento, G.B. & Parreira, G.F. 2014, 'Propostas de melhorias na prestação de serviços de uma empresa de topografia a fim de reduzir os índices de retrabalho', *Ponta Grossa*, vol. 3, p. 9.
- De Souza, M.C. & Peixe, B.C.S. 2019, 'Custos para definir o preço das diárias da prestação de serviço da hotelaria: estudo empírico de caso aplicado', *Proceedings of Congresso Brasileiro de Custos-ABC*.
- Duarte, A.H., Affonso, M.R., Vicente, R.R. & Ribas, E.B. 2022, 'Proposta à execução de um georreferenciamento de A a Z em uma propriedade rural', *PARAMÉTRICA*, vol. 14, no. 2.
- Felipetto, H.S., Carvalho Granemann, D., Robson Elias, A. & Fernanda De Faveri Marquesine, M. 2023, 'Análise do Georreferenciamento de Imóveis Rurais (Lei nº 10.267/2001) na Região Sudoeste do Paraná (2001-2022)', *Revista Paranaense de Desenvolvimento*, vol. 44, no. 145.
- Ferreira, R.D.S. 2019, 'Estudo comparativo entre os métodos de levantamento fotogramétrico (VANT) e o topográfico (estação total) para cálculo de volume em uma mineração', Undergraduate Thesis, Universidade Federal de Alagoas.
- Figueiredo Filho, A., Disperati, A.A. & Watzlawick, L.F. 2003, 'Integração de geotecnologias como topografia, GPS e base cartográfica na empresa florestal', *RECEN-Revista Ciências Exatas e Naturais*, vol. 5, no. 2, pp. 187-199.
- Fontes, M.L. 2018, 'Certificação de imóveis rurais gerada pelo INCRA/SIGEF: transcrição da certificação em serviço de registro de imóveis', *Revista Brasileira de Geomática*, vol. 6, no. 3, DOI:10.3895/rbgeo.v6n3.7114
- Gazola, S. 2002, 'Construção de um modelo de regressão para avaliação de imóveis', Master dissertation, Universidade Federal de Santa Catarina.

- INCRA – Instituto Nacional de Colonização e Reforma Agrária. 2022, *Manual Técnico para Georreferenciamento de Imóveis Rurais – 2ª Edição*, Brasília-DF, viewed 1 Jul. 2025, <https://sigef.incra.gov.br/static/documentos/manual_geo_imoveis.pdf>.
- INCRA – Instituto Nacional de Colonização e Reforma Agrária. 2013, *Manual técnico de limites e confrontações: georreferenciamento de imóveis rurais*, Brasília, 24 p.
- Lombardi, R.J.R. 2001, 'Identificação de áreas vulneráveis à ocorrência de incêndios florestais, provocados por atividades antrópicas, utilizando diferentes métodos de inferência espacial', Instituto Nacional de Pesquisas Espaciais.
- Lorenzi, G.S.G. & Rosa, L.D. 2007, 'Controle de custos em uma empresa de topografia', Undergraduate Thesis, Universidade Federal de Santa Maria.
- Maack, R. 2012, *Geografia Física do Estado do Paraná*, 4 ed, Editora UEPG, Ponta Grossa, ISBN: 978-85-7798-140-3.
- Malaman, C.S. & Amorim, A. 2017, 'Método para determinação de valores na avaliação imobiliária: comparação entre o Modelo de Regressão Linear e Lógica Fuzzy', *Boletim de Ciências Geodésicas*, vol. 23, no. 1, pp. 87-100.
- Ok, E. 2025, 'A Comparative Study of Conventional Survey Methods and UAV Structure-from-Motion for Topographic Data Collection', viewed 01 Jul. 2025, <https://www.researchgate.net/profile/Emmanuel-Ok-2/publication/388178122_A_Comparative_Study_of_Conventional_Survey_Methods_and_UAV_Structure-from-Motion_for_Topographic_Data_Collection/links/678d7f9d82501639f5fcd9db/A-Comparative-Study-of-Conventional-Survey-Methods-and-UAV-Structure-from-Motion-for-Topographic-Data-Collection.pdf>.
- Oliveira, M., Goulart, A.Á., Borges, U., dos Anjos Paiva, C. & de Paula, E.V. 2024, 'Levantamento de campo voltados ao georreferenciamento de imóveis rurais: Experiências e ferramentas essenciais', *Continentes*, no. 24, pp. 36-59.
- Oliveira, S.R.D. & Piccinini, V.C. 2011, 'Mercado de trabalho: múltiplos (des) entendimentos', *Revista de administração pública*, vol. 45, pp. 1517-1538.
- Pimenta, F.S., Ribeiro, F.V. & Cruz Júnior, D.C. 2021, 'Modelagem de Regressão Espacial para Estimativa de Valores em Massa a partir de Cartografia Cadastral', *Revista Brasileira de Cartografia*, vol. 73, no. 1, DOI:10.14393/rbcv73n1-51484
- Pissinatti, L.G. & Dias, E. 2022, 'A margem de contribuição como métrica de precificação visando lucro para a empresa', *Revista Ibero-Americana de Humanidades, Ciências e Educação*, vol. 8, no. 10, DOI:10.51891/rease.v8i10.7491
- Purificação, É.F.D.S., Neves, S.D.S., Cavalheiro, R.T. & Conceição, G.P.M. 2022, 'Precificação no Contexto das Micro e Pequenas Empresas (MPes): Podemos Sofisticar ou Ainda Pecamos no Básico?', *Revista de Contabilidade e Controladoria*, vol. 14, no. 3, DOI: 10.5380/rcc.v14i3.84458
- Rêgo, C.V. & Pena, M.G. 2012, 'Análise dos modelos de regressão espacial SAR, SEM e SAC', Undergraduate Thesis, Universidade de Brasília, Brasília.
- Rohr, P.B. 2023, 'Comparação do erro altimétrico da aerofotogrametria com drone com o método de posicionamento RTK GNSS', Undergraduate Thesis, Universidade Federal de Santa Maria.
- Santos, L.A.D. 2022, 'Análise de dados e modelagem matemática aplicada ao georreferenciamento de imóveis rurais', Phd Thesis, Universidade de Brasília.
- Silva, T.T.D.S.C., Rodrigues, J.L.N., Amaral, G.P. & Peixoto Júnior, A.A. 2017, 'Conhecimento dos profissionais de enfermagem sobre sepse: estudo em um hospital universitário de Fortaleza/Ceará', *Revista de Medicina da UFC*, vol. 57, no. 3, pp. 24-29.
- Sluter, C.R., Camboim, S.P., Iescheck, A.L., Pereira, L.B., Castro, M.C., Yamada, M.M. & Araújo, V.S. 2018, 'A Proposal for topographic map symbols for large-scale maps of urban areas in Brazil', *The Cartographic Journal*, vol. 55, no. 4, pp. 362-377.
- Tinoco, B.S.S.V.C. & Silva, R.I. 2019, 'Uma Metodologia de Precificação Dinâmica para Produtos e Serviços em Smart Cities', Proceedings of 14º Simpósio Brasileiro de Automação Inteligente, DOI:10.17648/SBAI-2019-111535
- Toledo, B.H.C. & Bertotti, L.G. 2014, 'Breve histórico da certificação de imóveis rurais no Brasil e apresentação do Sistema de Gestão Fundiária-SIGEF Brief history of certification of rural properties in Brazil and presentation of Landed Property Management System-SIGEF', *Ambiência*, vol. 10, no. 3, pp. 839-847.
- Veloso, H.P. 1992, *Manual técnico da vegetação brasileira*, IBGE, Rio de Janeiro, ISBN: 978-85-240-4272-0.

Author contributions

Rodrigo Fantin Xavier da Silveira: conceptualization; formal analysis; methodology; validation; writing – original draft; writing review and editing. **Caio Anjos Paiva:** conceptualization; formal analysis; validation; writing review and editing. **Adriano Goulart:** formal analysis; writing review and editing.

Conflict of interest

The authors declare no potential conflict of interest.

Data availability statement

All data included in this study are publicly available in the literature.

Funding information

Not applicable.

Editor-in-chief

Dr. Claudine Dereczynski

Associate Editor

Dr. Gerson Cardoso da Silva Jr.

How to cite:

Silveira, R.F.X.; Paiva, C.A. & Goulart, A.Á. 2025, 'The Challenge of Pricing Georeferencing Services for Rural Properties: A Critical Review', *Anuário do Instituto de Geociências*, 48:67665. https://doi.org/10.11137/1982-3908_2025_48_67665