Revista ARACÊ
ISSN: 2358-2472

CROSS-PLATFORM APPLICATION FOR URBAN AFFORESTATION

https://doi.org/10.56238/arev7n2-162

Submitted on: 01/12/2025 **Publication date:** 02/12/2025

Leonardo Neves Barbosa Thaly[1], Henriqueta da Conceição Brito Nunes[2], Madson Barbosa Martins[3], Maria Isabele Tavares da Silva Araújo[4], Mateus Guilherme Cruz Serrão[5], Maycon Jhonanta Souza Sodré[6] and Pedro Paulo Lobato Vilhena Filho[7].

ABSTRACT

The urban forest includes trees planted on sidewalks, parks, squares, gardens, backyards, parking lots, cemeteries and urban forests, which is directly linked to the quality of life of the population, as it has numerous advantages such as: reduction of air pollution, shading, anti-stress paper, carbon sequestration and storage, etc. In this context, the objective of this research was to develop a multiplatform application, which can assist the managers of the Municipal Department of the Environment of Castanhal, directly responsible for the planning, follow-up and monitoring of urban afforestation. The application called UrbanTree, was developed on the no-code platform FluterFlow, which allows you to create applications for Android, IOS, and web browser operating systems. The Application was tested in partnership with the Municipal Department of the Environment (SEMMA) of the municipality of Castanhal/PA, where a sampling of the trees that make up the space of Praça do Estrela and Avenida Barão do Rio Branco was carried out. During the test, dendrometric data were collected, such as total height, height of the first fork, PAC, etc.; as well as phytosanitary data such as trunk inclination, crown quality, presence of hemiparasites, among others, which are essential for a good analysis of urban trees, such information collected is categorized into: location, morphology and photographic images of the species. During the usability of the application, the performance of the application was evaluated in terms of registration time, efficiency in data collection and ease of use compared to traditional collection models. In all, 131 trees were inventoried, of which 73 individuals were evaluated as excellent, 49 presented good condition and only 8 individuals were certified as very bad. Inventorying all the trees with the UrbanTree took 4 hours and 9 minutes, while with the field sheet it took 9 hours and 46 minutes, a saving of 53% in total work time. The partnership with SEMMA - Castanhal and the practical application of UrbanTree tends to represent a significant advance in the modernization of urban tree management processes, providing an effective tool that meets the practical needs of public

[1] University of the State of Pará
Natural Sciences and Technology Centre
[2] University of the State of Pará
Natural Sciences and Technology Centre
[3] University of the State of Pará
Natural Sciences and Technology Centre
[4] University of the State of Pará
Natural Sciences and Technology Centre
[5] University of the State of Pará
Natural Sciences and Technology Centre
[6] University of the State of Pará
Natural Sciences and Technology Centre
[7] University of the State of Pará
Natural Sciences and Technology Centre

Revista ARACÊ
ISSN: 2358-2472

entities, significantly reducing the time needed to transcribe the data collected, as this data can be automatically directed to the Google Sheets spreadsheet, which reduces the time for data analysis.

Keywords: Android. Urban forests. Urban forest inventory. Iphone Operating System (IOS). Mobile.

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

It is known that a large part of the world's population lives in cities, characterized by continuous construction and the existence of social equipment for basic urban functions, such as housing, work, recreation and circulation (CEMIG, 2015). However, this space, when built disorderly, can have consequences for the environment and the population, since the demands of cities have caused changes in land cover and the suppression or modification of vegetation due to the replacement by sewers, streets, parking lots, buildings and houses (Ribeiro, Pesqueiro, Coelho, 2015).

From this context, it can be seen that urban afforestation has been widely discussed, since it is directly linked to the quality of life of the population and such commitment to the socio-environmental environment, brings numerous advantages to the urban fabric, such as: anti-stress role, reduction of temperatures in cities, carbon sequestration and storage, among other benefits. However, it is important to highlight that afforestation is not just planting trees on public roads, squares, etc.; but rather, to understand that this is a challenging action and that it needs to be monitored and planned correctly to be successful.

In view of this, it is important to reflect on the interaction between information and communication technologies (ICTs) and afforestation, a theme that is still little explored and that has great potential for the planning and monitoring of urban trees. An interesting use of this type of technology aimed at the environment is the applications that map and report trees planted in urban areas. These are applications aimed at the junction between technology and sustainability, which is behind the concept of smart city: new forms of planning and landscape of urban centers with a view to a more sustainable environment (Molnar, 2017).

To this end, the development of an application called UrbanTree was initiated, with a view to offering effective functionalities in the management of urban forestation. One of its main features is the detailed registration of existing trees in the city, providing information such as species name, geographic location, phytosanitary status and morphological characteristics. In addition, the integration of different tools, such as GPS, camera and typing interface, helps to simplify and speed up the process of collecting and recording information, allowing detailed monitoring of urban afforestation, facilitating the identification of areas that need intervention or adequate planning for new plantings.

Revista ARACÊ
ISSN: 2358-2472

In addition to the features mentioned above, UrbanTree offers a page dedicated to books and articles about afforestation that are in the public domain, that is, they are free to be shared and downloaded on the internet. This provides users with access to a selection of works that address various aspects of urban forestry, such as tree species, planting techniques and necessary care. Another interesting feature of the app is the page that helps you choose trees to plant based on the desired height. Users can specify the height they want the tree to reach and thus choose the one that best fits the planting site.

It is considered that the application will facilitate the management of the afforestation of cities, because although there are costs associated with the acquisition and maintenance of mobile devices, as well as energy consumption, the use of the application can bring substantial benefits that go beyond mere paper savings. One of the main advantages is the optimization of time, since the application enables faster and more efficient data collection compared to traditional methods of paper and pen cards.

JUSTIFICATION

This research proposal arose from the concern with the city, as a preliminary study on the green areas of Castanhal, showed that there is a poor distribution of trees, and a greater concentration of trees and ornamental plants in some areas to the detriment of others, with a predominance of the species *Mangifera indica* L. in the green spaces (Oliveira *et al*, 2018). From this, it can be seen that the municipality of Castanhal needs interventions in afforestation, either for monitoring and/or introduction of new species, following the rules for the implementation of the appropriate species, aiming at the benefits that the trees will bring to the local community.

However, the efficient management of this afforestation often comes up against logistical and bureaucratic challenges that can compromise the effectiveness of planting, maintenance and analysis actions. The techniques used in the management of afforestation are complex in the informational aspect, that is, they have a vast amount of information that must be obtained and treated. Considering that the registration of information is usually done on paper registration forms, which is a process that significantly burdens the time of the professionals involved in the data collection work (Trindade *et al*, 2021).

In this context, the development of a multiplatform application is proposed as a viable solution to optimize and modernize the processes of planning, monitoring and

Revista ARACÊ
ISSN: 2358-2472

monitoring urban afforestation. The product of this Course Completion Work (TCC) not only highlights the intrinsic relevance of urban forestation, but also recognizes the transformative potential of technology in this scenario, especially in the era of smartphones and mobile applications. As argued by Zhang, Gupta and Mohapatra (2012), the introduction of smartphones has significantly increased the demand for data communication and applications have started to consume more mobile browsing time.

Therefore, this study seeks the development of an application that will simplify and accelerate the processes related to urban afforestation, allowing monitoring, efficient data collection and detailed analysis of tree conditions, becoming an indispensable tool for urban managers.

OBJECTIVES

GENERAL OBJECTIVE

Develop a multiplatform application for urban forestation, which assists public and private managers directly responsible for planning, monitoring and monitoring urban forests.

SPECIFIC OBJECTIVES

- Create intuitive interfaces in the application that allow the professionals involved to record information efficiently, replacing the use of paper registration forms and reducing the time dedicated to these tasks.
- Include information and guidance in the application on the most suitable species for certain areas, following specific standards and laws, in order to promote diversified and sustainable urban afforestation.
- Streamline the data collection process while minimizing the financial costs required compared to traditional urban tree inventory methods.
- Conduct a study of the use of UrbanTree to quantify and compare the time required to execute the tree inventory, compared to traditional methods, identifying efficiency and agility gains.

Revista ARACÊ
ISSN: 2358-2472

LITERATURE REVIEW

URBAN AFFORESTATION

Urban afforestation, throughout history, has evolved from an early practice linked to gardening in Egypt and religious rituals in China, while in Greece, green areas have taken on a public role, intended not only for walks but also for meetings and philosophical discussions. In Rome, these spaces were geared toward the pleasure of the financial elite. In the Middle Ages, green areas disappeared with the growth of cities, reappearing in the Renaissance as gigantic scenographies and, later, in Romanticism, becoming urban parks (Maciel; Barbosa, 2015; Sirvinskas, 2000).

In Brazil, the practice of urban afforestation began to gain prominence at the end of the eighteenth century, influenced by the European aesthetic profile. However, the focus was more on the economic potential of nature, serving the interests of the Portuguese crown. Only at the end of the twentieth century, there was a political and popular awakening to the creation of public parks (Maciel; Barbosa, 2015).

The importance of urban afforestation goes beyond the beautification of the landscape. It performs several crucial functions for cities, such as reducing the impact of stormwater, providing shade, promoting biodiversity, and improving air quality. In addition, it is directly related to the quality of life of the population, being considered one of the essential means for the sustainability and well-being of a region (Mullaney; Lucke; Trueman, 2015; Duarte et al., 2018).

In this context, the need for efficient planning and management of urban afforestation becomes evident. The lack of organization in cities regarding the planning and management of trees on urban roads is a highlighted challenge (Provenzi, 2008). The creation of inventories becomes a common practice in some cities, providing control over the species present in each municipality. In addition, considering trees as elements equivalent to other components of urban infrastructure highlights their importance and monetary value (Schallenberger; Machado, 2013; Duarte et al., 2018).

The inventories, by contemplating the amount of each species in the afforestation, offer accurate diagnoses, identifying problems and pointing out solutions. Data collection through continuous floristic inventories is essential to understand tree resources in cities, subsidizing actions aimed at the planning and maintenance of urban forests (Zambonato et al., 2021).

Revista ARACÊ
ISSN: 2358-2472

However, poor planning can lead to inconvenience, compromising the development of trees and affecting urban infrastructure. The lack of qualitative and quantitative information and parameters related to urban afforestation is one of the greatest challenges to urban environmental management (Teixeira, Silva, Tatsch, 2011; Brazil, 2021).

Therefore, urban afforestation in any space does not consist only of the act of planting trees. The collection of information and the execution of prior planning, the performance of adequate and constant management, management carried out in an integrated manner, are indispensable strategies to achieve better results in afforestation and provide benefits to the population.

MOBILE DEVICES AND APPLICATIONS

The history of transformation brought about by mobile devices begins with the industrial revolution, which expanded the human body through mechanical machinery. However, the contemporary era extends human minds through computing technology, amplifying the capacity for information processing (Moresi et al, 2018). Internet browsing, once confined to desktop computers connected to wired networks, has witnessed a significant shift with the popularization of laptops connected to Wi-Fi networks, ushering in a new era for mobile apps (Moresi et al, 2018).

In 2007, the launch of the iPhone and Android turned mobile phones into mobile computers, creating a propitious scenario for the development of millions of innovative applications. Smartphones have not only expanded their computing capabilities, but they have also introduced mobile operating systems, such as Android, developed by Google, and distributed as free and open source software. This shift has benefited tech companies looking for affordable and customizable products for high-tech devices (Moresi et al, 2018). Mobile internet access has become more accessible, along with the popularization of smartphones, transforming these devices into objects desired by a large part of the population (Banbini et al, 2014).

Mobile apps have become a reality, impacting the telecommunications industry. The demand for data communication has increased significantly with the proliferation of smartphones, as highlighted by Zhang, Gupta, and Mohapatra (2014). Mobile operating systems, such as Android and Iphone Operating System (iOS), offer new forms of user interaction through sensors, GPS, accelerometer, and virtual keyboards, presenting unique challenges in application development (Wasserman, 2010).

Revista ARACÊ
ISSN: 2358-2472

The presence of mobile devices in everyday life is crucial not only for individuals, but also for public and private companies, such as the Secretariats of the Environment. The limitless connectivity and mobility offered by these devices have transformed the way people access information, obtain services, and connect with the world around them (Moresi et al, 2018).

TECHNOLOGIES USED

Android System

In 2003, Android was conceived by Andy Rubin, Rich Miner, Nick Sears, and Chris White, and was later acquired by Google in 2005. This open source mobile operating system is based on version 2.6 of the Linux kernel, covering crucial functions such as security, memory management, processes, network stack, and driver model (Fraga, 2017).

Android development passed into the hands of the Open Handset Alliance (OHA) in 2007, a technology consortium made up of major companies including phone makers such as HTC, Sony, and Samsung, phone carriers such as Sprint Nextel and T-Mobile, and chipset manufacturers such as Qualcomm and Texas Instruments (OpenHeadsetAlliance, 2011). Google maintained its position in the consortium, continuing to oversee crucial stages of system development and process engineering (Google Inc, 2011).

One of Android's distinguishing advantages over iOS is its foundation on Linux, an open-source operating system. The Linux kernel makes it possible for multiple applications to run simultaneously, allowing third-party applications to operate in the background without impacting the user experience.

The Android platform, launched by Google in 2007 and currently maintained by the Open Handset alliance (OHA), is dedicated to mobile devices, being totally open and free (Open Source) (Silva, 2015). OHA companies such as Motorola, LG, Samsung, and Sony Ericsson collaborate to provide a development platform that empowers developers to deploy and extend applications from their mobile devices.

Android's success is the result of Google's continued investment and OHA's effective collaboration. The system, flexible and updatable, attracted Google's attention due to its purpose of offering an open platform to manufacturers, providing freedom and flexibility to the user (Simões; Pereira, 2014). The versatility of Android is evident in the user's ability to customize the device in a basic, mid-range, and advanced way. This partnership not only benefits end users, but also simplifies the work of mobile device

Revista ARACÊ
ISSN: 2358-2472

companies, allowing them to focus on hardware development, while the operating system remains free.

System Iphone Operating System - iOS

The iOS operating system, developed by Apple, is a milestone in the history of technology, launched in 2007 during the Macworld Conference & Expo. Descendant of iOS X, it is designed especially for devices such as iPhone, iPod touch, iPad and Apple TV. The architecture of iOS stands out for its four distinct layers, as described by Yates (2010).

The first layer, CocoaTouch, offers tools and infrastructure to implement events and applications into the iPhone interface, including frameworks for appearance, multitasking, touch-based input, and push notifications. Then, the Media layer is responsible for providing advanced audio and video capabilities, promoting an exceptional multimedia experience.

The third layer, Core Services, provides the fundamental system services, such as AdressBook, Core Location, CFNNetwork, Security, and SQLite, through frameworks such as Core Foundation and Foundation. Finally, the Core OS layer houses the system kernel, drivers, and basic interfaces, and is essential in security negotiations and communication with external hardware, such as Bluetooth.

iOS app development is predominantly carried out in Objective-C, a language that combines features of Smalltalk and C. However, Apple's introduction of the Swift language in 2014 brought significant improvements such as stronger typing, extensions, shorter and more secure methods, transforming the approach in iOS development (Habchi, 2017).

Despite the advantages offered by iOS, such as seamless integration with Apple devices, there are notable limitations. For example, the system does not allow third-party applications to run in the background, terminating the process by minimizing the application. This means that when you reopen the app, it restarts in the initial state, not the previous state of use.

Customization of iOS is restricted, as the development environment is exclusive to Mac computers running Mac OS X. However, the mobile platform is open source, providing developers with access to the operating system's code for modifications, such as changing screens, icons, and contact list design.

Therefore, iOS is more than an operating system; it is an immediate interaction experience for users, allowing intuitive actions through gestures, screen touches, and other

Revista ARACÊ
ISSN: 2358-2472

interactions (Simões; Pereira, 2014). The constant evolution, with the introduction of Swift and continuous improvements, highlights Apple's commitment to providing an efficient and innovative platform for its users (Apple Inc, 2011).

Flutter Programming Language

Flutter is a framework developed by Google first announced in 2015 in a presentation by Eric Seidel, the result of an experiment where they tried to remove compatibility support layers from the Chrome browser, trying to make it run faster. After a few weeks of testing, it was found that the test results processed twenty times faster than Chrome (Mainkar; Giordano, 2019).

In the official documentation, *Flutter* is defined as a portable UI toolkit from Google for creating beautiful, natively compiled apps for mobile, web, and desktop devices from a single codebase, thus enabling cross-platform development.

However, unlike other cross-platform languages, *Flutter* It doesn't have a list of components that have native-language equivalents, but it does have its own *Engine* rendering system, which allows a quick recompilation of only the components that have undergone changes, without the need to rebuild the entire application. In December 2018, version 1.0 was released *framework* as the first stable version of the tool, where there was a great adoption of the tool with thousands of applications being developed.

The development *Flutter* uses language *DART. DART*, which follows the C language model, is object-oriented, class-based, with the optional type system and with inheritances (Google, 2013; Bracha, 2015). Launched in 2011, initially developed with the aim of replacing the *JavaScript* as the main language embedded in web browsers. Due to its characteristics such as: development productivity; object orientation; high performance and fast allocation, made the Dart language the base language for coding applications using the Flutter framework.

Taking into account the characteristics mentioned above and the great growth of the technology, Flutter, together with the Dart language, proved to be a great option for the development of the application proposed by this work.

Revista ARACÊ
ISSN: 2358-2472

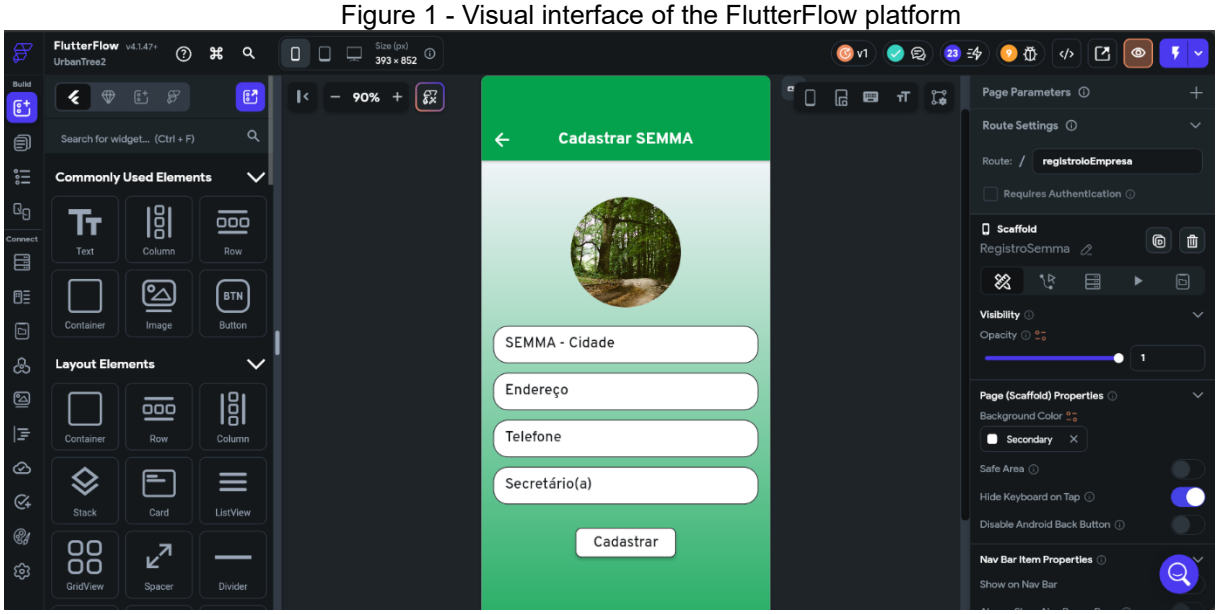
TECHNOLOGY EMPLOYED IN THE DEVELOPMENT OF THE APPLICATION

Front-End

The Front-End, or front part, is the highest-level programming layer that connects directly with the user, being the system interface. Its importance lies in the fact that it is the first contact with the user, being crucial to make a good initial impression. A well-built interface facilitates user access to all the features and functionalities of the application or system, preventing important functionalities from being hidden in unnecessary menus. Thus, the interface of a system must be designed to meet the needs of the majority of users.

In this sense, the development of the *Front-End* of the proposed application was carried out through the *FlutterFlow* platform (Figure 1) to ensure cross-platform compatibility, as it has the potential of the *Flutter* framework with a complementary drag-and-drop interface feature, allowing easy and effective code construction, even for citizen developers, facilitating the quick creation of mobile applications for designers, developers and entrepreneurs (Bacancy Technology, 2023).

Figure 1 - Visual interface of the FlutterFlow platform



Fonte: Site FlutterFlow, 2024.

The platform was created by two former Google developers, being presented at Google I/O and supported by Y Combinator (Gaio, 2022). This third-party visual app builder for the Flutter platform offers a visual approach to app creation, eliminating the need for coding. The visual tool provides efficiency in various industries, including healthcare,

Revista ARACÊ
ISSN: 2358-2472

banking, education, and technology, allowing for the development, management, customization, testing, and deployment of mobile applications with little to no code (Bonancy, 2023).

It then became an innovative app development platform, standing out by using Flutter technology, developed by Google, to create apps for iOS and Android in a visual and interactive way (Pedó et al, 2023). This browser-based platform goes beyond the traditional Flutter framework, featuring a third-party visual app builder that significantly speeds up the development process.

One of the crucial aspects that sets FlutterFlow apart is its ability to allow the construction of applications without the need for coding, thus, the platform becomes highly efficient in sectors such as healthcare, banking, education, technology, among others. This enables companies to reduce the time it takes to bring an app to market, contributing to a more agile and effective approach (Bonancy, 2023).

Additionally, the FlutterFlow community offers a variety of features, making it an exceptional choice for both ordinary citizens and traditional developers. Its extensive and exceptional drag-and-drop system makes it a preferred option for app development, providing an effective and personalized experience (Bonancy, 2023).

Finally, it is worth mentioning that Google's Flutter, a free and open-source framework, is the foundation behind FlutterFlow. This cross-platform framework allows for the creation of feature-rich native apps for iOS and Android from a single codebase. With the customization flexibility provided by Flutter, developers can create programs that offer a satisfying experience across different operating systems (Gaio, 2022).

During this process, intuitive interfaces were implemented to facilitate user interaction, including data collection functionalities, legislation, indication of species for planting, etc.

Back-End

The *Back-End* aims to deal with all internal processes, that is, everything that is executed in a transparent way to the user. Practically in this part of the system, there is no or very little interactivity with the user. These are lines of code that largely deal with the maintenance of databases, often installed on servers in the so-called cyber cloud.

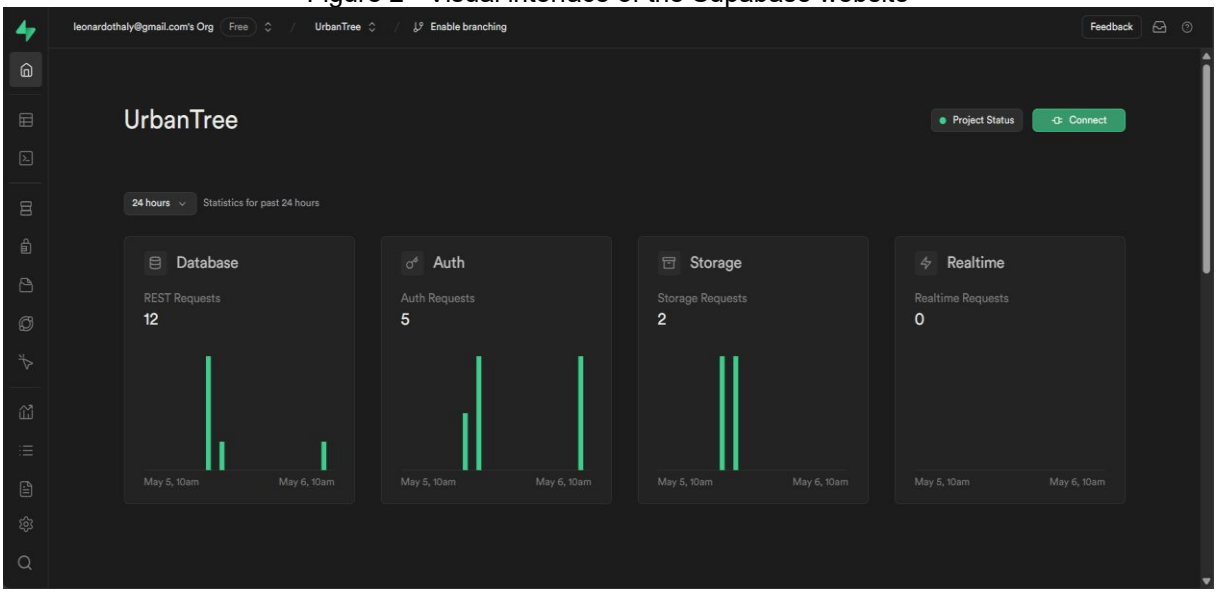
A database is an organized collection of interrelated data that represents information about a specific domain. There are different types of databases, the most common of which

Revista ARACÊ
ISSN: 2358-2472

are the relational database and the non-relational database. In the relational database, information is organized into tables, where each row represents a record with a unique primary key, and each column represents a field in the record. Data in different tables can have relationships, using foreign keys.

In this project, it was decided to use Supabase (Figure 2), a free and open source BaaS (Back-end as a Service) tool that meets the necessary requirements for the construction of the system. Supabase uses several technologies, such as Javascript, Typescript, Go, Elixir, Haskell, Tailwind, React, PostgREST, Pulumi, and Kong, among others.

Figure 2 - Visual interface of the Supabase website



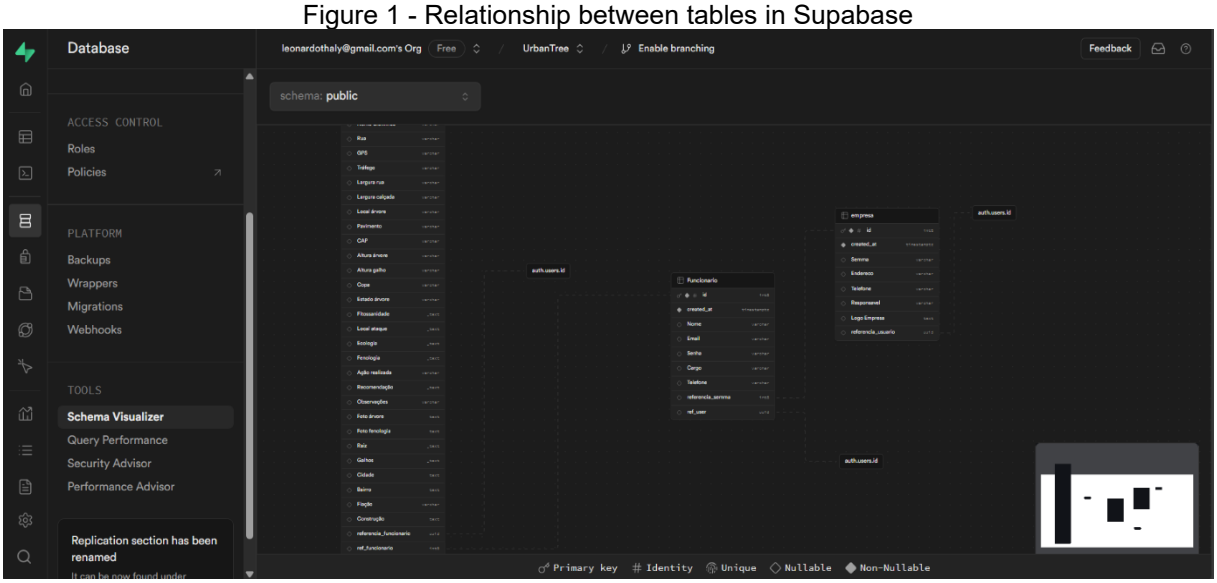
Fonte: Site Supabase, 2024.

What makes Supabase so interesting are the services and functionality it has, namely: authentication, real-time database, notification sending, analysis of data uses, etc. In this sense, managing the database, creating, deleting, changing tables, adding and removing policies through Supabase become quick and easy tasks to perform. In addition to bringing all the benefits of a PostgreSQL database with its robustness, it is fast, relational, and one of the most scalable databases out there.

Below, in Figure 3, you can see the relational diagram of how the UrbanTree application database was modeled.

Revista ARACÊ
ISSN: 2358-2472

Figure 1 - Relationship between tables in Supabase

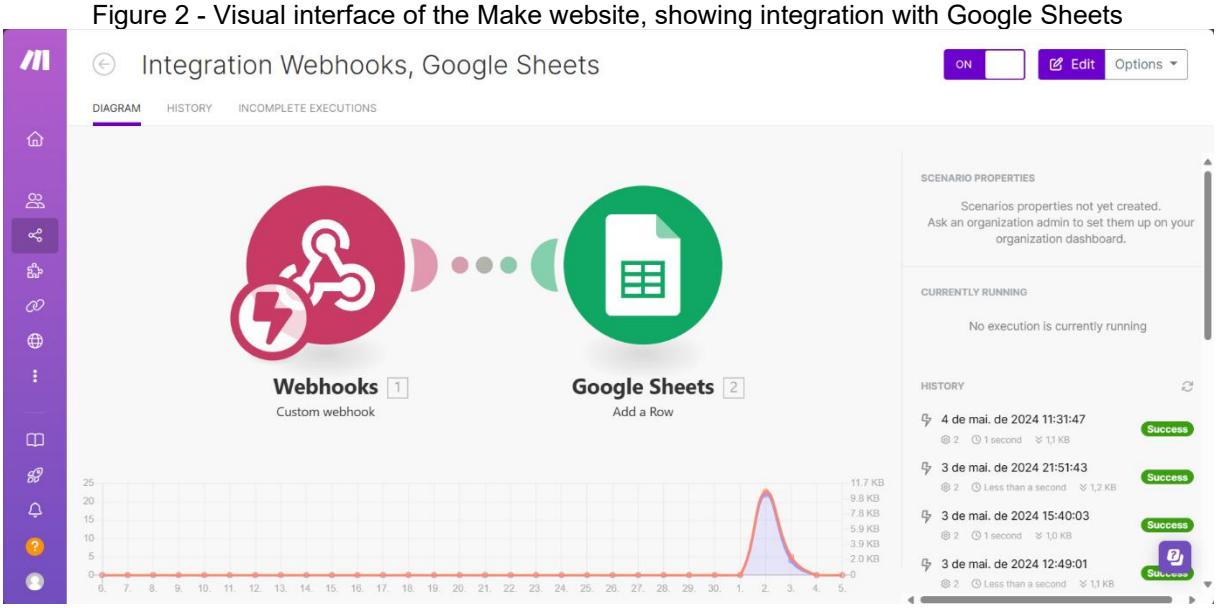


Source: Site Supabase, 2024.

A *well-built Back-End* contributes positively to an application and/or software with more responsiveness, fast updates, concise and efficient.

The Make Integration Site was also used to record the information in an Excel spreadsheet. Make (Figure 4) is a workflow integration and automation platform. It allows you to connect different applications and automate repetitive tasks without the need to write code, thanks to its visual builder.

Figure 2 - Visual interface of the Make website, showing integration with Google Sheets



Source: Site Mark, 2024.

Revista ARACÊ
ISSN: 2358-2472

The platform offers a wide range of ready-made connectors, allowing you to integrate a variety of applications quickly and easily. In addition, Make provides over 1,500 pre-configured scenarios that you can use to start automating your workflows right away.

METHODOLOGY

The research was developed between the State University of Pará (UEPA) Campus XX, and the Municipal Department of the Environment of Castanhal, where a tree sampling of Praça do Estrela and a stretch of Avenida Barão do Rio Branco, between Rua Major Wilson and Travessa Primeiro de Maio, was carried out.

DESCRIPTION OF THE STUDY AREA

The municipality of Castanhal is located 68 kilometers from Belém, capital of the State of Pará. Belonging to the metropolitan mesoregion of Belém, it has the following geographic coordinates: 01º17'42" South Latitude and 47º55'00" West Longitude of Greenwich. Castanhal has a predominantly humid equatorial climate, with average temperatures of 26.5 °C and precipitation volume of more than 2,400 mm per year. According to the Koppen-Geiger classification, it falls into the Af climate type, with no dry season. The soil is of the yellow latosol type of medium texture and the typical vegetation of the region is ombrophilous forest (FAPESPA, 2022; Vieira et al., 2020).

The municipality of Castanhal stands out for its trade activities, where there is a great contribution to the supply of neighboring cities (Bahia; Garvão, 2014) and is a strong agro-industrial hub in Pará, owning 22% of the state's fruit processing industries (Silva, 2011), in addition to other economic activities such as agriculture and the service sector.

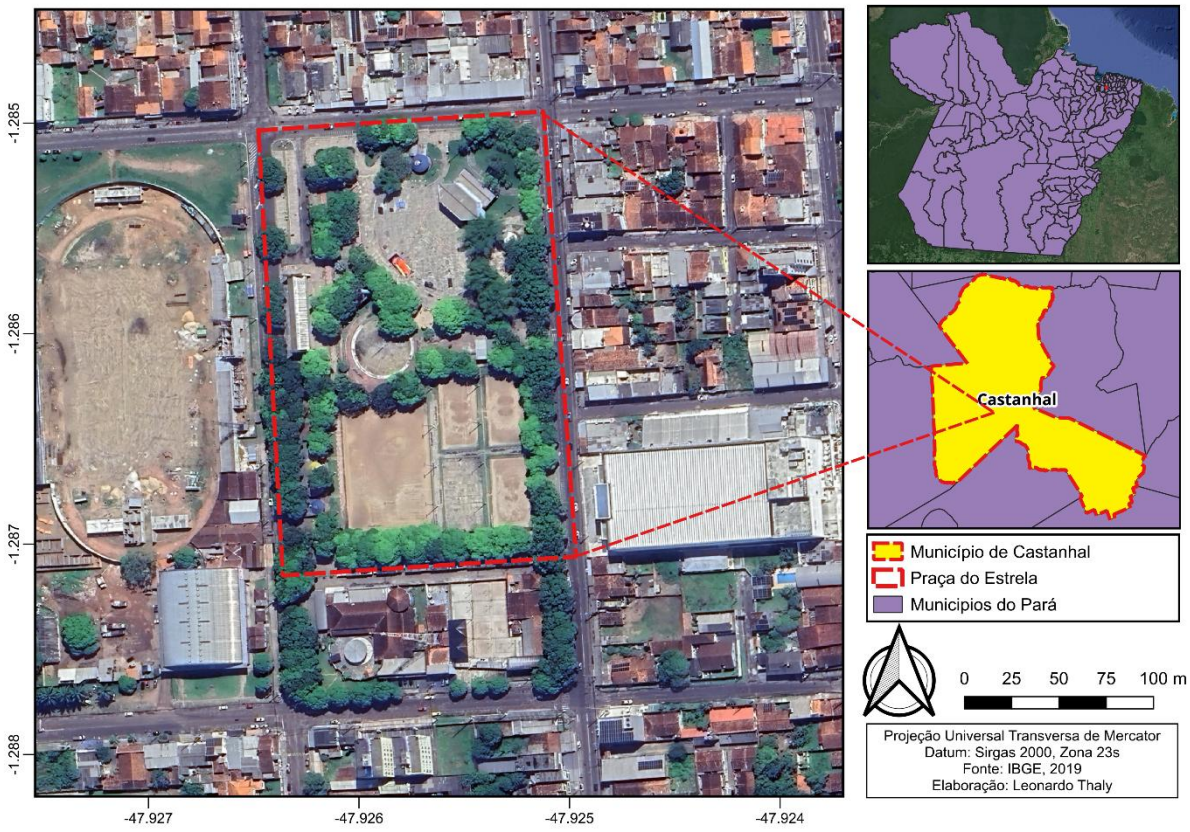
Data collection was done in a comparative manner and was carried out in representative areas of the city, where a traditional inventory survey form (Annex 1) and the UrbanTree application were applied at the same time. The time used in data collection and the financial resources employed were evaluated. The collected data were compiled and analyzed, comparing the results obtained between the use of the application and the traditional method.

The areas selected in the research were a square and a perimeter of an avenue in the city. These places are environments that represent urban afforestation and that play a fundamental role, whether in the environmental and aesthetic quality of the square, or in contributing to the thermal and visual comfort of the avenue.

Revista ARACÊ
ISSN: 2358-2472

The choice of Praça do Estrela (Figure 5) as a study area for the forest inventory is due to its abundant afforestation. The "Inácio Loyola Gabriel" square, popularly known as Praça do Estrela, is located in the urban perimeter in the municipality of Castanhal - PA, in the Northeast region of Pará. The square is located at latitude -1.2862 and longitude -47.9256, being confined to the north by Alameda Tiradentes, to the south by Rua Expedito de Araújo, east by Travessa Quintino Bocaiúva and west by Travessa Conego Luiz Leitão, it has a total area of 4.3 ha.

Figure 3 - Location map of Praça Inácio Loyola Gabriel (Praça do Estrela)



Source: Prepared by the author, 2024

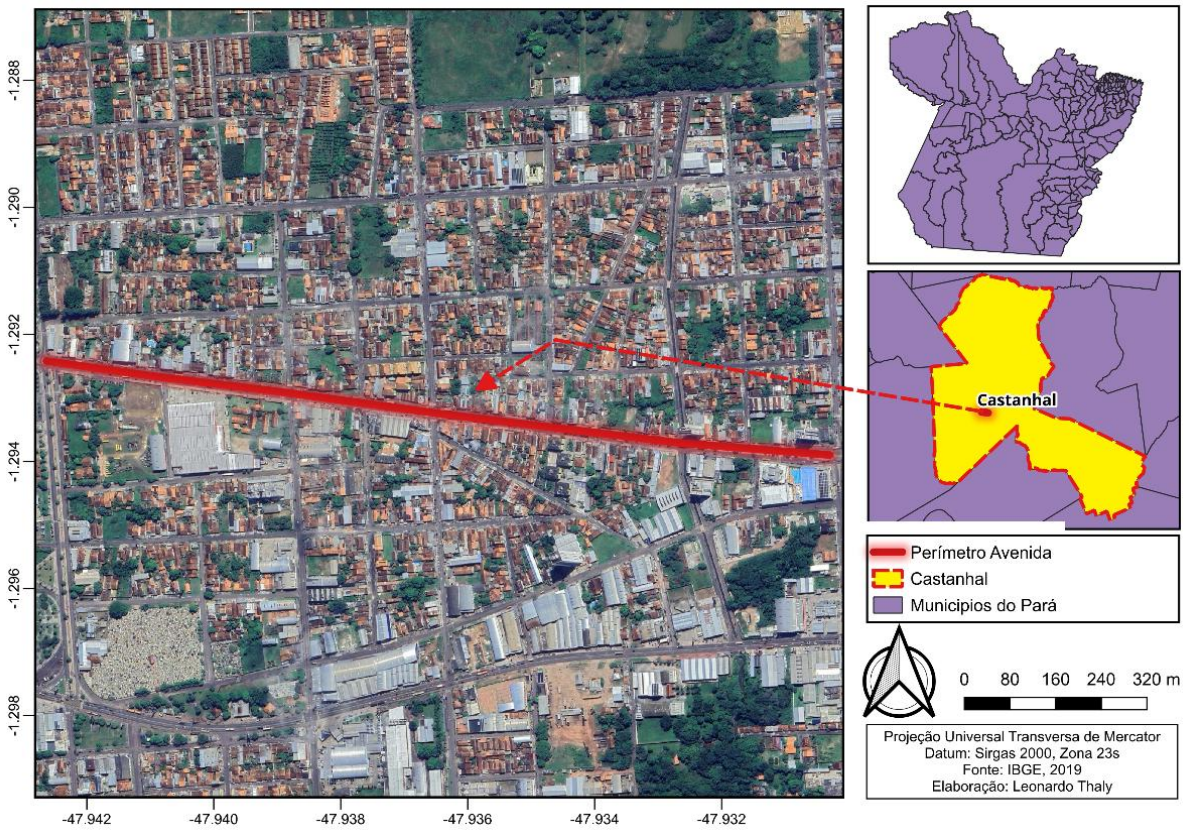
The square is recognized for having a significant amount of trees, which makes it an ideal place to compare the use of the UrbanTree app with the traditional field card in collecting data on urban trees. In addition, Praça do Estrela is one of the main squares in the city, being a central point and frequented by many people. This makes it easier to access and carry out the measurements and observations necessary for the inventory.

Avenida Barão do Rio Branco (Figure 6) is the main and oldest avenue in the city. In addition to its historical and cultural value, the avenue stands out for its afforestation, along

Revista ARACÊ
ISSN: 2358-2472

its route. This feature makes it an excellent place to compare the use of the UrbanTree app with the traditional field card in surveying and evaluating urban trees.

Figure 4 - Location map of the stretch of Avenida Barão do Rio Branco



Source: Prepared by the author, 2024.

The avenue is also known for its historical importance, being part of the route where the locomotive that connected the city of Belém to Bragança, known as the Belém-Bragança Railroad, passed. In addition, the avenue is an important road axis, connecting different neighborhoods and housing a variety of commercial establishments, public institutions and leisure spaces.

METHODOLOGY FOR THE EVALUATION OF URBAN TREES

A preliminary analysis was conducted, consisting of a literature review on traditional tree inventory models and their challenges, as well as a survey of norms and guidelines for urban afforestation. This stage included a review of the preliminary study on afforestation in the municipality of Castanhal carried out by Oliveira et al. in 2018.

Revista ARACÊ
ISSN: 2358-2472

The methodology was carried out in two distinct stages: first, the inventory of the trees was made using the traditional field form (Appendix 1), second Filho et al (2002). Then, the data were collected from the same trees using the UrbanTree application, which will allow a comparison between the two methods.

In the forms, the methodology used to carry out the tree assessment is in accordance with the guidelines of ABNT NBR 16246-3: Urban forests – Management of trees, shrubs and other plants, also in this standard are the recommendations for risk assessment, according to the tree risk assessment manual developed by the International Society of Arboriculture (ISA). This evaluation involves measuring parameters such as total height, height of first bifurcation, and diameter at breast height (DBH).

According to Machado and Figueiredo Filho (2003), the total height of a tree can be defined as the distance from ground level to the top of the tree, along its main axis, and are important parameters to determine the stability of the tree, thus, the total height and height of the first bifurcation were determined mainly from visual inferences, however, for some small and medium-sized individuals, it was possible to measure using a measuring tape.

To determine the DBH, the circumference at breast height (PAC) was measured, that is, at 1.30m from the ground, with the help of a metric tape, from this value the DBH of the trees was calculated from the formula DBH = CAP/π (where: π is Pi that is equivalent to 3.14). However, in some individuals, due to their height, DBH measurement was performed at the midpoint between the base and the first branches.

The plant health of the trees was also analyzed, that is, the health of the trees in relation to the attack of pathogens and pests. The analysis also includes the relationship of trees with the urban environment, considering factors such as distance to buildings, sidewalks, other trees and the presence of shallow roots.

To facilitate the evaluation process, the methodology used was based on the work of Texeira and Nunes (2019) that defines some parameters for evaluation, namely:

1. The quality of the crown: evaluated based on the exuberance, budding rhythm and color of the leaves.
2. Pruning quality: the remnants left by previous pruning on the plant and how much they influence the life of the tree are considered. Improper pruning can result in permanent damage to the tree, such as disordered growth, structural imbalance, and vulnerability to diseases and pests.

Revista ARACÊ
ISSN: 2358-2472

3. Tree balance: consists of comparing the condition of the crown and trunk as a result of previous interventions, ensuring that the tree maintains an adequate structure that is resistant to possible environmental impacts.
4. Contact with electrical wiring: When analyzing contact with the wiring, the urgency and/or need for intervention to avoid accidents and damage to the electrical infrastructure is assessed.
5. Trunk deterioration: it is a critical aspect in the risk assessment of trees, as the trunk is an important part for the support of the plant as a physical structure and is also a place of easy contamination by pathogens. The presence of hollows, cracks, rot, or other signs of deterioration can indicate a higher risk of the tree falling.
6. Bifurcation: according to the height of the bifurcation, a differentiated and specialized management can be planned for that individual, aiming to minimize the risks associated with its structure.
7. Inclination of the trunk: this is an aspect that can indicate the need for intervention, especially if the tree represents a risk of falling. However, it is important to consider that some species have a natural inclination and react badly to pruning, and special care is needed when evaluating this parameter.
8. Plant health of the tree: evaluated due to the negative impact that phytosanitary agents cause on the growth and development of the tree, in addition to causing fragility to the plant, such as the presence of hemiparasites, such as "bird herbs".
9. Root outcropping: the diameter of the roots and the potential for compromise for the specimen were observed, in order to ensure the stability of the tree and prevent accidents.
10. Exposed soil: it is evaluated to obtain a better diagnosis of the exposure of roots and the plant's collar, which may indicate soil compaction problems, erosion or lack of nutrients. This information is important for planning interventions that improve the health and stability of the tree.
11. Compatibility of the tree with the environment: the plant as a whole was evaluated interacting with the environment and its structures. This includes assessing the influence of the tree on the urban environment, considering its size, species, and location, to ensure a harmonious coexistence between trees and urban structures.
12. Distances for constructions: the free space for root and canopy growth was evaluated in relation to these structures. This information is important for planning

Revista ARACÊ
ISSN: 2358-2472

possible interventions, ensuring the safety of the structures and the health of the trees.

Thus, the careful evaluation of these aspects allows a comprehensive analysis of the health and safety of urban trees, providing subsidies for future management and preservation decisions. In addition, this approach allows a direct comparison between the two data collection methods, evaluating the effectiveness and practicality of the application in relation to the traditional field form.

Also during the research, a questionnaire was carried out to evaluate the opinion of users about the UrbanTree application. This questionnaire was prepared using the Google Questionnaires platform, allowing the creation of questions in a practical and efficient way. The form was then emailed to the app's users, making it easy to collect data from a specific and relevant audience. This approach allowed us to obtain valuable feedback on the ease of use, application interface, extra functions of the application, and overall satisfaction with the application, contributing significantly to the evaluation and improvement of the developed tool.

RESULTS AND DISCUSSION

URBANTREE

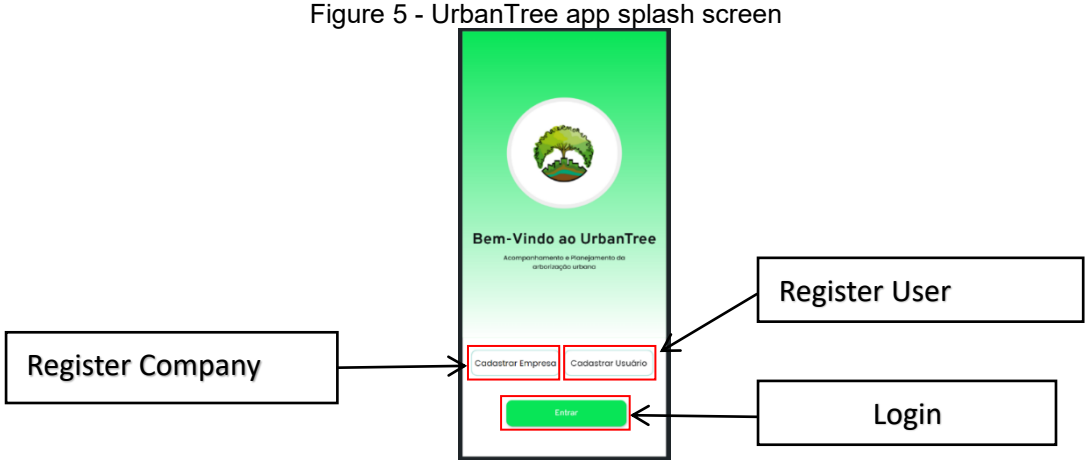
The development of the application resulted in an easy-to-use tool with an interactive interface, as described below:

Splash screen

The opening screen (Figure 7) is composed of three access buttons, the first to register the company or public and private body, the second to register the user and finally the button to log in, the name and logo of the application, UrbanTree, which is a simple and easy to remember name, is also presented in the form of an animation. which has a more modern and urban tone. It can be used to convey the idea that trees are an important part of city life and can bring more nature and well-being to the population.

Revista ARACÊ
ISSN: 2358-2472

Figure 5 - UrbanTree app splash screen

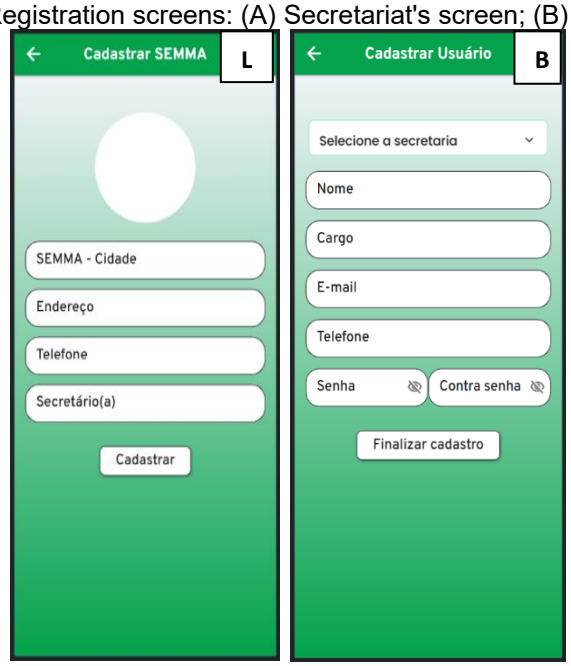


Source: Prepared by the author, 2024.

Company and user Registration Screen

The company registration (Figure 8A) and user registration (Figure 8B) screens are one of the most important in the project, in them we will obtain user information, and from this information each employee is related to their respective secretariat. This is an important step, as UrbanTree is a multi-company application, so each user will only be able to see, change, delete and enter data related to the secretariat they belong to.

Figure 6 – Registration screens: (A) Secretariat's screen; (B) User screen



Source: Prepared by the author, 2024.

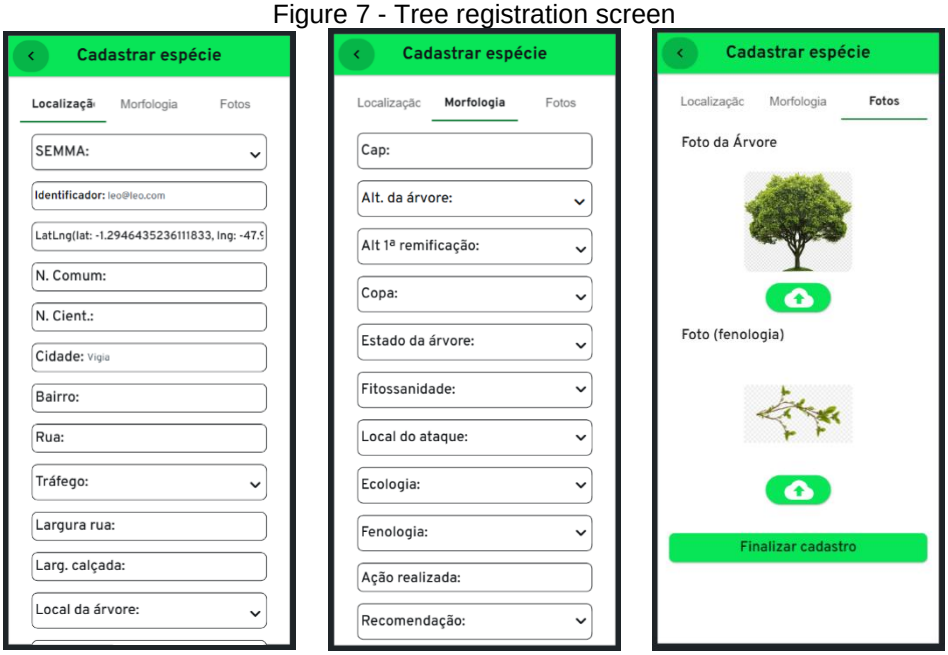
Species registration screen and species information screen

On the species registration screen, the information of the tree individual was collected, being divided into location, morphology and photos of the tree that is being

Revista ARACÊ
ISSN: 2358-2472

registered. On this screen (Figure 9), it will also be possible to connect information about the location of the tree, GPS point, height, circumference, whether or not there is construction, or conflict of branches or roots, as well as information on pests, insects, etc.

Figure 7 - Tree registration screen

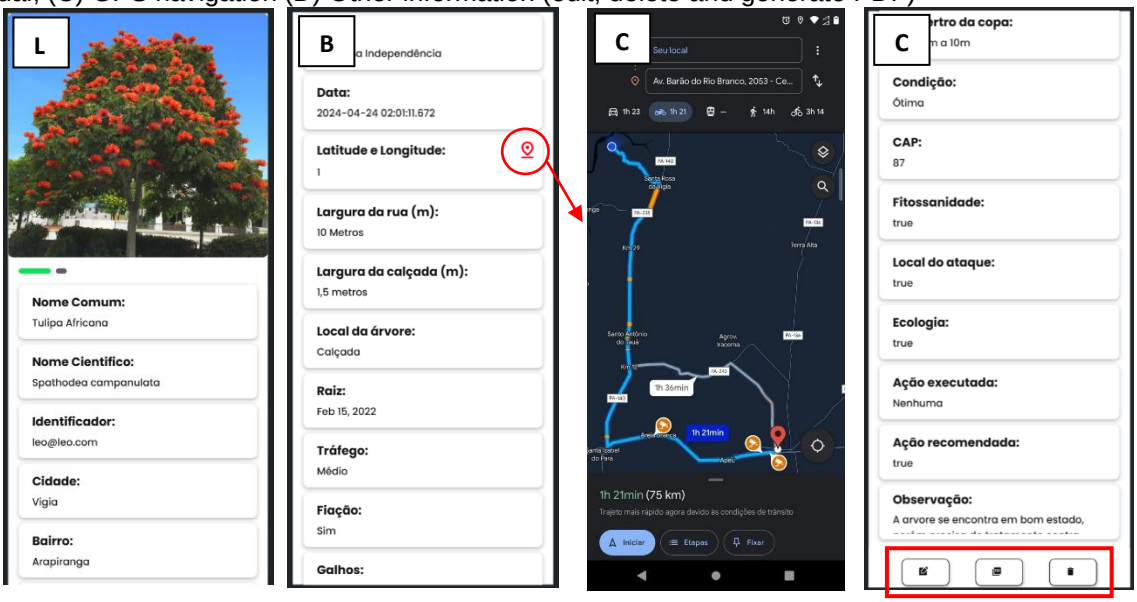


Source: Prepared by the author, 2024.

On the information screen (Figure 10) the user has the possibility to follow the information that was registered in the application, on this screen there is a very interesting function, which is the location icon (Figure 10B), which when clicked, opens a GPS navigation application (Figure 10C) where it will take the user to the tree whose information is being viewed. In case of GPS accuracy error, the user will be able to be guided by the description of the neighborhood, street and photo of the tree, which were collected in the application.

Revista ARACÊ
ISSN: 2358-2472

Figure 10 - Information screen of the registered tree. (A) Description of the individual, (B) Location of the individual, (C) GPS navigation (D) Other information (edit, delete and generate PDF)



Source: Prepared by the author, 2024.

In addition to viewing the data registered about the trees in the application, users will have the ability to edit, delete and generate PDFs of this information. The meanings of the three buttons (Figure 10D) at the end of the information screen:

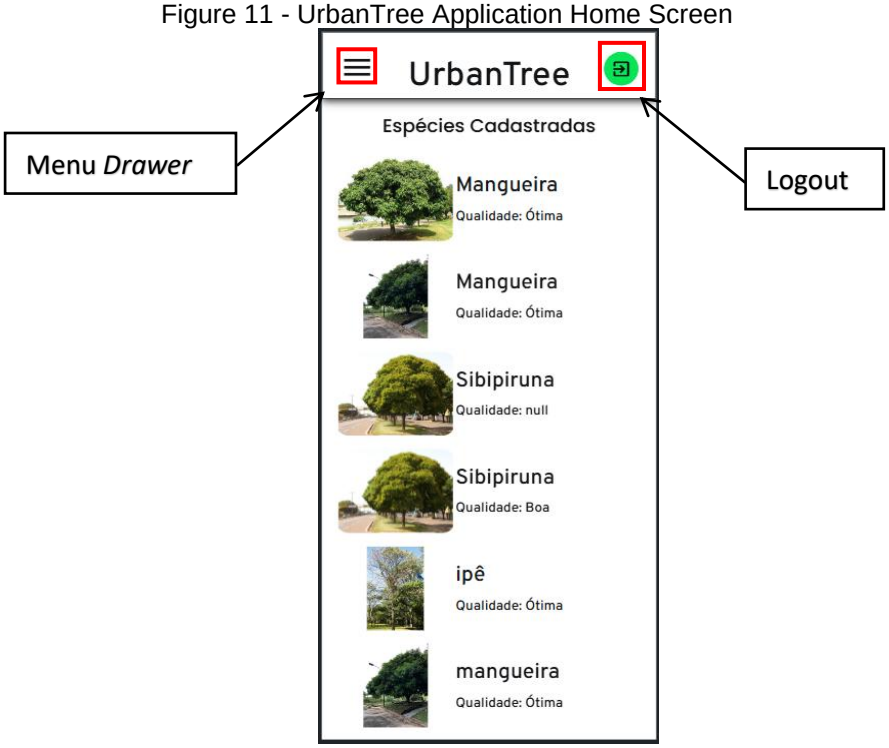
A. Edit: Allows the user to modify the tree's data, such as name, height, diameter, phytohealth, among others. This is useful for keeping the information up-to-date and accurate.
B. Generate PDF: Serves to generate a PDF document with the following tree information: common name, street, neighborhood, and tree state. This feature is useful for generating reports or sharing the information with others.
C. Delete: Permanently removes information from the application tree. Before deleting, a confirmation message is displayed to ensure that the user really wants to delete the data, preventing accidental deletions.

Home Screen

The initial screen is presented in Figure 11, the presentation of the content comes from the Supabase database and occurs in the format of cascading lists, on the screen the user will be able to observe all the registered trees, and the following information of the species: common name, general state of the tree and a photo of the inventoried tree. Also on this screen it is possible to access the *Drawer* menu and the logout button.

Revista ARACÊ
ISSN: 2358-2472

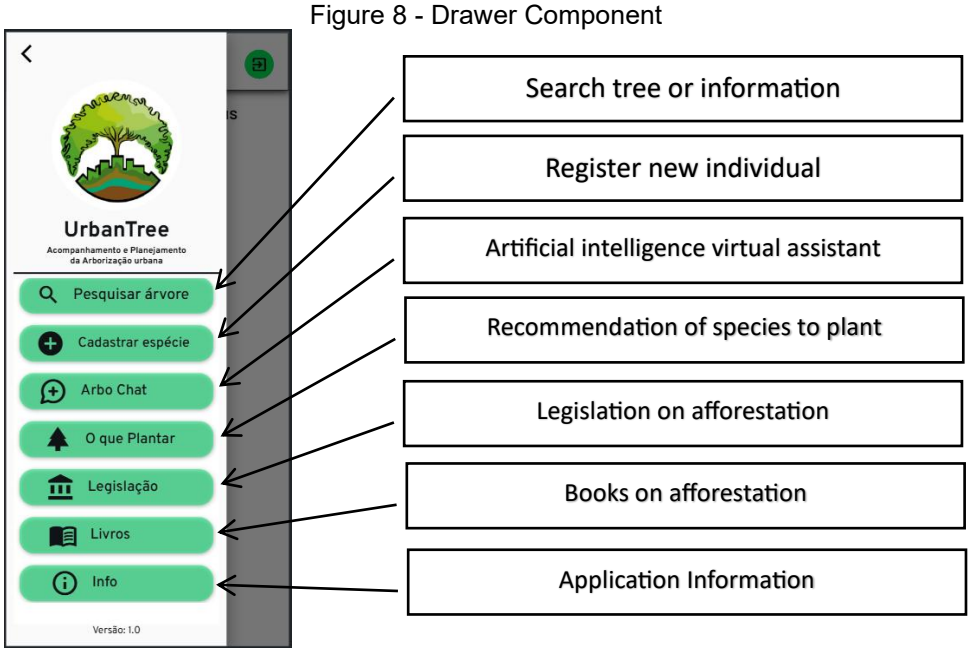
Figure 11 - UrbanTree Application Home Screen



Source: Prepared by the author, 2024

If the user wishes to access other features or register a new tree, it is possible by activating the icon in the upper right corner of the home page. When clicked, a component called *Drawer* opens, which contains buttons that direct the user to the other pages of the application, as shown in Figure 12.

Figure 8 - Drawer Component



Source: Prepared by the author, 2024

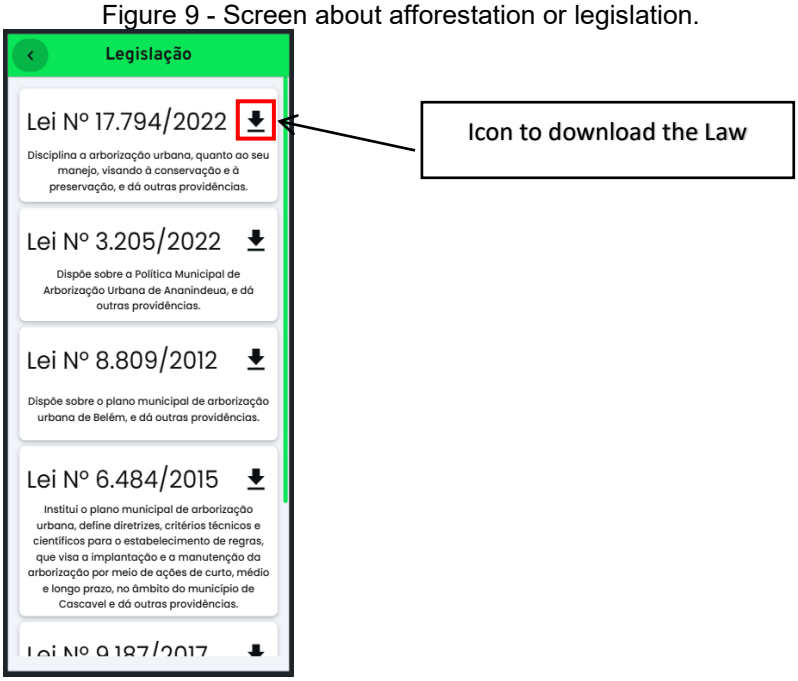
Revista ARACÊ
ISSN: 2358-2472

Other features

A screen was developed in the UrbanTree application dedicated to legislation on urban forestation, where users can download relevant laws, as illustrated in Figure 13. Although there is no specific national law on the subject, several cities such as Belém, Ananindeua and São Paulo have their own afforestation policies. There are also passages in Federal Laws that indirectly deal with the subject, such as Federal Law No. 12,651/2012 (Forest Code), Law No. 6,938/1981 (National Environmental Policy), Law No. 9,605/1998 (Environmental Crimes Law) and CONAMA Resolution No. 302/2002, which include guidelines applicable to urban forestation.

In addition, Bill No. 3,113/2023, known as the National Policy on Urban Forestry (PNAU), is pending in the Federal Senate. This project establishes the PNAU, defining principles, objectives, instruments and guidelines for the management of urban afforestation throughout the country.

Figure 9 - Screen about afforestation or legislation.

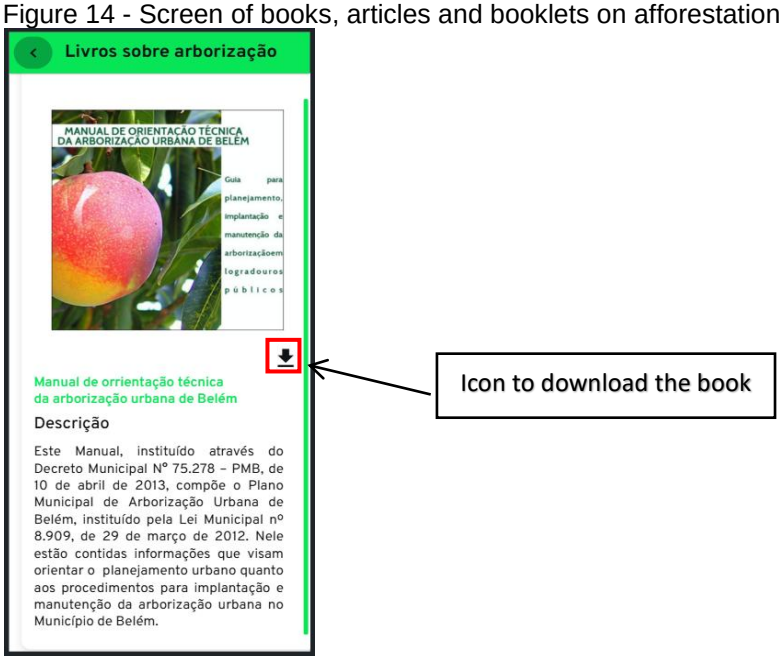


Source: Prepared by the author, 2024

Also in order to bring knowledge about the theme to the user, a screen of books, articles, booklets, etc., which work with urban forestation, was created, where it is possible for the user to download any copy (Figure 14).

Revista ARACÊ
ISSN: 2358-2472

Figure 14 - Screen of books, articles and booklets on afforestation

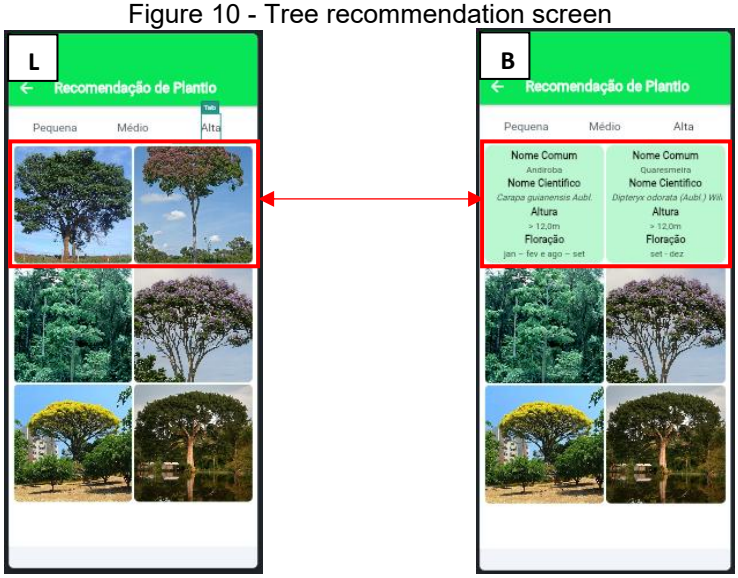


Source: Prepared by the author

A screen has been added where it is possible to see suggestions of trees that can be planted, without them conflicting with wiring, sewage, or that their fruits can cause accidents to people or damage to their property. Such indications of the species are based on the specialized literature and manuals of afforestation, especially the Manual of Technical Guidance of Urban Afforestation of Belém. The screen is presented from the size division of the trees, so we have a tab for small, medium and tall trees. The front of the card (Figure 15a) shows the image of the tree, the back (Figure 15B) presents the following information: common name, scientific name, height and flowering.

Revista ARACÊ
ISSN: 2358-2472

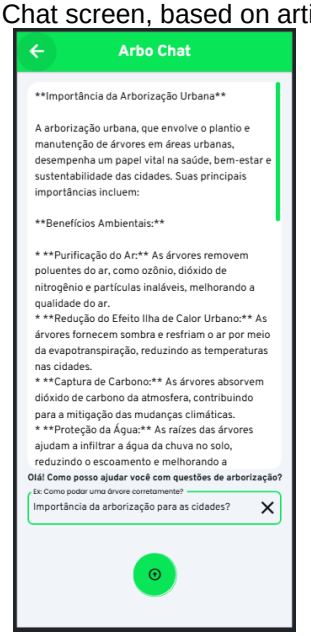
Figure 10 - Tree recommendation screen



Source: Prepared by the author, 2024

Finally, a screen called Arbo Chat (Figure 16) was added, where the user can ask questions, in which there is an integrated artificial intelligence called Gemini from the company Google, which is capable of answering the questions that the user has about afforestation and trees in general.

Figure 16 - Arbo Chat screen, based on artificial intelligence



Source: Prepared by the author, 2024

TREE PLANT DIVERSITY AND DENDROMETRIC ASPECTS

From the inventory in Praça do Estrela and Avenida Barão do Rio Branco, carried out using the Urbantree Application and using the traditional model of paper cards, a total

Revista ARACÊ
ISSN: 2358-2472

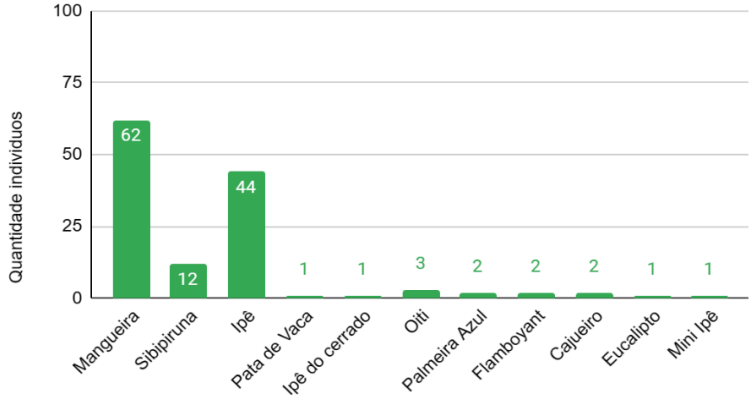
of 131 individuals were evaluated, including trees, shrubs, trees and palm trees from 7 botanical families (Table 1), which were submitted to each of the collection methods mentioned above.

Table 1 - Botanical families and species cataloged in the city of Castanhal-PA

Common Name	N. Científico	Family	Origin
Hose	*Mangifera indica L.*	*Anarcadiaceae*	South Asia
Cashew	*Anacardium occidentale L.*	*Anacardiaceae*	South America
Eucalyptus	*Eucalyptus globulus*	*Myrtaceae*	Australia, Tasmania
Flamboyant	*Delonix regia (Boje rex Hook.) Raf*	*Fabaceae*	Madagascar
Purple ipe	*Handroanthus heptaphyllus*	*Bignoniaceae*	South America
Common Name	**N. Científico**	**Family**	**Origin**
Ipê do cerrado	*Handroanthus ochraceus (Cham.) Mattos*	*Bignoniaceae*	South America
Ipê mirim	*Tecoma stans (L.) Jus sex Kenth*	*Bignoniaceae*	South America
Oitizeiro	*Licania tamentosa (Benth.) Fritsch*	*Chrysobalanaceae*	Brazil
Blue palm tree	*Bismarckia nobilis*	*Arecaceae*	Madagascar
Cow's foot	*The 2016 world's first-100-*	*Fabaceae*	Asia
Sibipiruna	*Caesalpinia pluviosa*	*Caesalpinioideae*	South America

The most frequent families observed were the Bignoniaceae, with 3 species, and the Anacardiaceae with 2 species, both found at the two collection points. However, only two species stand out in numbers of individuals: *Mangifera indica* L. (47.3%) and *Handroanthus heptaphyllus* (33.6%), representing 80.9% of the sampled population (Graph 1). In urban road afforestation, it is common for a small number of species to represent the majority of the individuals in the population, although this fact is not desirable, both for aesthetic reasons and for phytosanitary reasons (Silva, Cardoso, Raphael, 2012).

Graph 1 - Quantitative distribution of the species studied



Source: Prepared by the author, 2024

Revista ARACÊ
ISSN: 2358-2472

In fact, it is considered that when there is the dominance of only one plant species, plant health can be negatively affected, as it exposes the tree set to pests that find it easy to proliferate due to the abundant supply of only one type of food, in which the pest organism can be associated, for this reason, Rezende and Santos (2010) state that the maximum recommended for the same species is 15% of the total number of individuals in the population.

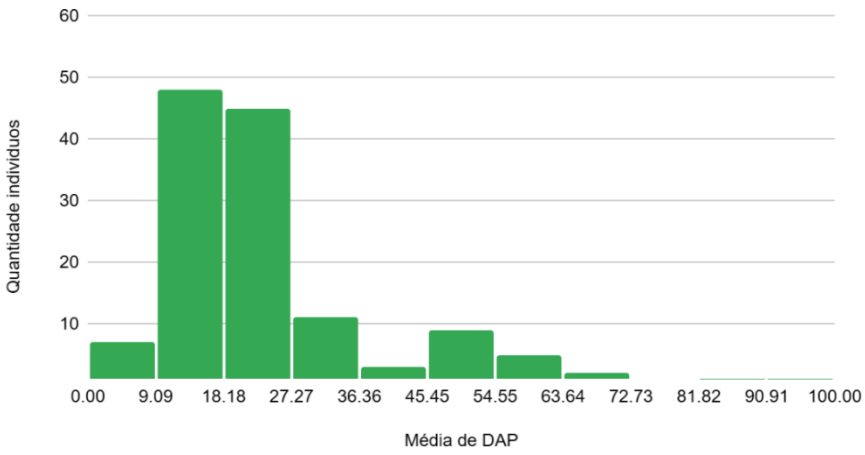
Another finding of the evaluation is related to the origin of the species that make up these spaces, where most are exotic, specifically the *Mangifera indica* L., showing the lack of appreciation of the local flora. This fact is consistent with the statement by Lorenzi & Souza (2003) that exotic species are widely used in afforestation, as in the case of the city of Belém, where the mango trees were planted by Antônio Lemos and are protected by the Historical Heritage Law No. 7709/1994 (Gueiros, 2002).

However, invasive alien species are considered the second largest cause of species extinction on the planet, directly affecting biodiversity, the economy and human health, and should be replaced by species preferably native to the local phytoecological region in the afforestation of public roads (Ziller, 2000). In this sense, native species such as *Cenostigma tocantinum* Ducke, *Clitoria fairchildiana* R.A. Howard and *Brownea grandiceps* Jacq. (Rosa-da-mata) are highly recommended for the afforestation of squares and public roads, both for their ornamental beauty and for their ability to provide shade.

Regarding the diameter at breast height (DBH), Graph 2 shows that most of the individuals inventoried have DBH below 40cm and with an average of 19.73cm, that according to Brasil (1994), plants with DBH below 25cm characterize vegetation at the primary level of development. Although they are at this stage, Del Caro (2009) emphasizes that the importance of these individuals should not be underestimated, since they contribute in the same way to the reduction of noise, air pollution, oxygen release and carbon sequestration.

Revista ARACÊ
ISSN: 2358-2472

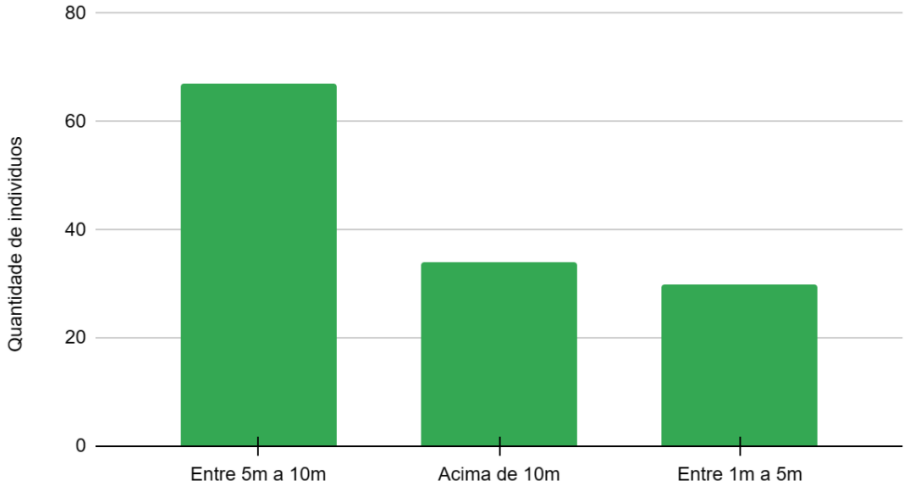
Graph 2 - Diameter and height of the chest (DBH)



Source: Prepared by the author, 2024

Regarding the height of the individuals (Graph 3), most of them were between 5m and 10m tall, reinforcing that they are young individuals and that they are still developing, and most are located on Avenida Barão do Rio Branco. A percentage above 10m, consisting mostly of mango trees can be found in the Estrela square. Regarding this record, it is emphasized that the mango trees in the square do not find much interference in their vertical growth, however, the individuals inventoried on the avenue can cause problems, because according to Milano and Dalcin (2000), the recommended for this type of environment the maximum height of the trees should be 12 meters.

Graph 3 - Height of the trees



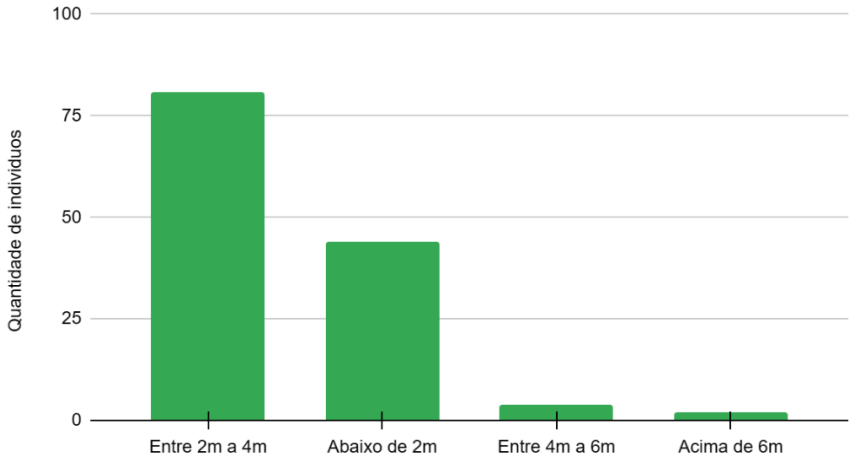
Source: Prepared by the author, 2024

Another important point in the evaluation of urban trees is related to the branches of the trees that can cause inconvenience to the population. In this sense, in Graph 4 it can

Revista ARACÊ
ISSN: 2358-2472

be seen that most of the individuals have branches between 2m and 4m and below 2m, corresponding to a percentage of 95.4%, most of them mango trees and present on Avenida Barão do Rio Branco.

Graph 2 - Average height of first branch



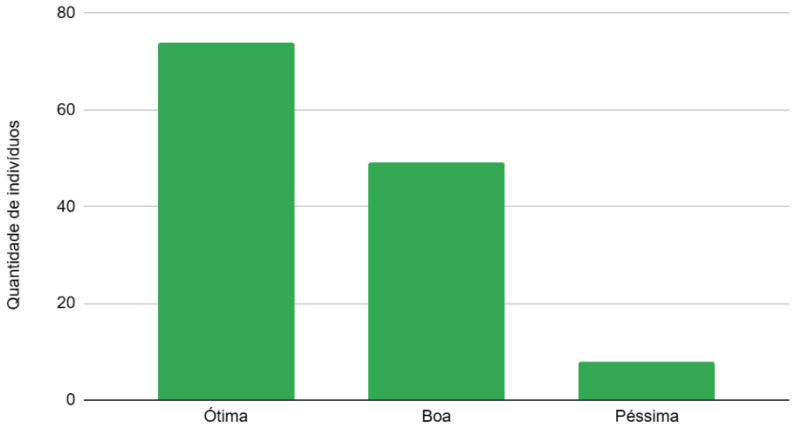
Source: Prepared by the author, 2024

It should be noted that these individuals in the future may cause difficulties in the traffic of pedestrians and vehicles or in conflict with the wiring, requiring interference that is exhausting and high cost for energy supply companies and municipal management. Analyzing the conflict with the electrical wiring, the data showed that 56.5% of the individuals had some type of contact with the electrical network or with internet wires, according to Mascaró J; Mascaró L. (2002), the contact of tree branches with wires can break them, causing interruption in the power supply, burning of appliances and accidents, in addition, the dispute between trees on the sidewalks and the electrical networks for the same space is certainly one of the main problems existing in the afforestation of a city.

Graph 5 shows that 73 individuals were evaluated as excellent, 49 presented good condition and only 8 individuals had their condition certified as very poor.

Revista ARACÊ
ISSN: 2358-2472

Graph 3 - Phytosanitary quality



Source: Prepared by the author, 2024

The final analysis allows us to infer that most of the individuals evaluated have a condition in which basically a control through a programmed management will maintain their sanity, on the other hand the very bad category, although it has few individuals, an even more technical analysis is suggested to decide the action to be carried out, whether it is a management with more complex silvicultural treatment practices until suppression, with replacement of other species in the same place.

Finally, it is emphasized the benefits and losses that afforestation returns to cities, and in this regard it is considered that both depend on planning, as the use of inappropriate species can offer risks and losses to society. In addition, the municipality of Castanhal still does not have a Master Plan for Urban Forestation, which reflects in inefficient management and poor distribution of species on roads and squares.

In this sense, we found in this inventory an excessive amount of mango trees, which according to Bessa et al. (2012) are not recommended for afforestation, since their fruits can cause serious accidents to pedestrians who circulate on the sidewalks, also causing damage to vehicles, in addition to their morphological characteristics such as crown, size and root system can conflict with electrical wiring and surrounding constructions (Parry, 2012).

Therefore, studies of species that can replace mango trees or other planted exotic species are suggested, based on planning, monitoring and monitoring of the urban afforestation of Castanhal.

Revista ARACÊ
ISSN: 2358-2472

PRACTICAL APPLICATION

In this research, we seek the possibility of replacing the traditional methodology using paper forms for the collection of field information on urban afforestation by an application that can be installed on a cell phone or tablet, and thus, carry out data surveys more quickly, aiming to reduce the time of data collection and analysis. In this sense, the UrbanTree application was tested by some forestry engineering students from UEPA, as well as by the servers of the Municipal Department of the Environment of Castanhal, responsible for the management of the city's afforestation, so that they could test the functionality, usability and security of the software.

A total of 131 individuals were inventoried, and the time spent measuring the qualitative and quantitative parameters of the sampled individuals is presented below (Table 2), it should be noted that travel times to the site or from one tree to another were not computed. Therefore, the time record is only related to the start and end of the registration in both methods.

Table 2 – Time comparison between field sheet and UrbanTree app

	Field file	**UrbanTree**	**Difference**
Average time per tree	4 minutes and 20 seconds	1 minutes 48 seconds	2 minutes 32 seconds
Total Time	9 hours and 46 minutes	4 hours and 9 minutes	4 hours and 48 minutes

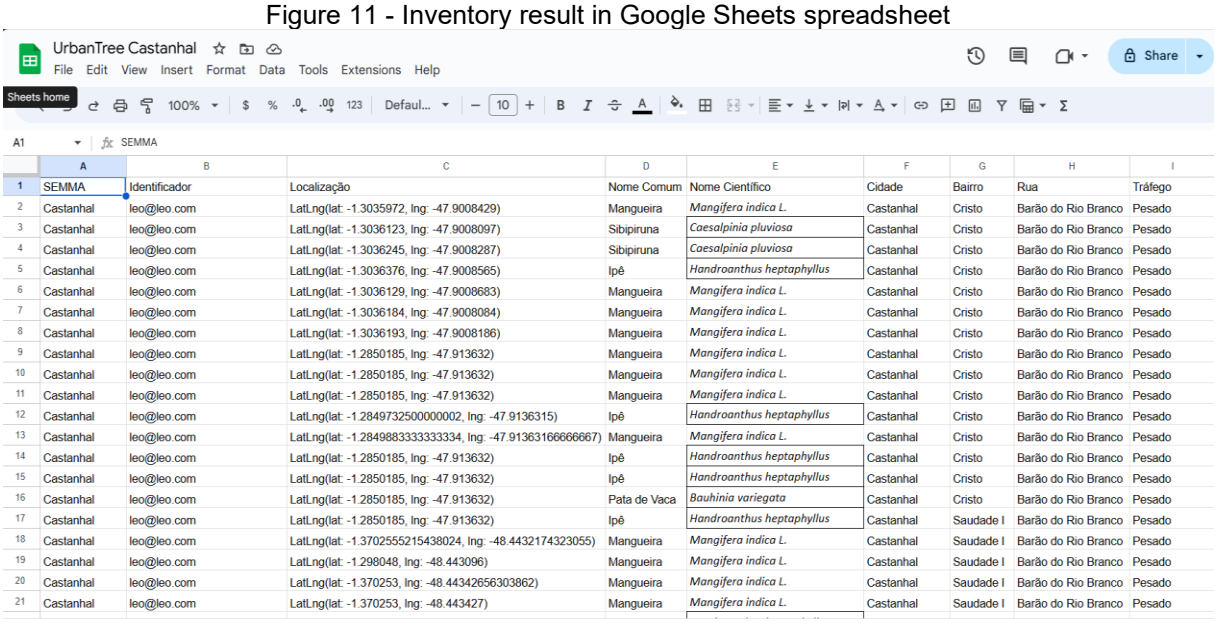
Source: Prepared by the author, 2024.

As can be observed, the time spent to carry out the tree inventory showed marked differences from one method to another. The average time per tree with the app was 1 minute and 48 seconds, while with the field sheet it was 4 minutes and 20 seconds, representing a 63% reduction in the time spent per tree. In total, the inventory of all trees with UrbanTree took 4 hours and 9 minutes, while with the field sheet it took 9 hours and 46 minutes, a saving of 53% in total work time.

Another important step is the post-processing of the information, which consists of exporting the data to the computer and thus generating a digital database of the information, this phase is considered a bottleneck that consumes a lot of time. In this sense, UrbanTree provides greater speed, since the application is directly connected to a digital platform, allowing that after registering the tree information, this data is automatically sent to a Google Sheets spreadsheet (Figure 17).

Revista ARACÊ
ISSN: 2358-2472

Figure 11 - Inventory result in Google Sheets spreadsheet



UrbanTree Castanhal

	A	B	C	D	E	F	G	H	I
1	SEMMA	Identificador	Localização	Nome Comum	Nome Científico	Cidade	Bairro	Rua	Tráfego
2	Castanhal	leo@leo.com	LatLng(lat: -1.3035972, lng: -47.9008429)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
3	Castanhal	leo@leo.com	LatLng(lat: -1.3036123, lng: -47.9008097)	Sibipiruna	*Caesalpinia pluviosa*	Castanhal	Cristo	Barão do Rio Branco	Pesado
4	Castanhal	leo@leo.com	LatLng(lat: -1.3036245, lng: -47.9008287)	Sibipiruna	*Caesalpinia pluviosa*	Castanhal	Cristo	Barão do Rio Branco	Pesado
5	Castanhal	leo@leo.com	LatLng(lat: -1.3036376, lng: -47.9008565)	Ipê	*Handroanthus heptaphyllus*	Castanhal	Cristo	Barão do Rio Branco	Pesado
6	Castanhal	leo@leo.com	LatLng(lat: -1.3036129, lng: -47.9008683)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
7	Castanhal	leo@leo.com	LatLng(lat: -1.3036184, lng: -47.9008084)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
8	Castanhal	leo@leo.com	LatLng(lat: -1.3036193, lng: -47.9008186)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
9	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
10	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
11	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
12	Castanhal	leo@leo.com	LatLng(lat: -1.2849732500000002, lng: -47.9136315)	Ipê	*Handroanthus heptaphyllus*	Castanhal	Cristo	Barão do Rio Branco	Pesado
13	Castanhal	leo@leo.com	LatLng(lat: -1.2849883333333334, lng: -47.91363166666667)	Mangueira	*Mangifera indica L.*	Castanhal	Cristo	Barão do Rio Branco	Pesado
14	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Ipê	*Handroanthus heptaphyllus*	Castanhal	Cristo	Barão do Rio Branco	Pesado
15	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Ipê	*Handroanthus heptaphyllus*	Castanhal	Cristo	Barão do Rio Branco	Pesado
16	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Pata de Vaca	*Bauhinia variegata*	Castanhal	Cristo	Barão do Rio Branco	Pesado
17	Castanhal	leo@leo.com	LatLng(lat: -1.2850185, lng: -47.913632)	Ipê	*Handroanthus heptaphyllus*	Castanhal	Saudade I	Barão do Rio Branco	Pesado
18	Castanhal	leo@leo.com	LatLng(lat: -1.3702555215438024, lng: -48.4432174323055)	Mangueira	*Mangifera indica L.*	Castanhal	Saudade I	Barão do Rio Branco	Pesado
19	Castanhal	leo@leo.com	LatLng(lat: -1.298048, lng: -48.443096)	Mangueira	*Mangifera indica L.*	Castanhal	Saudade I	Barão do Rio Branco	Pesado
20	Castanhal	leo@leo.com	LatLng(lat: -1.370253, lng: -48.44342656303862)	Mangueira	*Mangifera indica L.*	Castanhal	Saudade I	Barão do Rio Branco	Pesado
21	Castanhal	leo@leo.com	LatLng(lat: -1.370253, lng: -48.443427)	Mangueira	*Mangifera indica L.*	Castanhal	Saudade I	Barão do Rio Branco	Pesado

Source: Prepared by the author, 2024.

This automated workflow eliminates the need for manual transcription, drastically reducing the time and effort required to organize and analyze data, in contrast to the traditional field cards method where it requires the collected data to be manually transcribed into Excel, a time-consuming and error-prone process. Table 3 shows the comparison between both methods.

Table 2 - Comparison on *application* practice of both methods *Used.*

Aspect	**Field file**	**UrbanTree**	**Difference**
Data collection	Manual, paper	Digital, via app	Speeds up the process in the field
Transcript	Manual, for Excel	Automatic, for Google Sheets	Eliminates 5h30min of manual work
Average time per token	2 minutes and 43 seconds	-	Frees up time for other activities
Aspect	**Field file**	**UrbanTree**	**Difference**
Precision	Susceptible to human error	Increased data reliability	More reliable data for decisions
Organization	Data in different cards	Centralized data on one platform	Makes it easy to analyze and share

Source: Prepared by the author, 2024

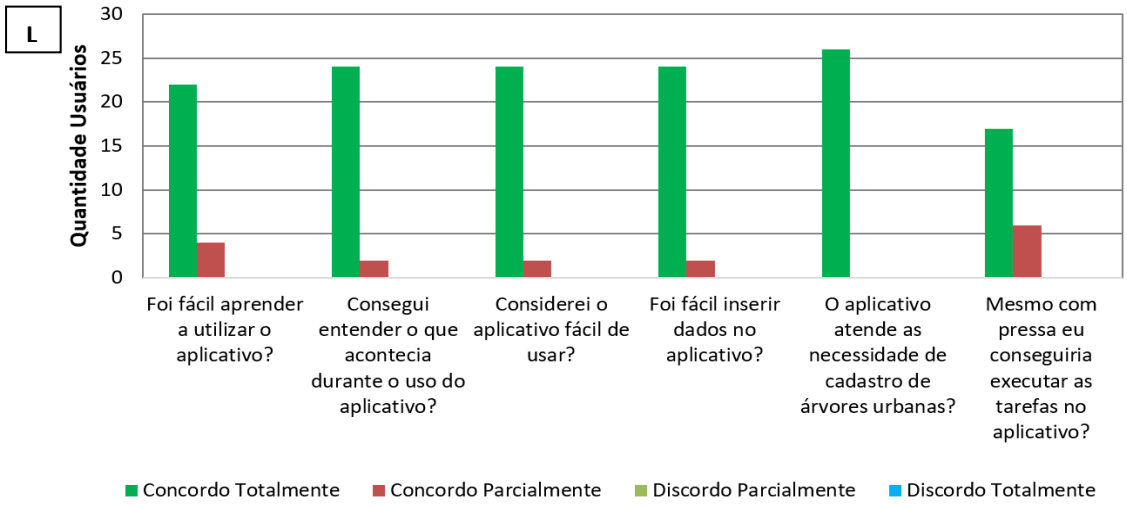
The table above clearly illustrates UrbanTree's superiority in terms of efficiency in the urban tree inventory process. But more importantly, the process of manually transcribing the data collected with the cards, which took 5 hours and 30 minutes for the field cards, is completely eliminated with UrbanTree. These efficiency gains allow for faster

Revista ARACÊ
ISSN: 2358-2472

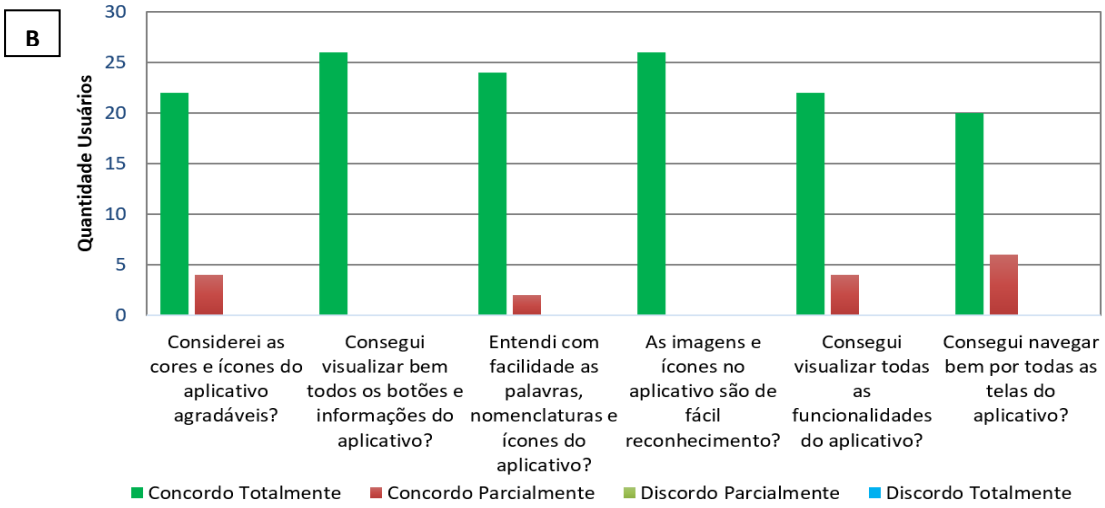
and more accurate management of information, freeing up time for other essential activities and improving the overall productivity of those responsible for managing urban forestry.

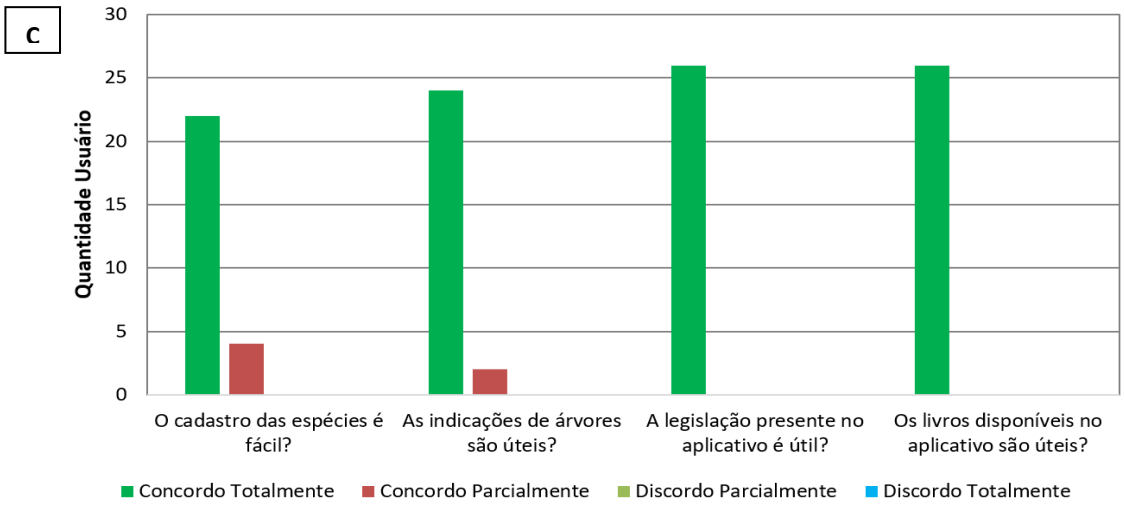
After the tests were carried out with the application, users were asked to answer a questionnaire about the application, the questions were divided into topics related to ease of use, application interface, application functions and application adjustments (Graphs 6). For the first three topics, the questions were objective, with the following alternatives: totally agree, partially agree, partially disagree and totally disagree.

Graph 4 – Analysis of questions related to the use of the Urbantree application. (A) Ease of use; (B) Application Interface; (C) Extra functions of the app



Revista ARACÊ
ISSN: 2358-2472





Source: Prepared by the author, 2024.

From the results presented in the graphs above, it can be seen that the UrbanTree app is widely accepted and well rated by users, with the majority expressing high satisfaction in terms of usability, visualization, navigation, and usefulness of the additional features. However, there are areas identified for possible improvements, especially related to navigation in a hurry and the clarity of some images and icons.

In the same questionnaire, a subjective question was prepared so that users could give their opinion on the experience of using the application, the following Table presents the answers.

Table 3 - Subjective evaluation about the UrbanTree app

	What is your opinion about the app?
User 1	*I found it easy to use, and very good for quick searches.*
User 2	*The app is innovative and complete. It meets what was proposed.*
User 3	*Very practical and easy to use.*

Revista ARACÊ
ISSN: 2358-2472

User 4	*Good*
User 5	*Urbantree is an innovative app and essential tool for anyone concerned with urban forestry, with features such as tree registration, planting tips, Arbo Chat and legislation on local species.*
User 6	*Very good, it helps a lot in monitoring the afforestation of an area*
User 7	*The beginning of a project that came to add, with an optimized interface, I see a promising future with this application.*
User 8	*The app is very interesting. It will certainly help in the registration of urban trees.*
User 9	*Very good. Easy to use. It will help in the management of afforestation*
User 10	*The application is fast, the information recorded is important in an inventory.*
User 11	*The app is great. The arbo chat is very good, it will help a lot*
User 12	*The app is useful for afforestation*
User 13	*urbantree makes it easy to efficiently catalog and track urban trees.*
User 14	*The interface is intuitive and user-friendly, which makes the experience very enjoyable.*
User 15	*The application is extremely useful for those who work with urban environmental management.*
User 16	*It will be very practical to monitor and maintain the health of urban trees.*
User 17	*The Arbo Chat feature provides effective communication between users*
User 18	*The agility in registering trees is one of the strengths of the application*
User 19	*It is an excellent initiative that can help in the way we deal with trees in urban areas.*
User 20	*The app is very good for environmental management.*
User 21	*The project is innovative and has great potential*
User 22	*The app is an excellent one, it will help a lot in the afforestation*
User 23	*The app will be an important addition to any city*
User 24	*The app is very good*
User 25	*It's pretty cool*
User 26	*The way to register is very fast*

Source: Prepared by the author, 2024.

Analysis of responses from 26 users of the UrbanTree app reveals a largely positive opinion of its usability and functionalities. Most users highlighted the app's ease of use, practicality, and innovation, with comments emphasizing its usefulness in monitoring and cataloging urban trees. Terms such as "very good", "innovative" and "essential" were frequently mentioned, indicating a strong acceptance of the features offered, such as Arbo Chat and planting tips.

The interface has been described as intuitive and user-friendly, making it easy for the user to experience. Several users pointed out that UrbanTree is an important tool for urban environmental management, contributing significantly to tree afforestation and health. The opinions reflect that the app not only meets expectations, but also has promising potential for the future.

Revista ARACÊ
ISSN: 2358-2472

CONCLUSION

The development of the UrbanTree multiplatform application proved to be an efficient solution to optimize the inventory and management processes of urban trees. The use of the application allowed for faster and more accurate data collection, which provided greater reliability and ease in organizing information, in addition to direct integration with the data analysis platform, which significantly reduced the time for inventory execution between traditional and printed methods, including reducing the use of paper.

Finally, the digitization of processes and the use of Google Sheets eliminate the need for data transcription, reducing errors and improving overall efficiency.

ACKNOWLEDGMENTS

I thank God with all my heart, whose light and guidance have been constant during this challenging journey, sustaining me through the most difficult times and illuminating the paths of my academic growth.

To my parents, Maria do Livramento Neves Barbosa Thaly and Auguste Mathilde Thaly, true pillars of my existence, I thank you for being my solid foundation and for your tireless support. Each achievement is also yours.

To the dedicated professors of my institution, especially to my advisor Henriqueta da Conceição Brito Nunes, my deep gratitude. Their wise guidance and the inspiration they provided were fundamental to my academic and personal development.

To the remarkable people at UEPA who contributed to my education, I thank them for their dedication to creating an enriching educational environment.

To my family and friends, I thank you for being the emotional support network that propelled me through the challenging times and shared the joys of this journey.

I thank my college friends (Lua, Keylla, Ana, Isa, Madson, Mateus and Pedro), thank you for making this journey lighter and happier, without you I would probably have gone crazy, I love you.

I dedicate this work to everyone who, in some way, made this achievement possible. May our paths continue to intertwine in learning and achievement.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Associação Brasileira de Normas Técnicas. (2019). ABNT NBR 16246-3: Florestas urbanas – Manejo de árvores, arbustos e outras plantas lenhosas. Parte 3: Avaliação de risco de árvores (1st ed.). 14 p. ISBN 978-85-07-08192-0.

2. Apple Inc. (n.d.). iOS overview. Available at: http://developer.apple.com/library/ios/referencelibrary/GettingStarted/URLiPhoneOS Overview/index.html//apple-ref/doc/uid/TP40007592. Retrieved April 13, 2024.

3. Bacancy Technology. (n.d.). FlutterFlow. Available at: https://www.bacancytechnology.com/blog/flutterflow. Retrieved December 15, 2023.

4. Bahia, M. L., & Garvão, R. F. (2014). Castanhal-PA: Um estudo avaliativo da 'Cidade Modelo' no paraense. EcoDebate.

5. Bessa, H. (2012). Brasil está entre os dez países com mais smartphones ativados, segundo relatório da Flurry. Mac Magazine. Available at: https://macmagazine.com.br/post/2012/08/27/brasil-esta-entre-os-10-de-paises-com-maissmartphones-ativados-segundo-relatorio-da-flurry/. Retrieved May 19, 2024.

6. Bracha, G. (2015). The Dart programming language. Available at: https://books.google.com.br/books?hl=pt-BR&lr=&id=UHAlCwAAQBAJ&oi=fnd&pg=PT13&dq=dart+language&ots=Po6Le2IeIN&sig=5ByMYr7T4UWxnRG8uUjkbmy2rs4. Retrieved February 9, 2024.

7. Brasil. Ministério do Meio Ambiente. (2021). Programa Cidades + Verdes. Available at: https://www.gov.br/mma/pt-br/assuntos/agendaambientalurbana/cidadesmaisverdes. Retrieved March 17, 2024.

8. Brasil. (1994, May 4). Resolução Conama. Lei n. 004, de 04 de maio de 1994. Brasília, DF. Available at: http://www.areaseg.com/conama/1994/004-1994.pdf. Retrieved April 8, 2024.

9. Cemig - Companhia Energética de Minas Gerais. (2015). Manual de arborização. Belo Horizonte: Fundação Biodiversitas. 112 p.

10. Del Caro, C. F., Oliveira, O. M., Senna, D. S., Lemos, R., & Caliman, J. P. (2009). Análise da arborização urbana das praças na região metropolitana da cidade de Alegre, ES. In Anais do XIII Encontro Latino-Americano de Iniciação Científica e IX Encontro Latino-Americano de Pós-Graduação – Universidade do Vale do Paraíba. São José dos Campos, SP: UNIVAP.

11. Duarte, T. E. P. N., et al. (2018). Reflexões sobre arborização urbana: Desafios a serem superados para o incremento da arborização urbana no Brasil. Revista Agro. Meio Ambiente, 11(1), 327-341.

Revista ARACÊ
ISSN: 2358-2472

12. Fapespa - Fundação Amazônia de Amparo a Estudos e Pesquisas. (2022). Estatísticas municipais paraenses: Castanhal. Belém: Diretoria de Estatística e de Tecnologia e Gestão da Informação.

13. Fraga, R. (n.d.). 9 anos do Android: Conheça a história da plataforma móvel do Google. @2006-2024 Google Discovery.

14. Gaio. (2022). FlutterFlow: Explorando o conceito e suas aplicações. Hashdork. Available at: https://hashdork.com/pt/fluxo-flutuante/. Retrieved March 5, 2024.

15. Google Inc. (n.d.). What is Android? Available at: http://developer.android.com/guide/basics/what-isandroid.html. Retrieved April 29, 2024.

16. Google Inc. (2013). Dart programming language. Available at: https://dart.dev/. Retrieved April 10, 2024.

17. Gueiros, H. M. (1994). Leis Municipais / Pará / Belém – Lei nº 7709/1994. Belém: Gabinete do Prefeito Municipal de Belém.

18. Habchi, S., et al. (2017). Code smells in iOS apps: How do they compare to Android? In International Conference on Mobile Software Engineering and Systems (MOBILESoft). IEEE Xplore. Available at: https://ieeexplore.ieee.org/document/7972725/. Retrieved April 19, 2024.

19. International Society of Arboriculture. (2011). Recognizing tree risk.

20. Lorenzi, H., & Souza, H. M. (2003). Árvores exóticas no Brasil. São Paulo: Instituto Plantarum de Estudos da Flora Ltda. 368 p.

21. Machado, S. A., & Figueiredo Filho, A. (2003). Dendrometria. Curitiba: Universidade Federal do Paraná. 309 p.

22. Maciel, T. T., & Barbosa, B. C. (2015). Áreas verdes urbanas: História, conceitos e importância ecológica. CES Rev, 29(1), 30-42.

23. Mainkar, P., & Giordano, S. (2019). Google Flutter Mobile Development Quick Start Guide: Get up and running with iOS and Android mobile app development. [S.l.: s.n.].

24. Mascaro, J., & Mascaro, L. (2005). Vegetação urbana (2nd ed.). Porto Alegre: Editora Mais Quatro.

25. Milano, M., & Dalcin, E. (2000). Arborização de vias públicas. Rio de Janeiro: Light. 206 p.

26. Molnar, M. A. S. (2017). Educação ambiental e serviços urbanos: Uso de aplicativos digitais para a gestão do verde urbano no município de São Paulo. (Master's thesis, Faculdade de Saúde Pública da Universidade de São Paulo). São Paulo: USP.

Revista ARACÊ
ISSN: 2358-2472

27. Moresi, E. A. D., et al. (2018). The Doei mobile app. In 2018 13th Iberian Conference on Information Systems and Technologies (CISTI) (pp. 1-7). Caceres, Spain. doi:10.23919/CISTI.2018.8399260.

28. Mullaney, J., Lucke, T., & Trueman, S. J. (2015). A review of benefits and challenges in growing street trees in paved urban environments. Landscape and Urban Planning, 134, 157–166.

29. Oliveira, L. S., et al. (2018). Análise da composição vegetal de espaços verdes urbanos das cidades de Belém e Castanhal, Estado do Pará. In III Congresso Internacional das Ciências Agrárias, COINTER – PDVAGRO. doi:10.31692/2526-7701.IIICOINTERPDVAGRO.2018.00010.

30. OpenHandsetAlliance. (2011). Overview. Available at: http://www.openhandsetalliance.com/oha_overview.html. Retrieved February 5, 2024.

31. Parry, M. M., Silva, M. M., Sena, I. S., & Oliveira, P. M. O. (2012). Composição florística da arborização da cidade de Altamira, Pará. Revista Sociedade Brasileira de Arborização Urbana (REVSBAU), 7(1), 143-158.

32. Pedó, T., et al. (2023). Kodular ou FlutterFlow, viabilidade para o projeto Programe seu Futuro. Salão do Conhecimento, Ijuí.

33. Provenzi, G. (2008). Áreas verdes urbanas em Xaxim, um processo de revisão. (Monograph, Especialização em Arquitetura de Interiores, Universidade do Oeste de Santa Catarina, Xanxerê). 110 p.

34. Rezende, T. M., & Santos, D. G. (2010). Avaliação quali-quantitativa da arborização das praças do bairro Jaraguá, Uberlândia – MG. Revista da Sociedade Brasileira de Arborização Urbana, 5(2), 139-157.

35. Ribeiro, H., Pesquero, C. R., & Coelho, M. S. Z. S. (2016). Clima urbano e saúde: Uma revisão sistematizada da literatura recente. Estudos Avançados, 30(86).

36. Schallenberger, L. S., & Machado, G. O. (2013). Inventário da arborização na região central do município de Mangueirinha – PR. Revista da Sociedade Brasileira de Arborização Urbana, 8(1), 54-64.

37. Silva Filho, et al. (2002). Banco de dados relacional para cadastro, avaliação e manejo da arborização em vias públicas. R. Árvore, 26(5), 629-642.

38. Silva, A. G., Cardoso, A. L., & Raphael, M. (2012). Diagnóstico quali-quantitativo da arborização viária da cidade de Jerônimo Monteiro, ES. Enciclopédia Biosfera, 8(14), 1179-1188.

Revista ARACÊ
ISSN: 2358-2472

39. Silva, L. B., Pires, D. F., & Neto, S. C. (2015). Desenvolvimento de aplicações para dispositivos móveis: Tipos e exemplo de aplicação na plataforma iOS. Centro Universitário Municipal de Franca - Uni Facef. Available at: http://www.lbd.dcc.ufmg.br/colecoes/wicsi/2015/004.pdf. Retrieved March 23, 2024.

40. Silva, R. F. (2011). Responsabilidade socioambiental: Uma reflexão das ações adotadas pela agroindústria Bela Iaçá no município de Castanhal-Pará. Movendo Ideias, 18(1), 117-130.

41. Simões, D. D., & Pereira, J. C. (2014). Operacionais móveis - Android X iOS. Universidade Paranaense – Unipar.

42. Sirvinskas, L. P. (2000). Arborização urbana e meio ambiente: Aspectos jurídicos. Revista Instituto de Pesquisas e Estudos, 263-276.

43. Teixeira, I. F., & Dos Santos Nunes, J. (2019). Método expedito de análise qualitativa da arborização da Praça Eufrásio Correia, Curitiba-PR. Revista da Sociedade Brasileira de Arborização Urbana, 14(3), 17-36.

44. Teixeira, I. F., Silva, R. M. da, & Tatsch, G. L. (2011). Compatibilidade da arborização de ruas da Avenida Celestino Cavalheiro, São Gabriel-RS. Floresta e Ambiente, 18. Available at: http://dx.doi.org/10.4322/floram.2011.06. Retrieved March 28, 2024.

45. Trindade, B. G., et al. (2021). Verdejar: Desenvolvimento de aplicativo móvel e módulo web para gestão da arborização urbana no âmbito das cidades inteligentes. In XIX Congreso ALTEC, Lima, Perú.

46. Vieira, I. G. O., et al. (2020). Balanço hídrico climatológico mensal para o município de Castanhal – PA em eventos de ENOS e efeitos na produção do açaizeiro. In COINTER PDVAgro. Sociedade 5.0: Educação, ciência, tecnologia e amor. Recife.

47. Wasserman, A. I. (2010). Software engineering issues for mobile application development. In Proceedings of the FSE/SDP Workshop on Future of Software Engineering Research, FoSER '10 (pp. 397–400). New York, NY: ACM.

48. Yates II, M. (2010). Practical investigations of digital forensics tools for mobile devices. In Information Security Curriculum Development Conference (pp. 156–162). New York, NY: ACM. Available at: http://doi.acm.org/10.1145/1940941.1940972. Retrieved February 18, 2024.

49. Zambonato, B., Klebers, L. da S., Farias, S., Grigoletti, G. de C., Dorneles, V. G., & Pippi, L. G. A. (2021). A proposta de método de inventário da arborização urbana. Revista da Sociedade Brasileira de Arborização Urbana, 16. Available at: http://dx.doi.org/10.5380/revsbau.v16i4.83602. Retrieved April 20, 2024.

50. Zhang, L., Gupta, D., & Mohapatra, P. (2012). How expensive are free smartphone apps? ACM SIGMOBILE Mobile Computing and Communications Review, 16(3), 21–32.

Revista ARACÊ
ISSN: 2358-2472

51. Ziller, S. R. (2000). A Estepe Gramíneo-Lenhosa no segundo planalto do Paraná: Diagnóstico ambiental com enfoque à contaminação biológica. (Doctoral dissertation, Universidade Federal do Paraná, Curitiba). 268 p.

Revista ARACÊ
ISSN: 2358-2472

ATTACHMENTS

APPENDIX 1 – FORM ON USING THE URBANTREE APPLICATION

Evaluation of the Experience with the UrbanTree Urban Afforestation Application.

This questionnaire is a fundamental part of my Course Completion Work (TCC) and seeks to capture your perception and experience when using the application. Your answers will play a crucial role in the development of this academic project, contributing to improving the effectiveness and usability of the app.

* Indicates a required question

ABOUT THE APP USER
What's your name?
_____
Email?
_____
Institution?
_____

EASE OF USE
Was it easy to learn how to use the app?
I totally agree
I partially agree
I partially disagree
Totally discord

Was I able to understand what happened while using the app?
I totally agree
I partially agree
I partially disagree
Totally discord

Did I find the app easy to use?
I totally agree
I partially agree
I partially disagree
Totally discord

Was it easy to enter data into the app?
I totally agree
I partially agree
I partially disagree
Totally discord

Revista ARACÊ
ISSN: 2358-2472

Does the application meet the needs of urban tree registration?
I totally agree
I partially agree
I partially disagree
Totally discord

Even in a hurry, would I be able to perform the tasks in the app?
I totally agree
I partially agree
I partially disagree
Totally discord

APP INTERFACE
Did I find the app's colors and icons pleasing?
I totally agree
I partially agree
I partially disagree
Totally discord

Was I able to see all the buttons and information in the app well?
I totally agree
I partially agree
I partially disagree
Totally discord

Did I easily understand the words, nomenclatures and icons of the application?
I totally agree
I partially agree
I partially disagree
Totally discord

Are the images and icons in the app easy to recognize?
I totally agree
I partially agree
I partially disagree
Totally discord

Was I able to see all the features of the application?
I totally agree
I partially agree
I partially disagree
Totally discord

Was I able to navigate all the screens of the app well?
I totally agree
I partially agree
I partially disagree
Totally discord

Revista ARACÊ
ISSN: 2358-2472

APP FUNCTIONS
Is the registration of species easy?
I totally agree
I partially agree
I partially disagree
Totally discord

Are tree indications useful?
I totally agree
I partially agree
I partially disagree
Totally discord

Is the legislation present in the application useful?
I totally agree
I partially agree
I partially disagree
Totally discord

Are the books available in the app useful?
I totally agree
I partially agree
I partially disagree
Totally discord

ADJUSTMENTS IN THE APP
What is your opinion about the app?
_____
What would change in content and functionality?
_____

Revista ARACÊ
ISSN: 2358-2472

ANNEX 1 – Species registration form

I - LOCALIZAÇÃO E IDENTIFICAÇÃO

Data: / /	Via Pública:	Nº	Bairro:
Nome Comum:	*Gênero:*	*espécie:*	Calçada: (m)	Rua: (m)

II - DIMENSÕES (CM)

Altura Geral:	Altura da 1ª Ramificação:	Diâmetro da Copa:	PAP:

III - BIOLOGIA

Estado geral	Equilíbrio geral	Fitossanidade		Intensidade	Local/ataque	Injúrias	Ecologia	Fenologia
ótimo ☐	Sim ☐	Pulgão ☐ Broca ☐	Inseto ☐		Caule ☐	Lesão grave ☐	Insetos ☐	
bom ☐	Não ☐	Cupim ☐	Bactéria ☐	Leve ☐	Raiz ☐	Lesão média ☐	Ninhos ☐	Folha ☐
regular ☐		Formiga ☐	Vírus ☐	Médio ☐	Frutos ☐	Lesão leve ☐	Liquens ☐	Flor ☐
péssimo ☐	Caule ☐	Lagarta ☐	Fungo ☐	Pesado ☐	Flores ☐	Lesão ausente ☐	Epífitas ☐	Fruto ☐
morta ☐	Copa ☐	Cochonilha ☐	Acaro ☐	Ausente ☐	Ramos ☐	Vandalismo ☐	Parasitas ☐	
		Vaquinha ☐			Folhas ☐			

IV - ENTORNO E INTERFERÊNCIAS

Local geral	Localização relativa	Pavimento	Afloramento de raiz	Participação	Tipo fiação	Tráfego
Cant. central ☐		Terra ☐	Calçada ☐		Derivação ☐	
Calçada ☐	Junto a guia ☐	Cimento ☐	Canteiro ☐	Isolada ☐	1ª. ria ☐	Leve ☐
Praça ☐	Junto a divisa ☐	Pedra ☐	Construção ☐	Duas ou mais ☐	2ª ria ☐	Pesado ☐
Via pública ☐	Centrada ☐	Cerâmico ☐	Leito carroçável ☐		Tel ☐	Médio ☐
		Grama ☐				

Recuo? ☐ **Situação adequada?** ☐ **Manilha** ☐ **Colo pavimentado** ☐ **Árvore dentro do imóvel** ☐

Fiação	Posteamento	Iluminação	Sinalização	Muro/Construção
Atual ☐	Atual ☐	Atual ☐	Atual ☐	Atual ☐
Potencial ☐	Potencial ☐	Potencial ☐	Potencial ☐	Potencial ☐
Ausente ☐	Ausente ☐	Ausente ☐	Ausente ☐	Ausente ☐

V - DEFINIÇÃO DE AÇÕES

Ação executada	Ação recomendada
Poda leve ☐ Poda pesada ☐ Plantio ☐ Reparos de danos ☐	Poda leve ☐ Poda pesada ☐ Plantio ☐ Reparos de danos ☐
Controle ☐ Substituição ☐ Ampliação de canteiro ☐	Controle ☐ Substituição ☐ Ampliar canteiro ☐
Qualidade da ação: Ótima ☐ Boa ☐ Regular ☐ Péssima ☐	Outra: