Mobility in the City and the University Campus Role: From an Outcome of Urban Anomalies to a Vector of a Sustainable Transition

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Abstract. The campuses of the most recognized Brazilian universities were an outcome of the country's modernization, which had the automotive industry as one of its most significant symbols. If the automotive industry has attracted massive public funding without much opposition, universities should provide more rigorous and systemic criticism. However, this is not the case. These universities have reproduced the cities' idiosyncrasies, offering free parking and communicating through their campuses the cars' predilection over pedestrians, public transportation, and the natural environment. This article aims to explore digital data from the Federal University of Santa Catarina main campus offering evidence to support deconstructing this message to their students, staff, and society towards a more sustainable and systemic approach, through a significant campus planning shift. To understand current circulation dynamics, we have investigated several university databases, such as the staff and students' home addresses and the Wi-Fi authentication records to the Eduroam network distributed in the campus territory. 538 access points registered nearly 30,000 daily users, who generated around 2 million records every day, containing the authentication time and the access point geographic coordinate. The studies' results illustrate mobility patterns of the academic community inside and outside the campus to support strategies to challenge the current campus planning. We conclude with a proposal for a more resilient campus based on environmental regeneration, particularly along the campus streams to connect the pedestrian entrances, stimulating inclusivity through a diversity of encounters, and promoting active mobility and public transport initiatives associated with parking shrinkage.

Keywords: Active Mobility · Social Inequalities · Campus Planning · Eduroam Authentication · Regenerative Design

1 Introduction

Through the implementation of a multidisciplinary approach, this study aims to examine inflection points in the role of Brazilian public universities regarding mobility and the planning of resilient and regenerative cities. Specifically, we aim to emphasize the

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data potential, such as the Eduroam Wi-Fi authentication database, to inform campus planning, as well as to explore the campus public open spaces and the surrounding communities through human mobility dynamics. We will shed light on socio-political and mobility infrastructure decision-making in the past that had a lasting impact on Brazilian urban life and has continued to do so to this day on many scales and social spheres. Impacting the car-pedestrian relationship is critical to our study, particularly when we verify the lack of a systemic approach to evaluate these vehicles' complexity that has contributed to severe urban problems, progressively exacerbating Brazilian cities' inequalities.

Private motorized vehicles embody Brazilian inequalities in the cities. During the last decades, the country has led inequality rankings in South America and even in the world. In the late 1980s, this inequality level slightly decreased, with a more significant reduction after the 2000s [1]. However, the cutback in state social benefits, exacerbated by the COVID-19 pandemic, might have changed this scenario in the last few years [2]. Addressing the private vehicles issue in city planning is a major challenge in most developing countries and Brazil has some particularities that make it even harder. Modernization in the country has been closely associated with the automobile industry since its implementation in the mid-XX century. American car companies inaugurated this industry, incorporated by Brazilian discourse as a national product, and advertised to middle-class owners with a message that impacted even those who could not afford them [3]. "This national auto industry played into ideas about the link between consumerism and citizenship, as owning a car became a key component of Brazilian identity" [3 p.9]. Therefore, private vehicles are not only a social status symbol, but carry an image of a progressive country, society, and citizens.

The negotiation to implement the automobile industry in the country was initiated by President Getulio Vargas's (1951–54) administration, but it really launched during Juscelino Kubitschek's government (1956–1961). Kubitschek is known for the slogan "fifty years progress in five" and followed the Fordism approach, conveying the message of turning the poor into consumers and citizens as factory workers [3]. He was able to design, construct and inaugurate, in his five-year administration, the new capital in the heart of the country. Brasília "was the most accomplished symbol of this project of progress, development, and modernization […] and was designed to mirror to the rest of Brazil, the modern nation that it would become" [4 p.395–396]. Strictly following the CIAM precepts, the city's national-developmentalist project of modernization had the motorized private vehicles as a radical structuring component, making it nearly impossible for the pedestrian experience. Although advertised as a socially egalitarian plan, it displayed the opposite result augmented by cars and garages for every apartment [3, 4]. Most of those who had conditions to own it live in the planned city and most of those who do not have, live in the informal outskirts.

The automotive industry played a significant role in a country urbanized mostly near the coast. The placement of Brasília in the middle of the country represented the power of this industry that provided technological means to deal with the great geographic challenges. Therefore, investment in road infrastructure to connect a large country such as Brazil, which did not have a proper rail infrastructure, was a Kubitschek focus. "Brasília brought about a new sense of mobility, change, and development that would unleash

the nation's true potential as a great regional and perhaps even world power" [3 p.137]. Although this industry has been, since then, entirely controlled by international companies, it has been largely funded by the state, with privileged incentives not shared by other industrial sectors [5, 6]. The automotive industry's economic power is gigantic, it represents in the last decades around 15% of the country's GDP [7], and it is intrinsically embedded in the government decision-making from the city to the national levels. Regardless of its ideology, every government since Kubitschek has supported this industry with a significant burden to society.

One needs to consider, among other issues, the onus for the large Brazilian cities of vehicle increments in the last decades. The Brazilian vehicle fleet grew 84.22% from 2006 to 2015, starting with 7.8 inhabitants per vehicle in 2006 to reduce to 4.8 in 2015 [8]. Such a complex issue requires a systemic approach and multiple strategies [9]. Private vehicles have significantly impacted the economy of Brazilian cities, similarly to other Latin American counterparts. Among other expenditures in this region, traffic congestion may cost up to 10 percent of the GDP, and another 5 percent is diverted to road accidents [10]. Public investment in road infrastructure and transportation should focus on these expenses associated with social well-being. However, even when advertised as public transport-oriented initiatives, these enterprises frequently penalize the lower-income population while providing gains to higher-income groups [11]. Furthermore, between 2000 and 2012, bus transport fares costs had much higher growth than items associated with private transport [12]. Another study [13] confirmed these results, demonstrating that between 2006 and 2017 bus fares had a much more significant increase than gasoline prices.

The 2022 presidential campaign promoted an extreme break in Brazilian society [14]. One of the few issues that both candidates and former presidents, Lula (2003–2010) and Bolsonaro (2019–2022), agree on is the support for the automotive industry. Lula's political trajectory and the Workers Party were nurtured in this very industry's labor union. His first two turns as president displayed protection for the automotive industry directly associating it with the nation's economy and the belief that cars should be available to lower-income citizens [3]. Bolsonaro, on the other side, oriented his discourse during his government towards a free-market economy [15] – maintaining the public incentives to the automotive industries, and a few other privileged enterprises of the government supporters –, to the right-wing "growing mistrust and the need to feel safe from others" – embodied in the spread of large Sport Utility Vehicles (SUVs) – [16 p.57], as well as the dissemination of motorized demonstrations as his campaign symbol.

Confronting this national consensus is a major challenge and our argument is that the university has a major responsibility to assume such leadership. Furthermore, it is not enough to disseminate this idea in some research groups, classes, publications, or institutional missions [17]. If the university continuously communicates an opposite message through its own actions – and the campus is one of the most relevant instruments –, this is the one that is disseminated [18]. Therefore, to promote a major shift in the academic community, one that will be multiplied by its students and staff, it is foremost for Brazilian universities to divert from car prioritization to privileging pedestrians, green open spaces, and personal encounters.

Promoting encounters is embedded in the very notion of the university campus existence and should direct every planning action. For Kellerman [19], moving in space is guided by three major needs, curiosity in searching for information and knowledge, desire for proximity, and interaction with other human beings. For the author, these needs are best accomplished while walking or using public transport, while the car serves only the primary function of locomotion. The study by Solnit [20] follows this argument, stating that "the frankness of the encounter and the fluidity of the contact" provided by walking cannot be reproduced even by driving very slowly.

Thus, our study's challenge is to demonstrate, through digital data available at the Universidade Federal de Santa Catarina (UFSC), the feasibility, gains, and obviousness of necessary changes in its main campus. Furthermore, these changes oriented towards walking and environmental regeneration are intrinsic to the university mission [21]. We have summarized above the Brazilian construction of the car's mythos inherited in an indisputable worldview shared by most university decision-makers. Therefore, we aim to geographically display the association of different university databases to support a narrative that could deconstruct such a strong discourse. The studies described below are part of a broader research project on the university campus regenerative development. This research departs from a systemic understanding of the region's ecosystem and its urbanization, particularly related to the campus' rivers. It searches for synergies between campus planning and environmental dynamics. Along these lines, understanding human dynamics is key to pursuing shared positive impacts. Therefore, staff and students' home addresses and the Eduroam Wi-Fi authentication records became the main data sources of these studies, and they exhibit the relevance and feasibility of campus investments' prioritizations concerning walkability and environmental regeneration. The results of the mobility studies within and outside the campus quantify the academic community with a potential to reach the campus by walking or with public transport and when they arrive on campus, the studies illustrate the more used pathways, those that connect to the main campus entrances and those with the capacity to promote interdisciplinary encounters. Furthermore, they display the potential of using the university's streams as circulation axes for pedestrians, for environmental regeneration, and ultimately, for the university's resilience to the climate extreme events that frequently impact the university campus [22].

2 Case Study Context

The Brazilian public universities and other state-financed enterprises guided a series of infrastructure investments linked to land valorization and urban sprawl. A federal decree established the UFSC in 1960 – the year of Brasília's inauguration – as part of the national modernization plan. The new capital proudly represented the national urbanization ideal. Therefore, since the first master plans for the UFSC campus, in the city of Florianópolis, from the late 1950s and early 1960's functionalist zoning and segregation from pedestrians and cars determined the university territory. One emblematic passage from the second master plan emphasized the buildings and its dedicated great parking lots as a symbol of the university nobility [23]. Later, in the 1070s, the most recognized Brazilian landscape architect, Roberto Burle Marx, developed a plan for the university's

main square removing the roads that fragmented its space. Burle Marx, notorious for his landscape designs in Brasília, planned an exclusive pedestrian connection to the main buildings of the campus at the square edges. Another symbolic move of Burle Marx's plan implementation is that the square pavement and gardens followed his instructions, but the roads for motorized vehicles have mutilated the square until today [24].

The military regime (1964–1985) followed the coup d'état by the Brazilian Armed Forces in April 1964, through convergences with the United States. Their agreements with territorial implications on Brazilian public campuses are crucial points of the spatial strategies implemented nationwide. UFSC embodied these strategies that promoted strict spatial disciplinary fragmentation on the campus. The fragmentation of different worldviews on campus and its separation from the rest of the city was particularly suitable for the military regime and became an obstacle to a systemic approach to mobility, environmental regeneration, biodiversity, and equity.

The current campus infrastructure and the prioritization of cars as a commuter alternative are entangled factors. Precarious active mobility infrastructure, irregular – or inexistent – deteriorated sidewalks, unsafe bicycle lanes, and, especially, free parking, are among the most conspicuous campus features emphasizing private vehicles overactive and public transportation modes. The faulty physical connectivity between the campus and the city leads to results such as those seen in the survey carried out by the university [25]. More than 70% of faculty and 52% of staff use their own car to reach the university, but 30% of the students prefer walking as their means of commute, according to the results of an online questionnaire. These dynamics have a critical impact on campus, mainly in land occupation and in the suppression of public spaces for encounters and green areas. Today, 34.134 m^2 of the streams' margins on campus, which are environmentally protected under federal law, serve as free parking spaces as well as internal vehicle pathways [26].

The UFSC main campus is the most prominent bus travel attraction hub in the Florianópolis metropolitan region for students [27] and acts as a point of confluence between human and natural flows. Based on the lower areas of the Itacorubi Basin, the campus collects water from the surrounding hills. The implementation of the UFSC campus has a profound impact on the urban landscape, as it influences the expansion of new infrastructure in the Itacorubi Basin region (Fig. 1). However, this expansion has caused frequent floods on campus, traffic congestion, pollution, and the depletion of natural resources.

3 Methodology

We have developed for this paper studies structured from three main specific databases: the vector-based physical information of the campus (buildings, infrastructure, road system, and natural features), the home address registered at the university Identity Management System (idUFSC), and mobility inside the campus, captured by the Eduroam Wi-Fi authentication database. The integration of the university databases in an interdisciplinary process involved the Superintendency of Electronic Governance and Information (SETIC) and other administrative sectors, and researchers from the Computational Security Laboratory (LABSEC) and the Urban Ecology Laboratory (LEUr). Data complexity

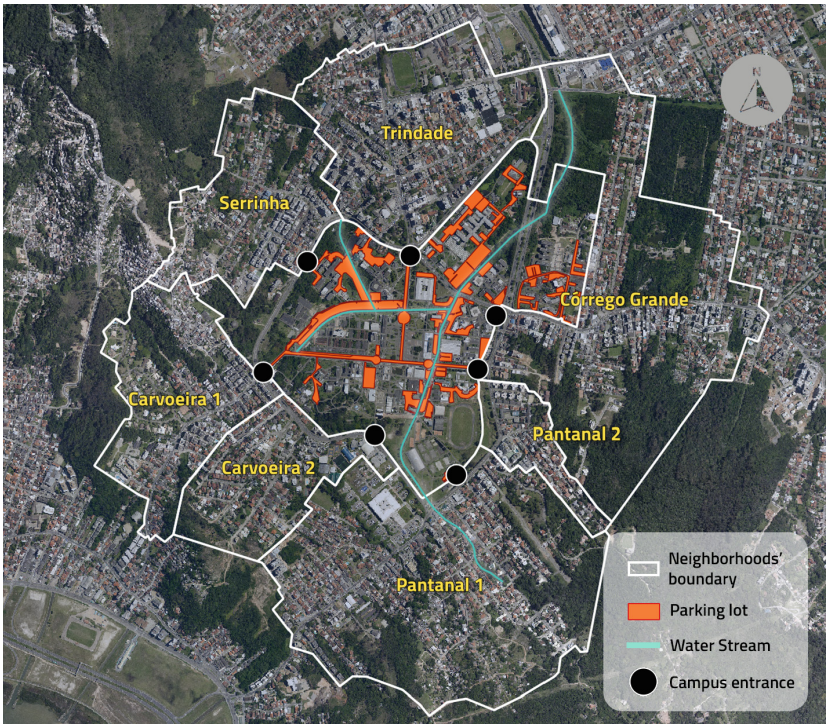


Fig. 1. The urban and natural context of UFSC main campus.

resulting from the large quantity of Eduroam authentication records required specific procedures to manage and dynamically visualize the volume of stored data, according to the Brazilian data protection regulations, which have demanded strict protocols to provide data safety to other interested parties.

We identified a strong potential of the idUFSC platform, which stores records of each university member, such as personal data and academic information. Despite the relevancy of idUFSC's home address records, the database was outdated and obsolete. A partnership established in 2019 with the University President's Office focused on the mobility dynamics and resulted in 39,108 members (74% of total registrations) updating their addresses and authorizing the use of personal data for academic surveys through the SETIC's supervision.

The Eduroam Wi-Fi authentication database represented a central role in these studies, providing relevant data on human dynamics that would be difficult to acquire with other methods. Eduroam service has provided worldwide, since 2002, Wi-Fi access to the larger international research and education community. Each device authentication process generates log files associating user identification and the connection's location and time. Location is given by the access point geographic coordinates, which has an approximately 50-m radius of coverage. Around 500 access points generate millions of daily records.

The queries' definition for the Wi-Fi studies is directly associated with the anonymization process and data manipulation and treatment to guarantee the quality of the results. These queries concentrate on the studies inside the campus, while their association with dynamics outside the campus is mainly regulated by the user's home address. Data group characterization initiates the queries which proceeded to define the patterns evaluated by the search algorithms. After choosing the data groups, the records are selected, extracted, and made available by SETIC to LABSEC, which was responsible for anonymizing the results. One of the techniques for this process is β-k-anonymity, devised by Gomes [28] for the trajectories anonymization and personal data protection, establishing a k value equal to or greater than 5 to define the valid sets. Therefore, more than 4 records are necessary to validate the results. Since the larger the data groups, the better the results' quality due to the anonymization process, electing group categories constituted a major challenge, ensuring a balance between sample quality and avoiding user identification.

Therefore, if we use large disciplinary fields, such as Human Science, Technology, Health, and Social and Economics, we miss less data than if we use every university department to group students circulating in each walkway per hour, for instance. To reduce data losses, it could be better to group results in even larger groups, like undergraduate students, graduate students, staff, and faculty. The same applies to spatial dimensions chosen for the group, such as the access points grouping. The smaller the group of connected users, the greater the risk of data loss due to not meeting the minimum β-k criteria. Thus, we agreed to group data in predefined spatial clusters for each case. To explore the Wi-Fi authentication records, for example, we gathered the 538 access points into sectors named from A to J that, in smaller polygons, define blocks numbered from 1 to 4.

4 Studies on Academic Community Mobility

The work involving digital data and external mobility seeks to understand the university's territory based on its positive or negative impacts in the urban context of the city. The selection of home addresses initiated the studies outside the campus of the active modes of transportation. The challenge was to use logical methods to manipulate postal codes, anonymizing personal data in the records. We have assigned on the QGIS platform each postal code to streets and identified the streets within a polygon calculated by walking time on the routes connecting them to the Campus. Using this strategy, vectorized polygons with origin (residential streets) are grouped by five-minute walking intervals to the destination (campus). The individual home address records, related to the 5-min walking polygons, ensured enough records in the groups to reduce losses in the anonymization process. We have classified the academic community for this study into four categories (undergraduate students, graduate students, staff, and faculty) and the total sample constituted 35,470 individual records (67% of the total). It is noteworthy that 17% of the academic community reaches the university campus within a 10-min walk added by 3% within the 15-min polygon, a total of 7,192 academic members (Fig. 2).

Seeking to understand the dynamics of those who live over the 30-min walking polygon, the study evaluated the potential users of public transport. Crossing the idUFSC

database with the Eduroam authentication records provided each individual first and last connection times. These records, grouped in home address neighborhoods, generated two CSV files imported by the graphic tools, one with the entrance time given by the first authentication to the Wi-Fi network and another with the last authentication record, representing the departure time (Fig. 3). An initial sample of 10,284 users from the Eduroam authentication records authorized the use of their registered home addresses for the research. The anonymization process reduced the sample to 7,297 records grouped by home address associated with Wi-Fi authentication records registered every 30 min, starting at 6 a.m.

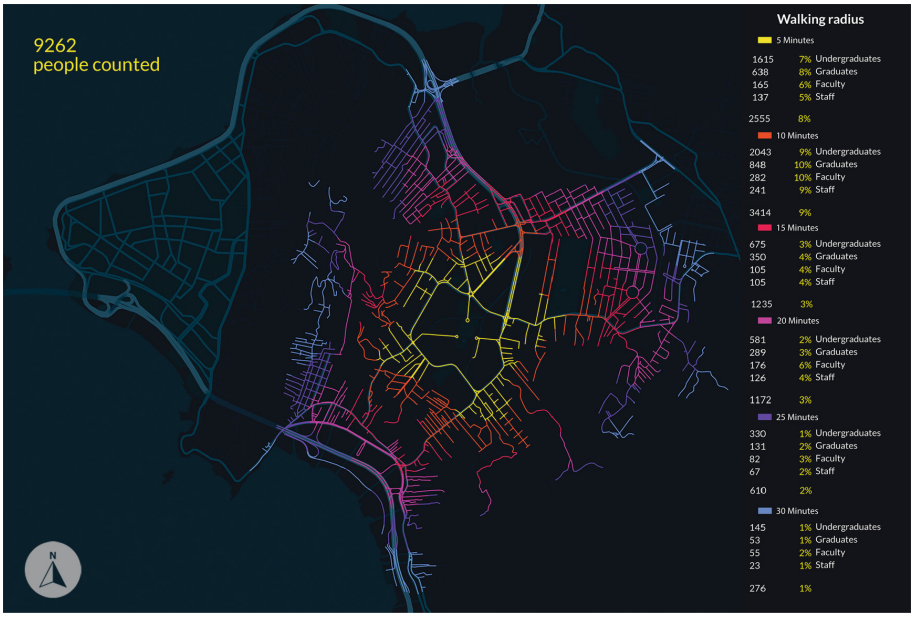


Fig. 2. Home address records classified by category (undergraduate student, graduate student, faculty, and staff) according to walking distance to the campus.

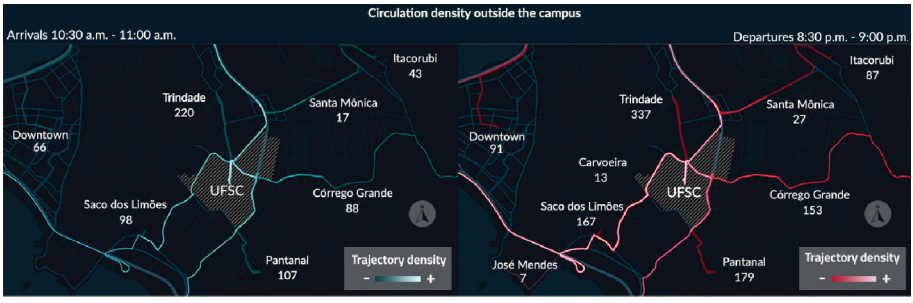


Fig. 3. Arrivals and departures according to a time interval and home neighborhood.

We were able to verify the time that students and staff arrive and depart from various locations in the city, supporting policies to move from private to public transport and reducing the need for parking spaces along the stream banks. The results obtained by crossing address records with the monitoring of authentication data to the Wi-Fi network, bring relevant evidence about the daily variation in the dynamics of entry and exit of members of the academic community. The precariousness and scarcity of infrastructure for active mobility and the little institutional incentive for public transport in line with free parking leads to the preference for individual motorized means in daily commutes. This information may be relevant to encourage municipal public transport, reducing the demand for parking on campus and freeing up free areas for an academic and social experience favored by walking around campus.

A new query developed for SETIC grouped the home address records of those who live within the 10-min polygon, distributed in smaller polygons associated with seven main accesses that connect the campus to the immediate surrounding neighborhoods (Fig. 4). Analyzes of digital data also contribute to meeting other demands of the community, such as the elaboration of inclusion policies at the university for the surrounding residents, increasing the university's extension actions, and leisure areas, and opening the university's social infrastructure to the external community. The number of 1,010 home address records in the Carvoeira neighborhood corroborates the finding that the open areas on the watercourse margins, currently occupied by parking spaces, form a relevant circulation axis for those living within a 10-min walking polygon from the campus. On the right, at the entrance to the other creek, the Pantanal neighborhood is another popular place (1,268 members). Both axes are close to the access to the Trindade neighborhood (1,456 members). The data exploration identified different problems that, based on integrated solutions between the university and municipal administrations, can inhibit the traffic of individual motor vehicles, reduce the demand for parking, enhance the use of active and collective transport, and environmental regeneration.

The choice of the 10-min polygon as a limit for this study was due to the current traffic conditions for active transport, whether on municipal roads or in the internal infrastructure of the campus. Furthermore, the 10-min polygon relates to the university border, or to one of its entrances and was obtained with the isochrone map tool v.net.iso in QGIS, which provides a new polygon with the areas reachable from a starting point within a specific timeframe [29]. For the study, we chose a walking speed of 5 km/h. Individuals may need an additional walk to reach their destinations within the campus.

Thus, to evaluate walking dynamics within the campus we have explored the Wi-Fi authentication records to quantify the trajectories, defined by the origin and destination points as two consecutive access points authentications. The time interval between the consecutive authentications determines the distinction between patterns of *movements* and *stops*. If the interval is longer than 10 min, the algorithm interprets it as a 'stop', otherwise, it indicates that the individual who carries the device is in motion. The trajectories between the origin and destination coordinates were calculated using v.net.path, the shortest path algorithm in QGIS [30]. This process generates a new shapefile representing the trajectories. We computed the sum of all trajectories in each segment of the path within the campus pedestrian network. Each segment has a maximum length of 5 m,

totaling 9100 path segments throughout the campus. We highlight that the number of trajectories in each path segment represents the academic pedestrian dynamics throughout 24 h, and the dynamics may vary for each hour, for example, during the opening hours of the university restaurant or at night, when the concentration of people is much higher in CSE (Center of Social and Economic Studies) and CCJ (Center for Law Studies) that have a large course offers in this period. Mapping pedestrian trajectories density as a heat map (Figs. 1 and 4) associated with the campus entries and the number of individuals living up to 10-min walking distance from them displays the paths' potential for internal and external connectivity.

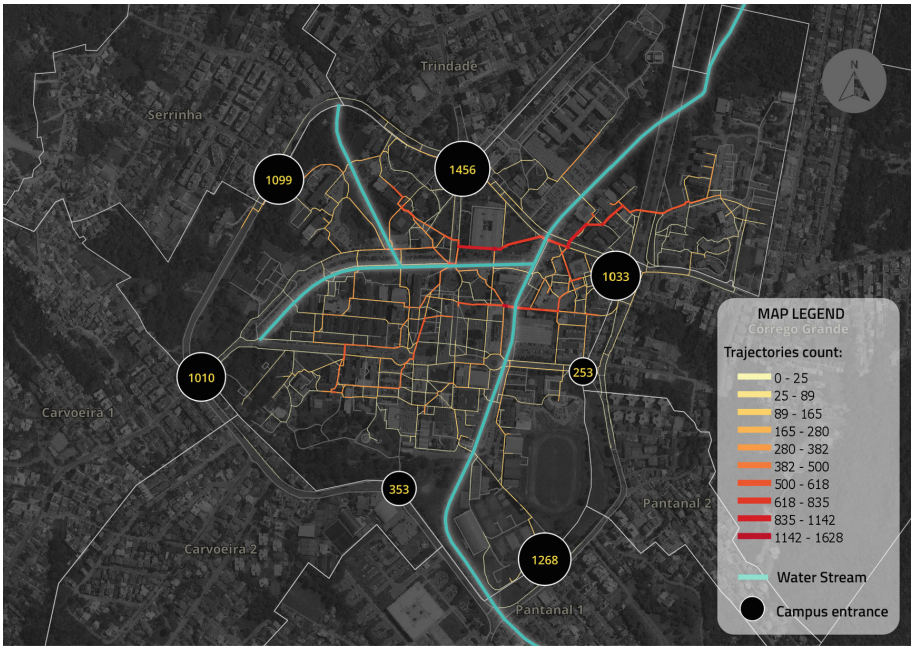


Fig. 4. Internal maps connecting the entrances.

The following study explores the routes, categorized by disciplinary fields, to identify the potential for interdisciplinary encounters among undergraduate students through circulation patterns (Fig. 5). Authentication records in the Eduroam Wi-Fi network from the largest university disciplinary centers – Technology (CTC), Communication (CCE), Health Sciences (CCS), and Philosophy, and Human Sciences (CFH) – structured this study's queries. SETIC provided the results associating the authentication Eduroam data to the idUFSC information, grouping them by the disciplinary fields. LABSEC's anonymization algorithm provided a CSV file with the number of records, with columns for the disciplinary field, the time and location of the authentication access point, with its geographic coordinates. The CSV file imported into QGIS displayed data as trajectories represented as layers of lines along the walkways that connect the origin and destination associated with the two subsequent authentication records. The path selection

represented the shortest route between the two consecutive authentication records. Line segments with lighter colors display more overlapping trajectories, suggesting greater chances of encounters between people from different backgrounds. The results allow one to identify the campus areas most visited by undergraduates from different disciplinary fields and the departure points with the highest occurrence of Eduroam authentications. According to the study outcomes, one of the busiest routes is shared by a parking area for more than 500 vehicles along the Carvoeira River' banks with a strong potential to become a new open public space.

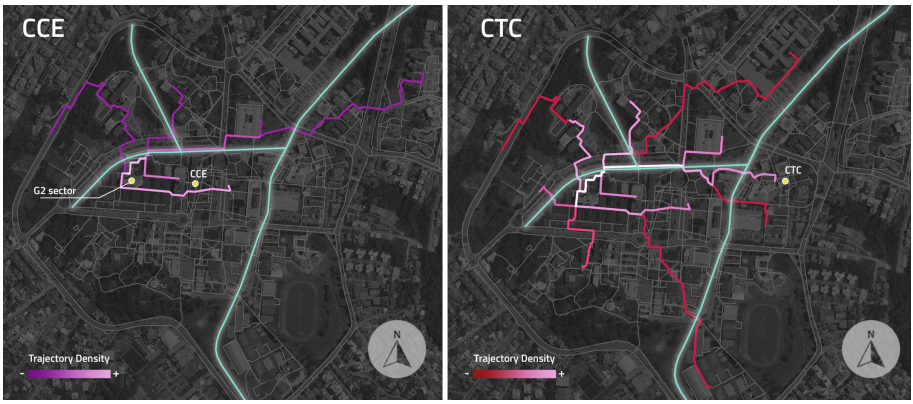


Fig. 5. Trajectories filtered by two centers CCE (left) and CTC (right) between 9:45 a.m. and 10:45 a.m.

5 A Walkable Campus to Impact CITy's Urban Strategies

Universities not only produce knowledge but are also powerful tools for addressing local and global problems, compelling society to act. UFSC's socio-environmental impact extends beyond its physical boundaries, and the university plays a crucial role in identifying and addressing urban challenges that affect daily life in the region where it is situated. Within this context, university territory must be inclusive and engage in a dialogue with the surrounding environment, considering a range of conditioning factors such as climate crises and social inequalities. This approach will enable a more comprehensive identification of problems and the development of project proposals that are better aligned with the specific context of the location. Academic and policy debate has focused on these issues from various perspectives in recent years under multiple nomenclatures: walkable cities, 15-min cities, and isobenefits, for instance [31, 32]. These works underscore how providing a fabric that connects communities, facilities, and services on foot, as well as identifying factors that influence walkability has become a crucial task in promoting life quality, environmental benefits, and social justice.

Information and communication technologies are at the core of critical urban transformations. On one hand, they act as tools to overcome physical and temporal boundaries,

on the other, they face critical perspectives over their technocratic pervasiveness and concern with data protection. This scenery persistently posits scientists – and increasingly other practitioners as architects and urban planners – to confront ICTs with newly complexified approaches, especially when dealing with concepts such as territory, the current global context, and its prospects. Data availability, data processing, and even the recent advance in artificial intelligence allowed measuring and visualizing urban dynamics and environmental data with increasing and unprecedented detail.

University campuses reflect the ideas, values, and conceptions of society from their spatial conception to their management and development policies. However, the university also nurtures studies that promote criticism of these ideas, values, and conceptions, particularly nowadays, when studies have demonstrated the vulnerability of life on the planet and the difficulty to implement the necessary changes. It is the university's duty to manifest, through its own actions, that these changes are not only necessary but possible and provide a healthier life to the community. Therefore, as a conclusion of the studies' results, we propose a design for the campus, structured by a campus park network along the campus rivers that provides the regeneration of this ecosystem with pedestrian paths to afford the experience of these noteworthy natural features (Fig. 6).

The results from the studies above demonstrate the feasibility of actions to reduce parking space, particularly along the rivers, that could be associated with charging for parking on campus. The legitimization of these locations can be done on multiple scales, from buildings to territorial planning that demonstrates the interest in caring for this ecosystem that houses it. Thus, the reduction of car parking spaces has been unfolded in proposals such as a linear park that unifies the campus with surrounding neighborhoods, and in which the increase in the section of the university's streams associates spaces for pedestrians, bike paths, and adaptation for the expansion of water in extreme climates. The park challenges a process of denying the quality of these watercourses and privileging private vehicles. Systematically, places like parks and green areas make possible the interconnection of various paradigmatic moments of what is expected for an urban life that respects and integrates with nature in its ways.

The preservation of the edges of the two main streams would allow the creation of walks and bike paths to support longer distances, in green passages that would generate a pleasant experience for traveling to other university areas. New bridges can increase interactions between centers that house the broad disciplinary fields, and these new green areas can stimulate interdisciplinary meetings and exchanges. To ensure the effectiveness of connectivity with the surrounding area, walking axes must be aligned with qualified accesses that increase pedestrian entry to the campus. The guidelines conceived from digital data are based on the principle that it is up to the university to view its streams as a distinction, that is, as an ecological and socio-spatial quality capable of mobilizing the community in environmental preservation and enjoyment, in the valorization of active mobility and in the reaffirmation of the campus as a public space. Ultimately, the proposal aims to communicate to society that these changes that significantly contribute to overall life quality are possible.



Fig. 6. Proposal for a university park network.

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