Chapter 7
Ariquemes, the 15-Minute City: A Conceptual Proposal to Strengthen Social Inclusion and Sustainable Greening Through a 15-Min Urban Planning System

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Abstract Ariquemes, located in the heart of the Brazilian Amazon in the state of Rondônia, faces a complex set of urban challenges that require innovative solutions. Historically plagued by deforestation, rapid land use change and infrastructure deficiencies, the city is grappling with the consequences of unbridled urbanization. This book chapter explores a proposed transformative urban planning system, the "*15-Minute City*," tailored for Ariquemes. This concept seeks to reconfigure urban morphology and promote social inclusion, while addressing the environmental consequences of deforestation. By weaving accessible green spaces and essential services into the urban fabric, the concept aims to create a resilient, inclusive, and sustainable urban landscape. It is an integrative methodology that combines urban planning, community engagement, and sustainability principles. The results demonstrate the potential for the 15-Minute City planning in Ariquemes as a catalyst for social inclusion and green living. This project not only demonstrate the city's ability to address these complex issues but also highlights the imperative of respecting Indigenous/minority rights and cultural heritage in the context of planning. The "Ariquemes 15-Minute City" stands as a beacon for the urban future through the adoption of the 15-Minute City concept for the urban planning system, proving that resilient and green urban living is within reach, even in the heart of the Amazon.

Keywords Ariquemes · Rondônia · Sustainable development · Urban planning · Integrative planning

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7.1 Introduction

The Amazon rainforest, often referred to as the "lungs of the Earth," is the largest tropical rainforest in the world. It stretches across nine countries in South America, with a majority of its territory located in Brazil. Within Brazil, the state of Rondônia, located in the western part of the Brazilian Amazon, holds unique importance due to its particularities. Rondônia has experienced significant deforestation and land use change, driven by agricultural expansion, logging, and infrastructure development. Its complex socio-environmental landscape highlights the tensions between conservation efforts and economic development in the Amazon.

Rondônia's history is intertwined with that of its Indigenous populations, and the state has been a focal point for discussions on indigenous rights and cultural preservation. The complex dynamics of this region serve as a microcosm of the broader challenges facing the Amazon and illustrate the delicate balance required to protect its ecological richness while meeting the socio-economic needs of its inhabitants (Nepstad et al., 2006; Fearnside, 2005).

According to the World Wildlife Fund (WWF, 2023), deforestation in the Amazon was three times higher in the first half of 2022 than in the first half of 2017. It has increased every year for the past 5 years, with no sign of slowing down.

The MapBiomas (2021) project has analyzed land use change in Brazil over the last 38 years using satellite imagery. Their data show the conversion of natural areas, such as forests and grasslands, to agriculture and pasture over this period. Most of Brazil's recent deforestation due to land use change for pasture has occurred in the Amazon region, and Rondônia state has played a key role in this story. Rondônia is located in the south-western part of the Brazilian Amazon and was originally entirely rainforest. In 2021, compared to 1985, the natural forest vegetation area in the state was reduced by 66% (Mapbiomas, 2021). The threats are related to land use changes that directly cause deforestation at the local or regional level. These include certain types of agriculture, mining, other extractive industries (e.g., oil, timber) and infrastructure that directly replace forests (Hänggli et al., 2023).

Rondônia is currently undergoing a period of major agricultural expansion, with the main crops being rice, banana, coffee, cassava, and soy. Besides the agricultural development, beef production is the main driver of deforestation in the Brazilian Amazon. However, its development has presented specific characteristics and challenges in terms of the occupation and use of the territory, as it has been marked by periods of different land use for agriculture, cattle ranching, and the exploration of mineral and environmental resources (Carvalho & Delgado, 2018).

Pedlowski et al. (1997) and Piontekowski et al. (2014) explain that the two main cycles of urban growth and development in the region were due to the nineteenth Century events and the World War II, the former being especially related to rubber extraction and the later to the exploitation of cassiterite (tin oxide, $Sn\ O_2$). These economic cycles were factors that increased the migration flow to the region.

However, these are not the only two main cycles in the growth of cities in the state of Rondônia, and the infrastructure development also plays a key role.

In 1985 the 364 Highway was built to connect Rondônia to the state of Cuiabá. This infrastructure encouraged the start of deforestation in Rondônia: Following the pavement of the highway in 1985, 8% of the region was deforested for farming. By 2017, 33% of the state's forested land had been converted to pasture and agriculture (MapBiomas, 2021).

Due to the highway construction, urbanization along the highway axis increased, also linked to the land grants made by the Institute of Colonization and Agrarian Reform (INCRA). The demarcation of settlements has led to a large flow of migration to the region, which has resulted in the expansion of the agricultural frontier and, on the other hand, has contributed greatly to the destruction of the forest (Tourneau & Bursztyn, 2010).

At the end of the 1970s, as a result of the Brazilian government's strategy of occupation and local development, implemented by INCRA, native forest areas were replaced by agriculture (temporary and permanent crops) and pastures for cattle farms (Tourneau & Bursztyn, 2010). Cardille and Foley (2003) confirm that in 1990, Rondônia had the highest deforestation indexes due to a large expansion of cattle ranching, with peaks in the municipalities of Ji-Paraná and Ariquemes. This expansion took place around Porto Velho and in areas in the south of the state.

Established in the late 1970s, Ariquemes' origins are linked to Brazil's National Integration Plan (PIN), a visionary undertaking plan orchestrated by INCRA. This aimed to unlock the Amazon's vast potential for colonization and agricultural expansion, propelling the city into existence (Nepstad et al., 2006).

Yet, as Ariquemes emerged, it became a microcosm of challenges facing the Amazon. The city's rapid development was paralleled by the reality of deforestation and dramatic land use changes, emblematic of the broader Amazonian narrative. While agricultural ambitions flourished, this growth came at an environmental cost, casting a shadow over the region's natural resources (Fearnside & Salati, 1985).

Ariquemes is the third largest population center in the state of Rondônia, with around 111 thousand inhabitants in 2022, according to the estimates of the Brazilian Institute of Geography and Statistics (IBGE, 2023a, 2023b). It is a nucleus of agricultural colonization commissioned by the INCRA, implanted on the banks of the Jamari River and close to a small pre-existing village. It was designed by the architect and urban planner Antonio Carlos Cabral Carpintero in the 1970s (de Paiva & Trevisan, 2023).

The topography and the pre-existing layout of the Highways BR-364 and RO-257 strongly influenced the position chosen for the urban core, which could not be a direct expansion of the old core, with the new city being built to the north. Carpintero also implemented two parallel roads about 2.5 km from the BR-364 Highway that functions as a structural axis of the urban morphology. These avenues delimit the Institutional Sector of the city, which has a different form of occupation, with a predominance of open spaces. This forms a different landscape in the midst of the urban layout of the city (de Paiva & Trevisan, 2023).

Perpendicular to the Institutional Sector, the connecting roads that delimit the neighborhoods of Ariquemes depart, originally called Sectors, with most shops and services placed close to the Institutional Sector. The blocks are rectangular in shape

and are laid out sequentially as a regular plot (de Paiva & Trevisan, 2023). Currently, the city has been faced with many challenges pertaining to deforestation, severe land use change, lack of infrastructure, and so on, which we will analyze further in-depth.

To explore this complex reality, this chapter begins with an overview of the historical context of the city of Ariquemes. It then examines the impact of agricultural colonization and migration to the region from the 1970s onward, which affected the region's demography, culture, and socio-economic landscape.

This book chapter also explores a comprehensive approach to green urban planning and design. Rethinking the city offers us a unique opportunity to reconcile environmental conservation, Indigenous heritage protection, and sustainable development. By adopting sustainable practices, engaging Indigenous communities, promoting cultural preservation, and forging collaborations, we aim to create a better life in the city. It is within this framework that we answer our research questions: *(1) How can we re-imagine Ariquemes as a model city that thrives in harmony with its natural environment and celebrates its diverse cultural heritage? (2) How can we reduce the impact that agricultural expansion has on the ecology and environment of Ariquemes without hindering the economic benefits produced by the city? (3) How can we integrate the lost heritage and culture of the Indigenous communities and minorities of Rondônia?*

To further elaborate this study, the following **hypothesis** is proposed: *The implementation of sustainable urban planning strategies, including the integration of green infrastructure, efficient transport systems, adequate blue infrastructure, and cultural preservation initiatives, will lead to improved environmental quality, enhanced social well-being, and increased economic opportunities in Ariquemes.* Then, a **vision** is developed to strengthen inclusivity and promote sustainable greens, using the *15-min grid concept, a city planning strategy* and a strategic roadmap to guide the next steps of urban planning and design in the city. Finally, to conclude our research, an intervention is proposed in the form of a policy and a master plan.

7.2 Methodology

To answer our research questions, we systematically reviewed the available literature on Amazonian deforestation, agricultural colonization, the history of Ariquemes, and its socio-economic growth and development, from the years 1970 to 2023. We analyzed this evidence base using a framework derived from our theoretical model to identify specific deforestation drivers and how the city of Ariquemes has been affected by it.

The following steps were conducted:

7.2.1 Analysis

A comprehensive analysis of the city was conducted at both the macro- and micro-scales. This involved gathering data on the existing urban fabric, land use patterns, infrastructure, mobility, green spaces, and social nodes. This was followed by an assessment of the current strengths, weaknesses, opportunities, and challenges (SWOT analysis) within the area. This analysis provided a holistic understanding of the context and formed the basis for the following steps.

The analysis phase was followed by the integration of geospatial tools and diverse data sources, such as QGIS software for generating NDVI, NDBI, flood hazard, and elevation maps. This is complemented by the MapBiomas data source (2021) and satellite imagery for deforestation and land cover insights, and with data from the Brazilian Institute of Geography and Statistics (IBGE, 2023a, 2023b) for social analyses.

To calculate the NDVI and NDBI of specific time periods 1997, 2012, and 2023 we used satellite imagery from Landsat-TM (for 1997 and 2012), and Landsat-8/9 OLI (for 2023). From the NDVI and NDBI maps, we can summarize that the quantity of primary vegetation has been decreasing rapidly over time, mostly due to mass agriculture and urbanization of land. Also, the quality of bare soil and the agricultural lands itself have been deteriorating over time.

7.2.2 Problem Definition

Based on this analysis, the key urban design challenges are defined. These can be divided into two distinct categories: physical problems and socio-economic problems. This step forms the basis for the formulation of strategic interventions.

7.2.3 Strategic Planning

A comprehensive strategic plan has been developed to address the identified issues and opportunities, to create a vision for a vibrant and sustainable urban environment for the city. This is to be achieved by combining the 15-minute city and mixed-use functional concepts with the grid system as well as the integration of the green spaces into the city.

7.2.4 Strategy Framework

A strategy framework outlining the specific measures and actions required to implement the strategic plan was created. This consisted of three categories of improvement: environmental, infrastructural, and social. These improvements were later applied to five distinct layers: infrastructure, commercial, residential, green, and social.

7.2.5 Toolbox Component Selection and Application

A series of toolbox components, in line with the strategic plan and the problem definition, were identified and applied to the urban design area. The process was concluded with a master plan. Architectural and urban design-oriented software such as AutoCAD, Adobe Photoshop, QGIS, and so on, were used to conceptualize and create the graphics for the Master Plan, Strategic Map, Vision Map, and many more.

7.2.6 Timeline

A timeline was created to outline the steps and milestones of the planning and design interventions, including the future developments that could take place in the city. The timeline acts as a guide for execution of public policies as well.

7.3 Analysis and Discussion

7.3.1 Macro-Scale Analysis

7.3.1.1 Deforestation

The Amazonian tropical forests have been disappearing at a fast rate in the last 50 years due to deforestation to open areas primarily for agriculture, posing high risks of irreversible changes to biodiversity and ecosystems (MapBiomas, 2021). The rural development in the Amazonia pushed the agricultural frontier swiftly, resulting in widespread land cover change. However, agriculture in the Amazon has been of low productivity and unsustainable (Nobre et al., 2016).

The loss of biodiversity and continued deforestation may lead to high risks of irreversible change in its tropical forests. Modeling studies have shown that the Amazon may have two "tipping points," namely a temperature increase of 4 °C or deforestation of more than 40% of the forest area. If these thresholds are crossed, a large-scale "savannization" (change of forest type from rainforests to savannahs) may occur, mainly in the southern and eastern Amazon. This is alarming information,

especially given that the region has warmed about 1 °C over the last 60 years, and total deforestation has reached 20% of the forested area (Nobre et al., 2016).

From 2002 to 2022, Rondônia lost 3,740,000 ha of humid primary forest, which is around 80% of its total tree cover, lost in the same period. The total area of humid primary forest in Rondônia decreased by 24% in this time (MapBiomas, 2021). However, the recent significant reductions in deforestation—an 80% reduction in the Brazilian Amazon in the last decade opens opportunities for a novel sustainable development paradigm for the future of the Amazon (Nobre et al., 2016).

According to the data collected from MapBiomas, the city of Ariquemes had an area of 347,296 ha of primary vegetation, that is, undisturbed plant community that develops in an area over a prolonged period in the absence of significant human or natural disturbances like fire or clear-cutting. This vegetation is in a stable state and is often well-adapted to the local climate and soil conditions.

The city also had an area of 150 ha of secondary vegetation, that is, plant community that develops in an area after it has been disturbed or altered in some way. This disturbance can be caused by human activities like agriculture, logging, or urban development, as well as natural events like wildfires or volcanic eruptions.

However, in 2000 this figure was estimated to be 223,150 ha of primary vegetation and 12,643 ha of secondary vegetation. Subsequently, we can observe even more decline in 2021 with only 134,635 ha of primary vegetation and 18,731 ha of secondary vegetation. When further investigated, the secondary vegetation included pasture, agriculture, forest plantation, beach, dune and sand spots, urban areas, mining, and other non-vegetated areas, with agriculture primarily constituting temporary crops like soybean, sugar cane, rice, cotton, etc. and perennial crops like coffee, citrus, and others (MapBiomas, 2021).

7.3.1.2 Land Cover Change

Land development in the Brazilian Amazon has gone through phases of rubber extraction, agricultural development, immigration, road building and the promotion of large-scale cattle ranching, timber extraction, and mining. The expanding land use activities in Rondônia have resulted in an increase in the human population and the rate of deforestation so that by 1993 about 25% of the forest area had been lost. In Rondônia, the main activities responsible for deforestation are small farmers, cattle ranchers, miners, and loggers. The implications of the Rondônia Natural Resource Management Project (PLANAPLORO), which is just now being implemented, are critical to the future of the environment and economy of the region (Pedlowski et al., 1997).

In the maps above (Fig. 7.1), we compare the land use change in Ariquemes in three main time periods: 1985, 2000, and 2021. From the data collected, we can infer that the use of agricultural and pasture has increased significantly over the last three decades, with soy being the most important temporary crop produced. Subsequently, the forest areas have decreased tenfold. Urban areas, on the other hand, have increased steadily over time and have not been the major driver of land use change. Another notable aspect is the increase in legal and illegal mining in the region (Table 7.1).

Fig. 7.1 Land cover change in Ariquemes from 1985 to 2021. (Source: Thakuria and Özdemir, with data from MapBiomas (2021))

Table 7.1 Land use change area in Ariquemes from 1985 to 2021

Land use	1985 (ha)	2000 (ha)	2021 (ha)
Forest	351,511	234,262	146,423
Agriculture	80,919	196,637	278,478
Pasture	80,919	196,633	271,182
Non-vegetated area	1658	4509	6894
Urbanized area	1424	2177	3416
Mining	234	2333	3478

Source: Thakuria and Özdemir, using data from MapBiomas (2021)

7.3.1.3 Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI)

The NDVI is a major indicator of urban climate. It provides indications of the presence of vegetation and the amount or condition of vegetation on a pixel basis. The NDVI is derived by using the surface reflectance of the red band (band 3 in TM and band 4 in OLI) and the surface reflectance of the near-infrared band (band 4 in TM and band 5 in OLI). The NDVI values range from −1 to 1, with positive values representing vegetated areas and negative values representing non-vegetated areas.

$$\mathbf{NDVI} = \left(\mathbf{NIR} - \mathbf{RED}\right) / \left(\mathbf{NIR} + \mathbf{RED}\right)$$

where NIR = band 4 (for Landsat TM—wavelength 0.76–0.90 μm) and band 5 (for Landsat OLI—wavelength 0.85–0.88 μm) and RED = band 3 (for Landsat TM—wavelength 0.63–0.69 μm) and band 4 (for Landsat OLI—wavelength 0.64–0.67 μm).

The NDBI, on the other hand, is an index for identifying and classifying built-up areas or impervious surfaces. The positive values of the NDBI indicate built-up areas and those close to 0 indicate vegetation, while the negative values represent water bodies. The NDBI is expressed as the following equation:

$$\mathbf{NDBI} = \left(\mathbf{MIR} - \mathbf{NIR}\right) / \left(\mathbf{MIR} + \mathbf{NIR}\right)$$

where MIR = band 5 (for Landsat TM—wavelength 1.55–1.75 μm) and band 6 (for Landsat 8—wavelength 1.57–1.65 μm) and NIR = band 4 (for Landsat TM—wavelength 0.76–0.90 μm) and band 5 (for Landsat OLI—wavelength 0.85–0.88 μm) (Ranagalage et al., 2017).

Figure 7.2 shows that a healthy landscape predominated the entire region of Ariquemes, with high NDVI values indicating dense primary vegetation cover in 1997. The urban region is also reflected within the map; however, it is mostly confined to the center along the edges of the major transportation channels. By 2012, the impact of deforestation for agriculture and urban expansion became evident, with a noticeable decline in NDVI values, especially in areas surrounding the city, to the North-west where lies the mines of Bom Futuro region and toward the East where lies the large-scale farms. The current NDVI calculation reflects that there is no healthy primary vegetation in Ariquemes as of now.

Figure 7.3 shows that in 1997, the NDBI values were relatively low, consistent with limited built-up areas and the prevalence of healthy vegetative cover. Subsequently, in 2012, a substantial escalation in NDBI values was observed, reflective of intensified agricultural expansion. This can be confirmed with the NDVI analysis (Fig. 7.2), which when overlayed tells us that bare soil or agricultural and pasture land have significantly increased over this period and there has been a massive tree cover loss. This trajectory persisted into 2023, with NDBI values reaching even higher levels, signifying the progressive expansion of agriculture. However, it is to be noted that roads, or other infrastructural developments like the built-up of the city has been increasing at a steady pace.

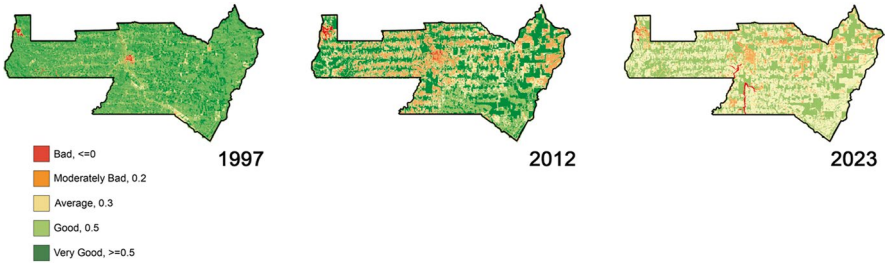

Fig. 7.2 The NDVI calculation for Ariquemes. (Source: Thakuria and Özdemir, based on Landsat images)

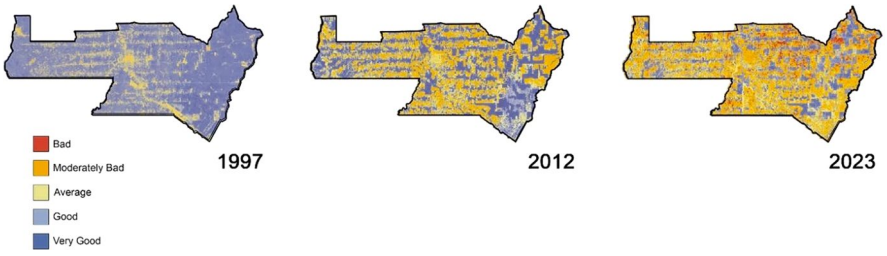

Fig. 7.3 The NDBI calculation for Ariquemes. (Source: Thakuria and Özdemir, based on Landsat images)

7.3.1.4 Topography and Flood Analysis

Ariquemes has a topography characterized by a mixture of low-lying areas and hilly terrain due to its location within the Amazon rainforest region. Specific flood analysis data from MapBiomas (2021) highlights the city's vulnerability to flooding, particularly during the rainy season when rivers and water bodies overflow. The data highlights the importance of robust water management infrastructure and flood mitigation strategies in Ariquemes.

Additionally, it accentuates the critical role of sustainable urban planning in addressing this challenge, incorporating adequate drainage systems and floodplain management to safeguard the city's population and infrastructure from seasonal flooding events. In the city, flooding issues area a major concern for the city's residents and infrastructure. The topographical characteristics, combined with heavy seasonal rainfall, contribute to the recurrent flooding events affecting various parts of the city, emphasizing the need for comprehensive flood risk assessment and mitigation measures.

7.3.1.5 Socio-Economic Analysis

The city's economy is mainly based on cattle ranching and agriculture, which has led to the conversion of forested areas into agricultural land (this phenomenon can be seen in the analysis mentioned above). In addition, the indigenous people historically living in the region have been displaced from their lands due to the urbanization and deforestation of the area. Their former lands are now mostly used for either cattle ranching or agriculture, economic activities that put pressure on the indigenous reserves and threaten the sustainability of the indigenous territories.

Most concerningly, these issues have led to the marginalization of the indigenous people, as the majority of them are no longer able to occupy the lands to which they are rightfully entitled. This leads to problems of social inclusion as well as problems of preserving the heritage and cultural identity of the minorities, as they are no longer able to experience their traditional way of life (Santos & Gomide, 2015).

7.3.2 Micro-Scale Analysis

7.3.2.1 Urban Morphology and Land use

The city is built on a grid layout system adopted on the streets and roads. In addition, the city has a central core in the strategic center of the city. The grid system has immense potential in terms of navigation and land use allocation; however, currently the full potential of this system is not being realized.

When analyzing the morphology of the city, four prominent typologies can be highlighted: The first typology covers the commercial areas; the second covers the rural residential areas; the third is the traditional urban center residential area, characterized by alameda streets, and the fourth covers the contemporary suburban residential areas (Fig. 7.4).

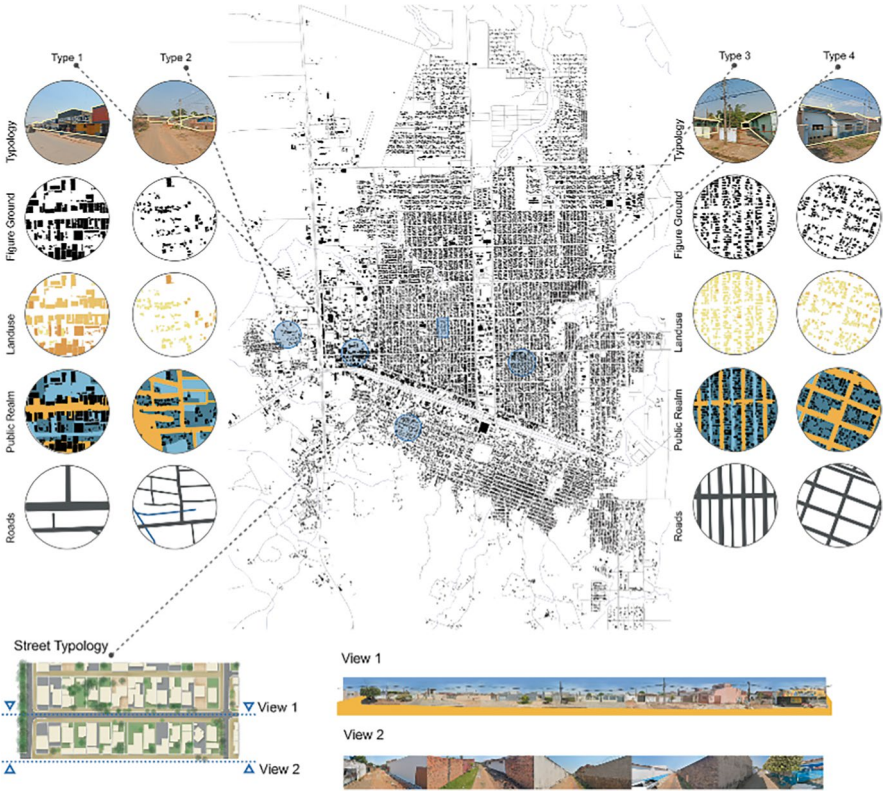

Fig. 7.4 Morphology analysis

There are three main functions, namely residential, commercial and industrial, and institutional (Fig. 7.5). These functions are usually segregated in the form of functional zones. While functional segregation can facilitate focused and efficient resource use, it can also inhibit a holistic and connected urban experience. An approach that focuses on fluid functions and their integration could create a more dynamic urban environment that fosters cross-functional interactions and synergies, contributing to a vibrant, livable city.

Overall, the existing urban fabric is characterized by its density, densely populated structures and very limited open spaces areas. Moreover, the city also lacks green spaces. Due to these issues, the city could be prone to problems of well-being, environmental stability and infrastructural resilience, as well as an unfavorable esthetic appeal of the city.

7.3.2.2 Green and Blue Analysis

Within the urban fabric, there is a notable scarcity of green infrastructure, such as urban parks, green corridors, and natural green spaces. This deficiency is most evident in the denser urban areas. Overall, the green potential of the city has not been

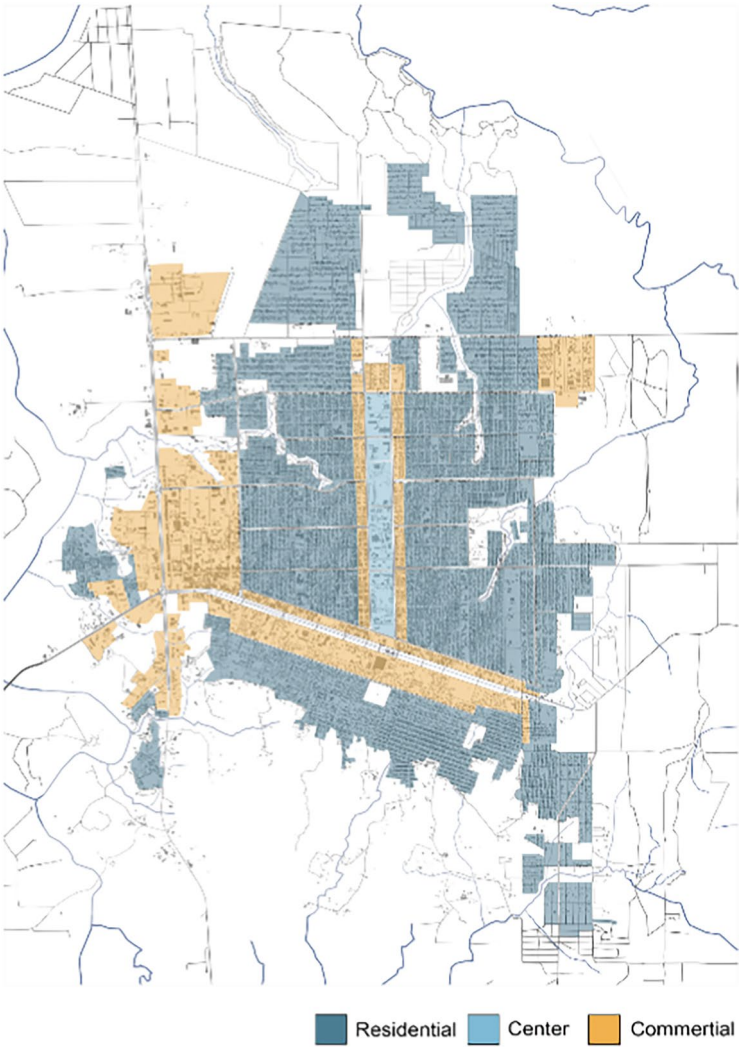

Fig. 7.5 Land use analysis. (Source: Thakuria and Özdemir)

exploited, especially in the central core, where the integration of these elements could enhance the urban landscape and create a sense of connection to the green. It is also important to note that large areas on the periphery of the city are not forest lands, but rather pasture and agricultural land, illustrating the lack of availability of the green space on the city's periphery (Fig. 7.6).

Overall, there is a disconnection between the urban landscape within the city and the landscape present at the periphery and urban edges, which raises the need for a renewed emphasis on green initiatives in order to create a more harmonious and balanced urban environment. It is also important to note that the green function also has the potential to act as a catalyst for a range of functions, including social

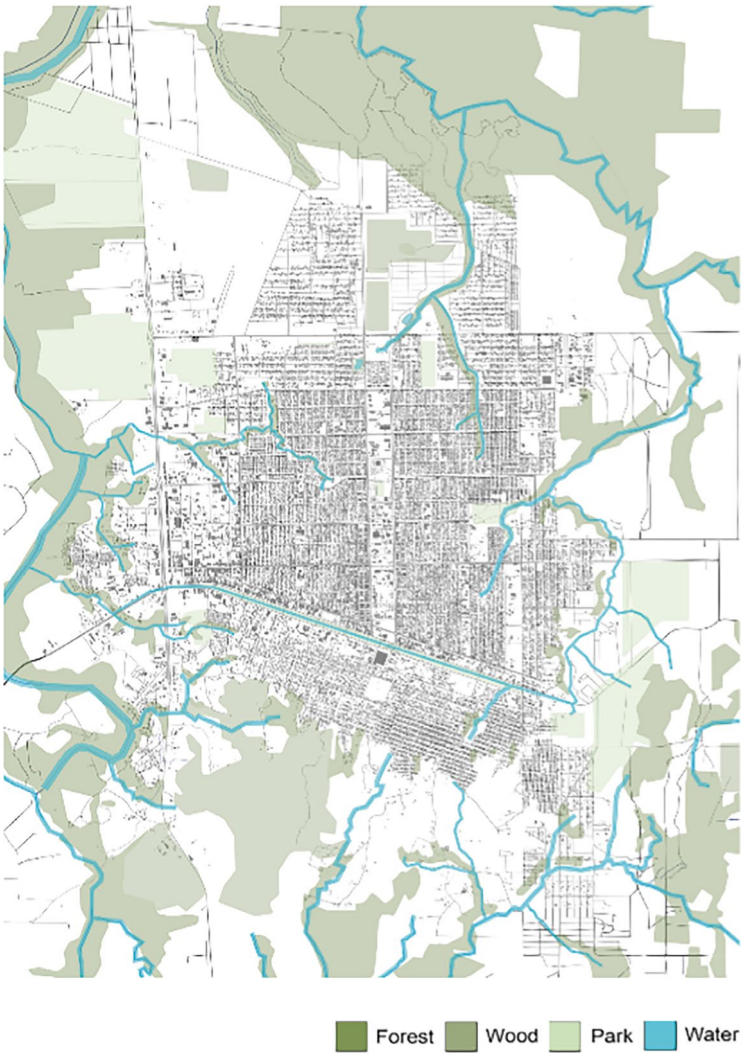

Fig. 7.6 The Green and Blue Analysis of Ariquemes. (Source: Thakuria and Özdemir)

interactions, commercial vitality, and residential improvements. Greenery can trigger a range of positive impacts across different dimensions of urban life.

7.3.2.3 Mobility Analysis

The city is isolated from its surrounding areas, due to inadequate regional mobility infrastructure. Mobility is also an issue at the city level, as public transport options are limited. As a result, people tend to rely on cars for their daily journeys. There is also no rail infrastructure in the city. The lack of a comprehensive railway

infrastructure further exacerbates the connectivity challenge. These collective shortcomings in mobility infrastructure create an urgent need for improvement not only to solve to address the issue of isolation but also to improve the overall accessibility and connectivity.

The road network hierarchy follows a structure characterized by highways as the main artery, followed by avenues, streets, and finally alamedas. This structure reflects an order designed to facilitate traffic flow and manage urban functions (Fig. 7.7).

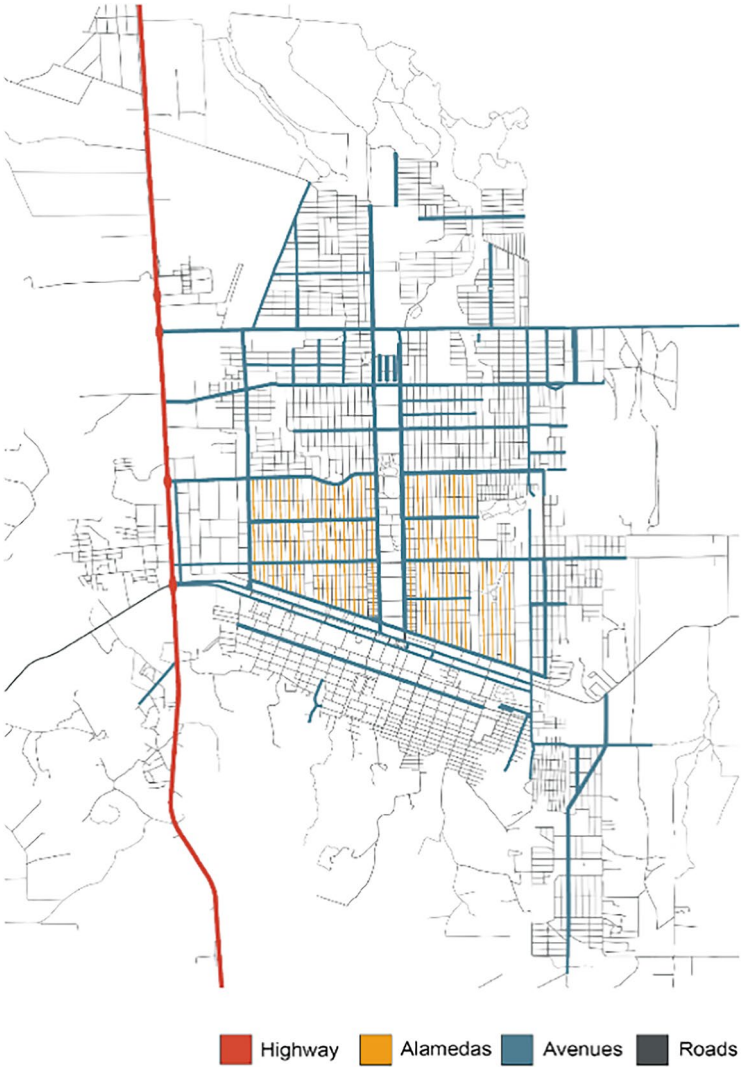

Fig. 7.7 The Mobility Analysis of the Ariquemes. (Source: Thakuria and Özdemir)

Unfortunately, the urban landscape is affected by the deteriorating conditions of both streets and buildings. This collective state of neglect contributes to a less favorable urban environment. This trend extends to the condition of the alamedas, which faces similar challenges and is part of the wider urban degradation.

As the city faces these challenges, there is a clear need for concerted efforts to improve mobility options and infrastructure, as well as the urban landscape. By addressing these issues, the city can work toward fostering a more cohesive and vibrant urban environment that benefits both residents and visitors.

7.4 SWOT Analysis

After the in-depth analysis, we can conclude the strengths, weaknesses, opportunities, and threats observed in Ariquemes, as follows:

7.4.1 Strengths

1. The presence of the city next to several natural resources, such as the Alto Jamari River, several rivers' streams, known as Igarapés, the Natural Reserve Madalena River, among others, proves to be a continuous asset to the environment around the city;
2. Even though the full potential of the grid system is not currently being used in Ariquemes, it has a functioning grid layout;
3. The proximity to larger cities like Porto Velho and the presence of the highway BR-364 prove to be an asset to the regional mobility.

7.4.2 Weaknesses

1. There is no drainage, sewage, water treatment stations or garbage disposal system within the city boundaries;
2. There are greens surrounding the city, however, there is a significant lack of urban greens within the city;
3. The city has no notable public transportation system and even lacks a railway line;
4. Within the grid system, the alamedas, designed as breathing spaces and back alleys for the residential areas, have now been neglected and left in deteriorated conditions;
5. Segregation of land use and building use results in dense and underutilized spaces.

7.4.3 Opportunities

1. There is a great opportunity to integrate the existing forests with agriculture and also introduce agriculture within the city limits to create a more sustainable agricultural environment;
2. There are significant spaces for reforestation combining them with large and vacant pasture lands;
3. The river poses opportunities to create sustainable riparian habitats for the flora and fauna to thrive in.

7.4.4 Threats

1. Monoculture farming is a threat to the climate, the environment, and to the conservation of forests because of its expansion;
2. Due to Ariquemes location in a flat region and significantly close to the Alto Jamari River and its tributaries, it is significantly affected by floods;
3. One of the major problems in this region is the deforestation and lack of greenery in the urban area.

7.5 Problem Definition

The problems in Ariquemes are multifaceted and present several major challenges that require attention and strategic solutions. We can divide the fundamental issues into two categories: physical and socio-economic.

Physical challenges include deforestation, inadequate infrastructure, and unplanned urban growth. Deforestation is driven by agricultural expansion and logging activities. This environmental degradation not only threatens the region's rich biodiversity and contributes to climate change, but also affects indigenous communities and their traditional lands. Inadequate infrastructure, including drainage, sanitation, and water supply systems, exacerbates flooding problems during the rainy season, affecting both urban and rural areas. Unplanned urban growth and deforestation for new settlements promotes the disconnection from the natural environment surrounding the city.

Socio-economic challenges include the segregation of social groups, poverty, and inequality. Addressing segregation requires the integration and empowerment of indigenous peoples, who have historically faced marginalization and displacement as a result of the region's colonization strategies. In addition, issues such as poverty, income inequality, cultural differences, lack of recognition and

representation, social inclusion of minorities, and lack of economic diversification needs to be considered. This underlines the importance of comprehensive, sustainable, and culturally sensitive approaches to addressing the issues facing Ariquemes and creating a more resilient and equitable future for the city and its people.

7.6 Vision: 15-Min City Concept, a Grid Planning System

Following the Paris Climate Change Conference in 2015, where the low-carbon city was selected as a policy agenda for large cities, Carlos Moreno introduced the 15-Minute City concept in 2016 as a framework for addressing greenhouse gas emissions (Moreno et al., 2021). The 15-Minute City concept aims to create a self-sufficient neighborhood with the essential functions of living, working, commerce, healthcare, education, and entertainment by decentralizing urban functions and services (Bocca, 2021; Ferrer-Ortiz et al., 2022). Moreno envisioned dense, connected, socially and functionally mixed neighborhoods based on the human-scale design that encourage walking and cycling (Balletto et al., 2021; Noworól et al., 2022).

In our vision for rethinking Ariquemes as a socially inclusive and sustainable city, we propose the 15-Minute grid urban planning concept based on eight dimensions: (1) Proximity to essential services; (2) proximity to public transportation; (3) built density, (4) mixed land use, (5) walkable and cyclable streets, (6) placemaking, (7) inclusivity, and (8) ubiquity. These are briefly discussed below.

1. ***Proximity to essential services:*** Residents should be able to access all essential services such as healthcare, education, work, etc. by foot, bicycle, or other non-motorized vehicle within a reasonable time from their respective place of living.
2. ***Proximity to public transportation:*** The residents should have various public transportation nearby and should be able to access them without any barriers, to reach outside the vicinity of their place of living avoiding using private vehicles.
3. ***Built density:*** The population and employment density of an area support the existence of local businesses and other services. Therefore, residents should be able to access as well as set up businesses or shops within the vicinity of their place of living.
4. ***Mixed land use:*** Residents should be able to access various land uses that fulfill all their daily needs and urban functions close to their place of living. Buildings should be able to cater to a variety of functions, for example, housing, office, and grocery store in one, to create an area that is not only saturated with uses but also creates a safe and vibrant environment for all.
5. ***Walkable and cyclable streets:*** Walking and cycling paths should be well-connected to all the urban functions provided in the 15-minute neighborhood. It should be barrier-free and comfortable for pedestrians, cyclists, and non-motorized vehicle users of all strata. Creating a pedestrian and cycle-friendly

network also encourages small-scale economic development and a more sustainable and eco-friendlier environment.

6. ***Livable public spaces and placemaking:*** Co-creation of spaces together with the people of the community to strengthen the connection and give identity to new spaces according to their needs and uses. This reduces the risk of dilapidated and unsafe spaces in the city.
7. ***Inclusivity:*** All residents should be able to move freely, safely, and without any barriers in public or private spaces, being able to make use of services irrespective of their individual capabilities, age, gender, origin, ethnicity, and so on.
8. ***Ubiquity:*** The above characteristics should be intertwined and widespread so that they are readily and easily available to each and every resident all around the city, irrespective of their socio-economic or demographic status. No space within the city should have any hierarchy.

The 15-minute grid system, as envisioned by us (Fig. 7.8):

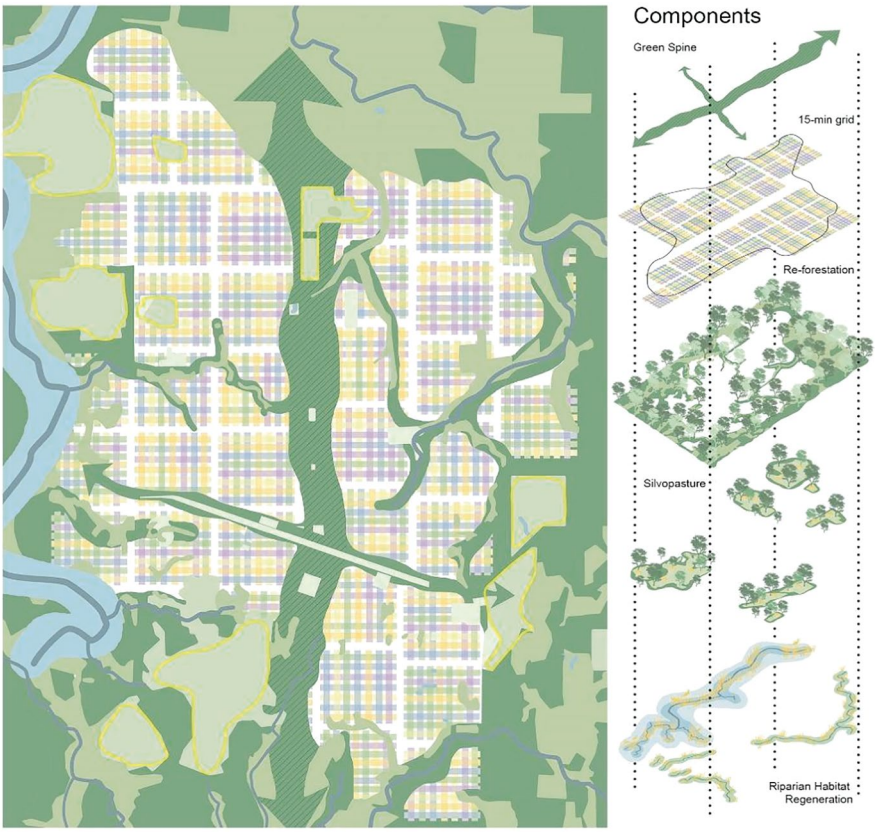

Fig. 7.8 Overall vision for Ariquemes, strengthening social inclusion and sustainable greens through a 15-min city planning system. (Source: Thakuria and Özdemir)

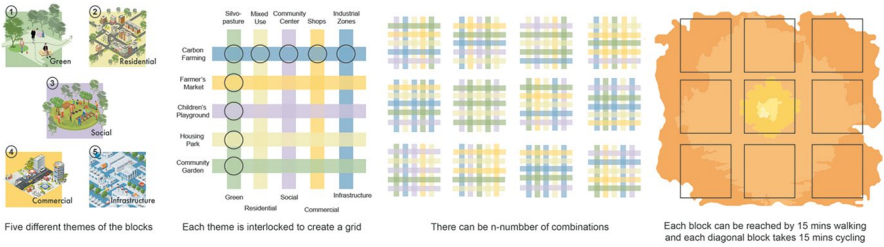

Fig. 7.9 The 15-minute grid system tailored to Ariquemes. (Source: Thakuria and Özdemir)

The "15-Minute" Grid System for Ariquemes is a transformative approach and a powerful tool to address the city's multifaceted challenges while fostering social inclusion, economic growth, and environmental sustainability. This innovative framework seeks to redefine urban living by seamlessly weaving five key themes—social, commercial, residential, infrastructure, and green—into the urban fabric, creating a dynamic and harmonious cityscape. At its core, the 15-Minute Grid System revolves around the idea that every intersection of this weave represents a distinct area with a unique function, contributing to a resilient and interconnected urban ecosystem enriching the lives of its inhabitants, and fostering a more sustainable and inclusive city (Fig. 7.9).

Social Nodes: Within this grid, social nodes are carefully integrated, ensuring that residents are never more than a 15-minute walk or bike ride away from essential community services and cultural amenities. These nodes encompass schools, healthcare centers, community centers and parks, promoting access to education, healthcare, social interaction, and recreational opportunities for all residents.

Commercial Hubs: Sprawling commercial districts thrive at various intersections, nurturing economic vitality while reducing the need for long commutes. Here, local businesses, markets, and retail establishments flourish, fostering entrepreneurship, creating job opportunities, and supporting the local economy.

Residential Enclaves: Amidst the urban weave, thoughtfully planned residential enclaves provide a range of housing options, from single-family homes to high-rise apartments. These areas prioritize green spaces, connectivity, and mixed-income neighborhoods, catering to diverse housing needs while enhancing community cohesion.

Infrastructure Innovation: Infrastructure nodes are strategically placed, addressing critical needs such as efficient transportation, smart utilities, and sustainable drainage systems. Modern transit networks, pedestrian-friendly streets, renewable energy solutions, and comprehensive waste management systems ensure the city's functionality and environmental zones.

Green Avenues: Green spaces are meticulously integrated into the weave, creating area of nature within the city. These areas include riparian habitats, parks, gardens, green corridors and urban agriculture, promoting biodiversity, mitigating urban heat, and providing residents with a connection to the natural world.

The success of the 15-Minute Grid System in Ariquemes lies in its embrace of mixed-use diversity (Fig. 7.10).

At the intersections where themes intertwine, dynamic mixed-use zones emerge (Fig. 7.9). These areas house innovative live-work spaces, cultural institutions, and entertainment venues, fostering creativity, and enriching urban experience. The horizontal and vertical interplay of these themes creates a cityscape where daily life is seamlessly woven into a vibrant spread of functionality. The 15-Minute Grid System not only enhances convenience but also encourages sustainable practices, reducing car dependency, mitigating congestion, and curbing pollution. Our vision for Ariquemes is to promote a harmonious coexistence of urban development and environmental preservation, creating a sustainable and inclusive city for future generations (Fig. 7.8).

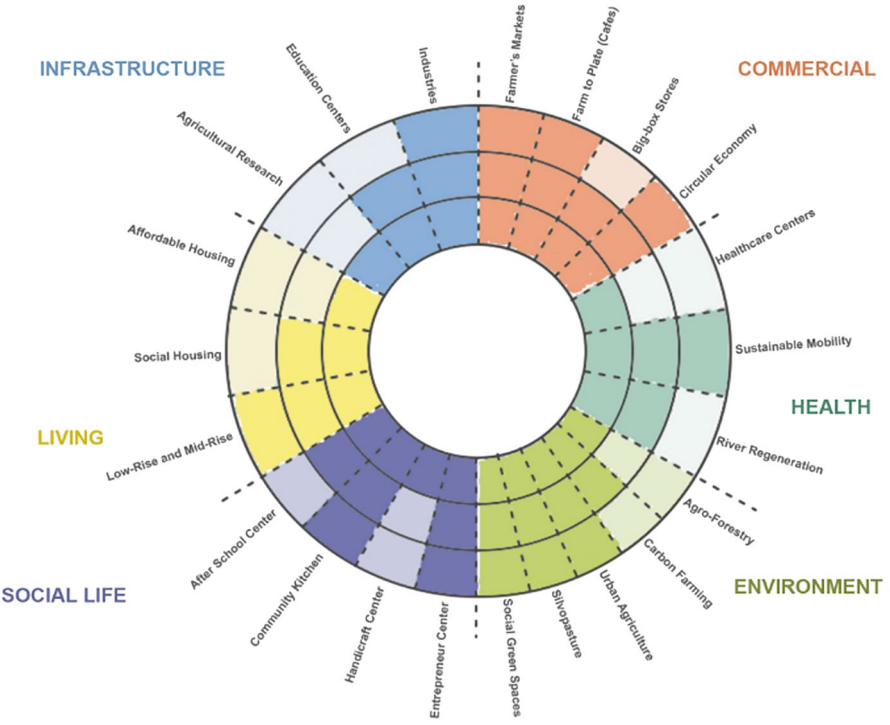

Fig. 7.10 The outcome of the 15-minute grid planning system. (Source: Thakuria and Özdemir)

7.7 Strategic Plan

The strategic plan envisages three main categories of improvements: environmental, infrastructural, and social. These categories are later applied into five distinct layers: infrastructure, commercial, residential, green, and social (Fig. 7.11). To improve the

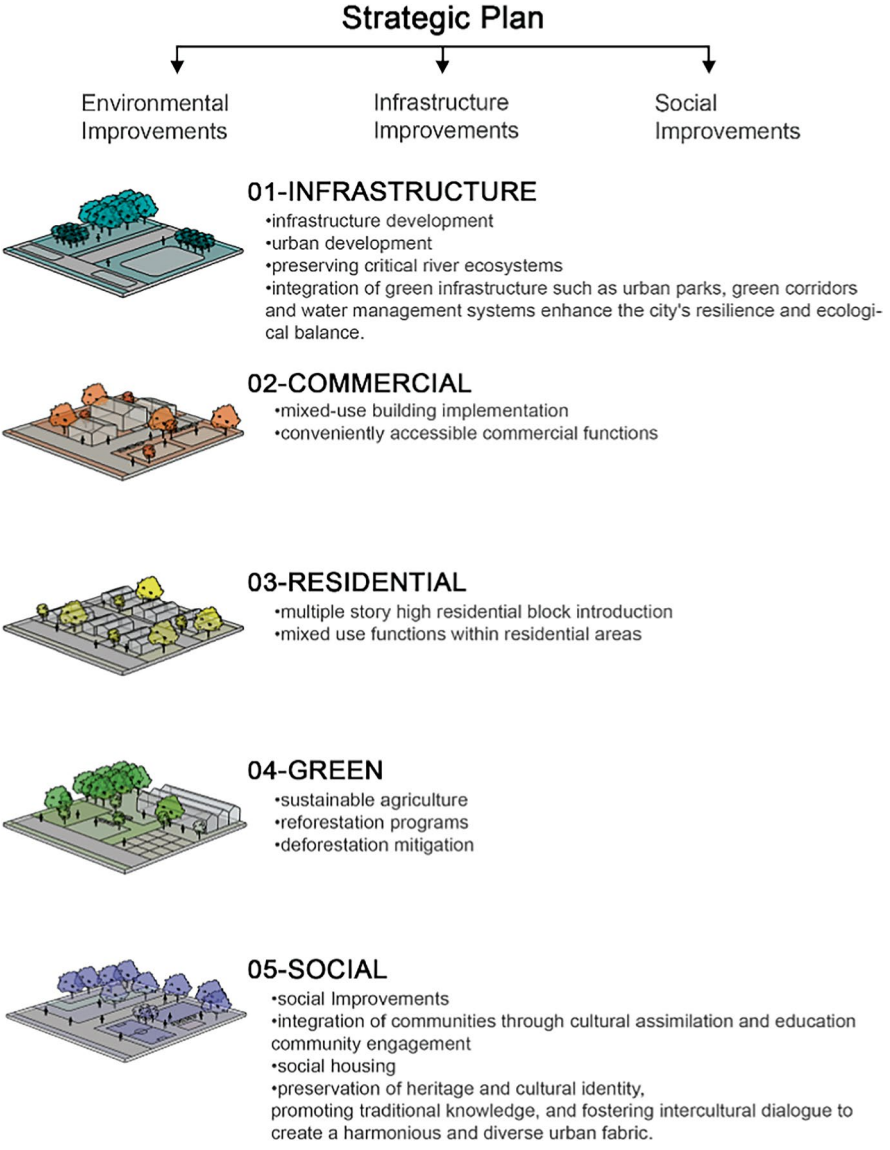

Fig. 7.11 Representation of three improvement strategies and five application layers. (Source: Thakuria and Özdemir)

city as a whole, the plan aims to create an urban landscape that seamlessly integrates a spectrum of improvements, weaving these layers into the urban fabric with renewed vitality. In this way, the city will benefit from a comprehensive transformation that considers environmental sustainability, infrastructure adequacy, social inclusion, and urban well-being.

1. ***Infrastructure***

   (a) Infrastructure development;
   (b) Progressive urban development initiatives;
   (c) Protecting the river ecosystems;
   (d) Incorporation of green infrastructure elements, such as urban parks, green corridors, and water management systems in order to enhance the city's resilience and ecological balance.

2. ***Commercial***

   (a) Implementation of mixed-use building structures;
   (b) Facilitating convenient access to commercial functions.

3. ***Residential***

   (a) Introduction of multi-story residential blocks;
   (b) Introduction of mixed-use functions within residential areas.

4. ***Green***

   (a) Promotion of sustainable agricultural practices;
   (b) Reforestation programs;
   (c) Mitigation of deforestation.

5. ***Social***

   (a) Initiatives for social improvement;
   (b) Integration of communities through cultural assimilation and educational initiatives;
   (c) Providing social housing solutions;
   (d) Preservation of heritage and cultural identity, promotion of traditional knowledge, and encouragement of intercultural dialog in order to create a harmonious and diverse urban fabric.

The strategic plan includes the integration of the 15-Minute Grid concept, which aims to improve the accessibility of daily activities and basic needs within a convenient 15-minute walking or cycling radius from any point of the city. In this case, this concept harmonizes residential, commercial, social, institutional and green functions. A key aspect of this approach is also to improve mobility infrastructure and the reduce car dependency, thereby promoting a healthier lifestyle (Fig. 7.12).

Fig. 7.12 Strategic Map 2050+. (Source: Thakuria and Özdemir)

7.8 Toolbox

The city can be made more vibrant and livable by harmonizing the urban fabric, including green infrastructure and open spaces and by improving environmental balance. The well-being and social inclusion improvements are linked with the better urban experience. In order to achieve this, a methodology is implemented with a complementary toolbox (Fig. 7.13).

Step 1: ***Current condition.***

The current urban condition of the city is characterized by the dense urban fabric in a grid system with lacks functional diversity, forming a monotonous city.

Step 2: ***Building land cover reduction.***

Some of the residential blocks will be removed to make space for the upcoming green infrastructure.

Step 3: ***Reclaiming the green and re-densification of the built environment.***

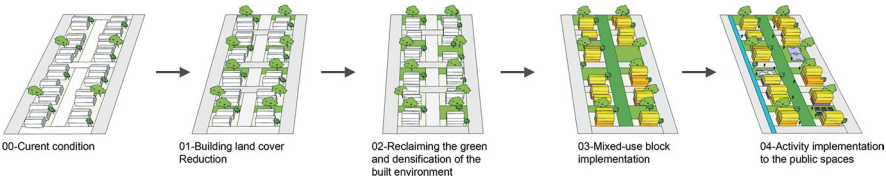

Fig. 7.13 Toolbox, step by step development representation of the selected area. (Source: Thakuria and Özdemir)

Figs. 7.14 and 7.15 View of two redesigned and reimagined alamedas of Ariquemes. (Source: Thakuria and Özdemir)

There will be a green infrastructure implementation to the newly vacant land (Fig. 7.16). Subsequently, some of the buildings will be replaced by new mid-rise blocks.

Step 4: ***Mixed-use block implementation.***

In order to enhance functional diversity, mixed-use functions will be implemented on the new midrise blocks. Moreover, the recreation of alamedas will be undertaken (Figs. 7.14 and 7.15).

Step 5: ***Activity implementation.***

The implementation of social spaces aligned with the new green infrastructure will facilitate the integration of social activities and community engagement along with a recreational corridor (Fig. 7.16).

These proposed steps have the potential to be implemented throughout the city, creating an inclusive framework for the transformation. This collective act aims to reshape the urban fabric for the benefit of a more sustainable, well-connected, and social city (Fig. 7.17).

In the future, as the development of the city continues, the aim is to continue the same strategic plan and concept, preserving the essence of the concept. This approach reflects our commitment to maintaining a consistent course of action, ensuring that future expansions are guided by the same framework that has been set for the urban city's development.

Fig. 7.16 View of an integrated urban farm, with agroforestry and community engagement. (Source: Thakuria and Özdemir)

Fig. 7.17 Masterplan, in the selected zoom-in area. (Source: Thakuria and Özdemir)

7.9 Master Plan

The central core of the original city plan is retained in the new Master Plan (Fig. 7.17), but its full potential as a green spine is now recognized. Therefore, in order to connect the Northern and Southern green proposed in the structural plan, a connective green infrastructure is introduced to the central core. The green infrastructure implementation initiative involves the incorporation of various types of green infrastructure, including botanical gardens, community farms, forest gardens, and so on. In addition, institutional and commercial functions will be implemented along with the green infrastructure, respecting what was already there. These measures will provide the link which was missing in the pre-existing formation of the city, contributing to a holistic urban fabric.

Within the designated prototype area, the strategic plan is integrated with a comprehensive toolbox of measures, characterized by the presence of green spaces and vibrant social areas integrated with a grid system. As the strategic plan covers the 15-Minute Grid concept, accessibility and affinity concepts are also present in the area. As a result, accessible public transport system can be implemented along with the presence of mixed-use functions.

7.10 Timeline

7.10.1 Year 0–5: Social Development

Year 0 Initial Planning: The city government initiates the 15-Minute Grid System project, setting the vision and goals. Public consultations begin to gather input from the community.

Year 1 Social Node Pilots: Pilot social nodes are established in select neighborhoods, integrating schools, healthcare centers, and community spaces. These pilots serve as models for future development.

Year 2 Cultural Hubs: Cultural nodes are designated, including theaters, museums, and community centers. Investments in cultural infrastructure starts, fostering creativity, and community engagement.

Year 3 Green Initiatives: Parks and green spaces are expanded, promoting outdoor activities and enhancing the city's greenery. Sustainable landscaping projects begin to improve the urban environment.

Year 4 Inclusivity Programs: Initiatives to empower marginalized communities, including Indigenous groups, are launched. Cultural preservation and awareness campaigns gain momentum.

Year 5 Education Hub Expansion: The expansion of educational institutions begins, with new schools and universities in strategic locations. The integration of education into the grid system progresses.

7.10.2 Year 5–10: Green Infrastructure Developments

Year 6 Green Corridors: Green corridors are established to connect parks and green spaces, enhancing biodiversity and providing accessible recreational areas.

Year 7 Energy Efficiency: Investments in renewable energy sources, such as solar and wind power, reduce the city's carbon footprint. Energy-efficient infrastructure projects are implemented.

Year 8 Waste Management: Comprehensive waste management systems are introduced, emphasizing recycling and reducing waste generation.

Year 9 Sustainable Mobility: Initiatives to promote cycling and pedestrian-friendly streets are launched, reducing car dependency.

Year 10 Urban Farming: Urban farming projects take place, providing locally sourced produce and enhancing food security. Rooftop gardens and community gardens flourish.

7.10.3 Year 10–15: Functional Developments

Year 11 Mixed-Use Zones: Mixed-use zones at intersections gain prominence, promoting live-work-play environments and boosting economic activity.

Year 12 Community Resilience: Disaster preparedness programs are expanded, including flood-resistant infrastructure and emergency response mechanisms.

Year 13 Affordable Housing: Affordable housing initiatives address housing inequality, providing housing options for diverse income groups.

Year 14 Public Spaces: Public spaces and plazas become focal points for community gatherings, cultural events, and markets.

Year 15 Heritage Preservation: Historic preservation efforts intensify, safeguarding the city's cultural heritage for future generations.

7.10.4 Year 15–50+: Infrastructure and Transportation Developments

Year 15 Transportation Expansion: Comprehensive public transportation systems, including buses and light rail, are expanded. Pedestrian-friendly streets and bike lanes connect the city.

Year 20 Smart Infrastructure: Implementation of smart city technologies enhances efficiency in energy use, traffic management, and public services.

Year 30 Sustainable Water Management: Advanced water drainage systems are implemented, mitigating flooding risks and ensuring a clean water supply.

Year 40 Transportation Innovation: Electric and autonomous vehicles, along with advanced transportation solutions, become commonplace.

Year 50+ Continued Evolution: The 15-Minute Grid System is fully integrated into all neighborhoods, sustaining a vibrant, green, and inclusive city. Ariquemes becomes a global model for sustainable urban living, with ongoing innovation and adaptability at its core.

7.11 Conclusion

This book chapter is based on a comprehensive approach toward reimagining Ariquemes as a sustainable and harmonious city model. It demonstrates the potential for striking a balance between economic development, environmental preservation, and cultural integration.

The implementation of a strategic roadmap embodied in the 15-Minute Grid city planning strategy is a commitment to create a city that thrives in harmony with its natural environment and celebrates its diverse cultural heritage. By integrating green infrastructure, efficient transportation systems, adequate blue infrastructure and cultural preservation initiatives, we envision an Ariquemes that not only mitigates the impact of deforestation but also enhances its future.

The sustainable urban planning strategies were designed to pave the way for a future where improved environmental quality and social well-being go hand in hand with increased economic opportunity. Our vision extends beyond the city limits of Ariquemes; it stands as a testament to the potential for responsible urban development in ecologically sensitive regions. By embracing sustainable green spaces and nurturing the cultural richness of indigenous and minorities communities, we aim to set an example not only for the Amazon, but for cities around the world. In this vision, Ariquemes emerges as a resilient and thriving city that celebrates its unique identity and demonstrates that the harmonious coexistence of nature, culture, and progress is indeed possible in the contemporary urban landscape.

To re-imagine Ariquemes as a model city harmonizing with its environment and celebrating heritage, the strategic planning prioritizes green infrastructure by developing green spaces, urban forests, and parks to enhance biodiversity and mitigate urban heat. Further it tackles sustainable urban planning wherein we implement land use policies that protect natural areas and promote eco-friendly building practices and addressing cultural preservation so as to collaborate with indigenous communities to ensure cultural heritage preservation, establishing cultural centers and organizing events, and so on. The 15-Minute Planning System fosters community connection, making this vision achievable.

Also, balancing agricultural expansion and environmental protection involves, promoting sustainable farming practices, preserving critical natural areas, and nurturing eco-friendly industries, promoting and incentivizing sustainable farming techniques, such as no-till agriculture, crop rotation, and organic farming, educating farmers on responsible pesticide and fertilizer use to minimize soil and water contamination, implementing strict land use regulations to protect critical natural areas, forests, and watersheds from agricultural encroachment, establishing buffer zones around sensitive ecosystems to reduce the impact of agricultural runoff, etc. Through

this the project aims to reduce the impact that agricultural expansion has on the ecology and environment of Ariquemes. Furthermore, promoting and investing in eco-friendly industries like eco-tourism, sustainable forestry, and non-timber forest products, encouraging entrepreneurship and innovation to diversify the local economy beyond agriculture, encouraging the adoption of precision agriculture technologies to optimize resource use and reduce waste, supporting research and development of eco-friendly farming technologies, and many more can ensure further agricultural expansion and economic benefits without hindering the environment.

And, to integrate lost Indigenous heritage and culture in Rondônia, the book chapter aims to establish cultural centers, educational programs, and community dialogs to collaborate closely with indigenous communities and minority communities, ensuring their voices are heard in city planning. The goal is to promote cultural awareness and appreciation, foster inclusivity and understanding, participatory planning, and create a safe space for all.

While the 15-Minute City planning system is for the existing grid planning system of Ariquemes, where the vision is to revitalize the already existing, but dilapidated neighborhoods of the city, there always exists certain limitations, with difficulties in implementing changes all over, as the city is constantly expanding. However, in saying that, this concept can always be treated as a prototype with possibilities of executing the idea in newer regions as a part of their urbanistic planning policies and the master plan in the future.

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