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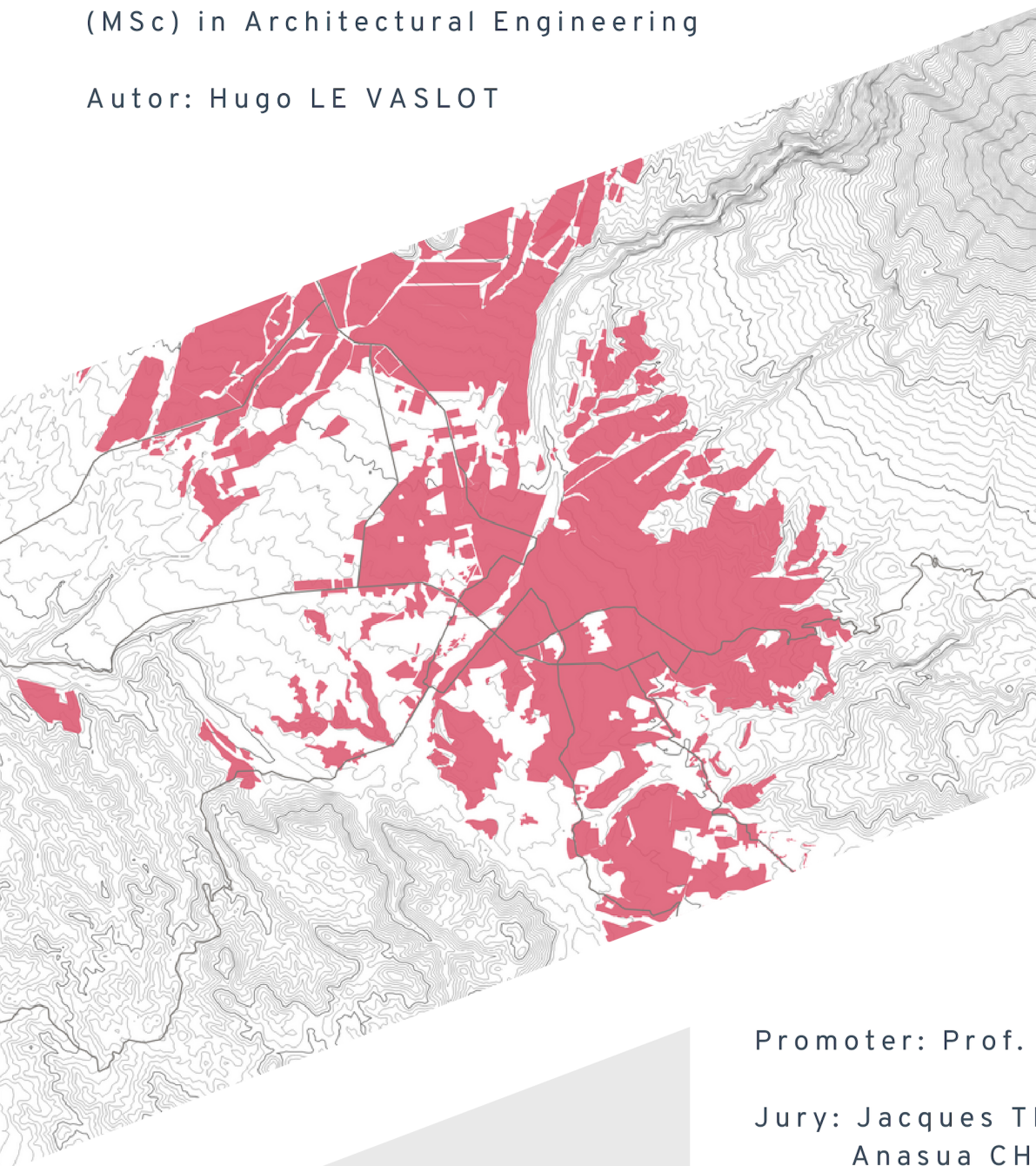
Understanding Urban Expansion and Informal Urbanization

A Case Study of Informal Settlements
in Arequipa, Peru



Final Year Research carried out with a
view to obtain the Master of Science
(MSc) in Architectural Engineering

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Abstract

Based on scientific research conducted on the topic of urban expansion and informality, it appears that only very few scientific works have established definitive criteria for describing informal urbanization and its development patterns. This is primarily due to the inherent complexity of the subject, which exhibits significant variations depending on the specific country or city under examination. Conducting such studies is indeed challenging, as it necessitates an analysis of the local socio-economic and social context, while also considering the prevailing spatial planning policies at the local level.

Furthermore, the forthcoming work will concentrate on examining urban expansion in Peru, with a specific focus on the city of Arequipa. This will be achieved through the integration of various approaches and the utilization of different analytical criteria. The study aims to shed light on the significant urbanization trends observed in recent decades, driven by substantial population growth resulting from migration phenomena. It also aims to address the issue of relative poverty among populations residing in informal settlements, primarily due to limited resources, as well as the relatively lenient territorial management policies in place.

Considering the intricate nature of informal urbanization, the definitions and concepts related to it will be established based on a thorough review of existing scientific research on the subject. Through an investigation into the urbanization process of the city, involving the analysis of demographic and housing trends, as well as an examination of various informal settlements on the outskirts of Arequipa using historical satellite imagery, this study aims to shed light on both the broader urbanization patterns within the city and the specific areas that are susceptible to illegal land occupation. By considering multiple scales of analysis, the research will reveal the dynamics of urban growth and identify vulnerable sites where informal settlements have emerged.

The process of establishing informal settlements is influenced by several factors, including significant population growth resulting from rural-urban migration, limited housing options within the city, inadequate territorial governance, and a lack or absence of essential services and infrastructure. These conditions have played a critical role in shaping the emergence and development of these informal spaces. The study will explore how these interconnected factors contribute to the creation of informal neighborhoods, highlighting the implications of such conditions on urbanization dynamics in Arequipa.

Acknowledgments

This project is the culmination of three years of study in the Master's program at the University of Liège, where I pursued a degree in architectural engineering. It has provided me with a valuable opportunity to delve into a case study that is particularly meaningful to me, the development of Latin American countries, with a specific focus on Peru.

Over the course of three months, I had the privilege of immersing myself in Peru and gaining invaluable firsthand experience. This project would not have been possible without the generous support and assistance of numerous individuals, whom I would like to express my heartfelt gratitude to.

I would like to express my sincere gratitude to my project supervisor, Professor and researcher Jacques Teller, for his invaluable support and guidance throughout the study. His assistance greatly facilitated my fieldwork in Peru and contributed significantly to the improvement of this project's study and results.

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I am also very grateful to the planning experts at the Municipal Planning Institute (IMPLA) in Arequipa, particularly Michael Alfaro and German Cutimbo. Their involvement as territorial management agency members and provision of documents and data about the city greatly contributed to my study of Arequipa.

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Introduction

Urban expansion and informal urbanization are two interrelated phenomena that have become increasingly prominent in the context of rapid urbanization and population growth worldwide, especially in countries of the Global South. As cities continue to grow and evolve, the dynamics of urban expansion and informal urbanization pose significant challenges for urban planners, policymakers, and communities alike.

According to United Nations data, it is projected that two out of every three people will be residing in cities or other urban centers by the year 2050. This significant urbanization trend highlights the ongoing global shift towards urban areas, as populations continue to grow and migrate. By 2030, the world could witness the emergence of 43 "megacities" with populations exceeding 10 million inhabitants, compared to the current count of 31 such cities. Importantly, the majority of these megacities are anticipated to be located in developing countries, reflecting the rapid urbanization occurring in these regions. This data underscores the need for effective urban planning, infrastructure development, and sustainable management practices to address the unique challenges that accompany the rapid growth of cities in the coming decades.

- Background information and problem statement

According to data from the Peruvian National Institute of Statistics (INEI), there has been a significant transformation in the country's population distribution over the years. In the 1940s, a majority of the population, 64.6%, resided in rural areas, while only 35.4% lived in urban areas. However, by 2017, this trend had undergone a remarkable shift, with 82.4% of the population residing in urban areas. This urbanization process can be attributed to internal migration from rural to urban areas, resulting in rapid urban expansion.

It is important to note that this urban expansion in Peru has been accompanied by the emergence of numerous illegal and informal neighborhoods. These settlements arise primarily due to the significant poverty levels experienced by a large segment of the population. The creation of these informal neighborhoods gives rise to a range of sustainability challenges. Issues such as inadequate access to basic services, substandard housing conditions, environmental degradation, and limited infrastructure development are prevalent in these areas.

Understanding and addressing the challenges associated with urban expansion and informal urbanization are crucial for sustainable urban development. It requires a comprehensive approach that considers the social, economic, and environmental dimensions of urbanization, while also taking into account the needs and aspirations of diverse urban populations.

- Research objectives

This project aims to delve into the concepts of urban expansion and informal urbanization, exploring their causes, impacts, and the dynamics of informality and formalization within the city of Arequipa, Peru. By examining case studies of informal settlements and the historical urbanization patterns of Arequipa, as well as drawing upon existing literature, the objective is to gain a deeper understanding of the complexities involved and identify key factors and parameters that have influenced this situation.

The research objectives for this study are as follows:

- Analyze and quantify the factors that have contributed to urban expansion in the city of Arequipa.
- Study the historical urban trends and areas that have experienced occupation and development.
- Define the processes of informal urbanization and formalization within the context of Peru.
- Examine a diverse selection of informal settlements located in different areas of the city to obtain a representative sample and characterize their patterns of urbanization.
- Conduct field visits and interviews on site within a settlement to get a comprehensive analysis of its level of development.

By achieving these research objectives, a comprehensive and in-depth analysis of the urban expansion and informality process within Arequipa can be conducted. This will provide valuable insights into the issues posed by these phenomena, enabling a better understanding of the challenges they generate.

- Main research questions and research sub-questions

Given the various themes and research objectives, it is possible to formulate a research problem that will provide a framework for the project and yield insights through a case study of Arequipa, Peru. Below are the main research questions that will be addressed in this study:

What are the factors that contribute and influence the urban expansion and to the emergence of informal urbanization in Arequipa, Peru? What are the characteristics of an informal settlement? Which patterns of development and urbanization occur within such areas?

I. State of the art

To begin with, this chapter aims to provide an overview of informality and urbanization processes to establish a clear understanding of the subject and its associated concepts. It is essential to grasp informality as a global concept before delving into a detailed analysis of specific cities or neighborhoods.

By defining and contextualizing informal urbanization, including its patterns, causes, and consequences, this chapter draws upon existing scientific literature and identifies new research directions.

The phenomenon of informal urbanization has been prevalent in Peru and other parts of the Global South for many years. This can be attributed to the mismatch between the economy and institutions that have not adequately adapted to the rapid and uncontrolled urban growth witnessed in recent decades. The management of land use in these areas is often flawed due to various factors, including socio-environmental concerns. Therefore, urban informality represents a major challenge in territorial management and urban planning.

1.1. Concepts and mechanisms of informal urbanization

1.1.1. Urban expansion process

1.1.1.1. Definition of urban expansion

This first section examines the urban expansion process, or urban sprawl, a concept that can be related to the notion of **urban growth**, which is used in demographic and spatial studies to understand the urbanization of a city or a town through urban growth rates, a measure of the increase of the urban population (United Nations Population Fund - UNFPA 2007). In this work, urban growth and urban expansion will be used interchangeably.

As reported by the *World Cities Report 2022*, the world is currently experiencing a global trend of ongoing high trend of urbanization, and this trend is expected to continue over the next three decades. Projections suggest that urban growth rates will rise from 56 percent in 2021 to 68 percent by the year 2050. This substantial increase indicates that the global urban population will expand by approximately 2.2 billion people during this period:

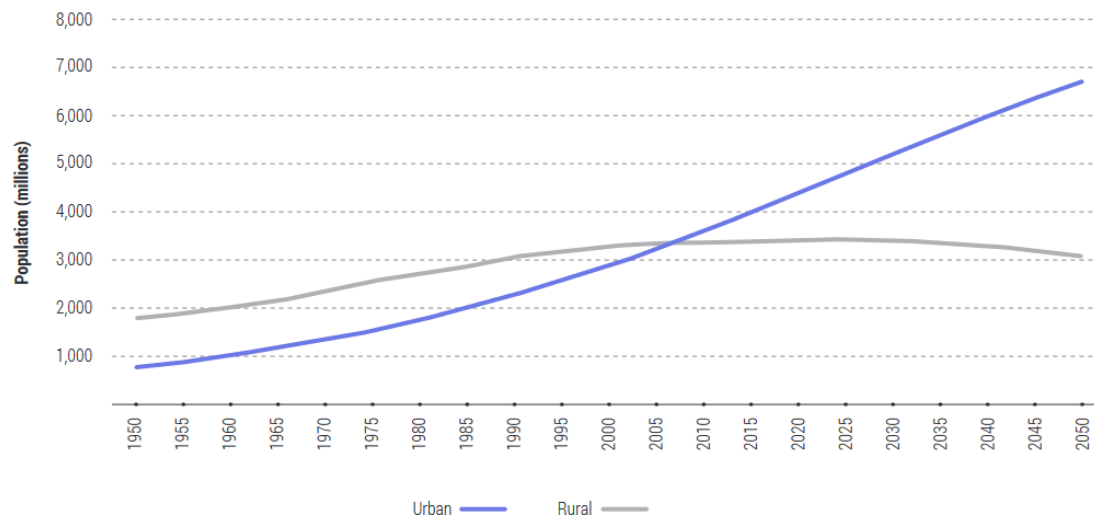


Figure 1: Urban and rural population of the world, 1950-2030 (World Cities Report 2022, 2022)

Urban growth is the result of three different dynamics according to sociologist Julien Damon: First is the ‘natural’ increase of the urban population, measured by the difference between the number of births and the number of deaths. Additionally, migration from the countryside to the cities, also known as the “rural exodus”, also contributes to urban growth, and finally the reclassification of municipalities previously considered rural, mainly due to urban expansion. Urban expansion corresponds to the rapid extension of the geographic boundaries of cities and towns.

Previous studies have reported that urban sprawl as a phenomenon, has different definitions that reflects the physical extension of cities:

- *“It signifies the constant rise of urban population (urbanization) and, on the other hand, the expansion of urban lifestyle and infrastructure within the settlement system”* (Hosszu, 2009).
- *“Urban expansion is the repercussion of the existence or the absence of development policy such as zoning, urban growth boundary or development control.”* (Galster, 2001)
- *“Urban sprawl is known by many as unplanned, and uncontrolled growth of the inner city towards its periphery causing pressure on the development near the boundary and also mainly contribute to negative impacts”* (Chorianopoulos, I., Pagonis, T., Koukoulas, S., & Drymoniti, S., 2010)

This last definition provides an accurate picture of how this urban expansion is occurring, as an uncontrolled growth of the city, extending itself beyond its peripheries while producing negative socio-environmental effects on the area concerned.

In this dissertation, urban expansion is understood as the expansion of the inner city towards its periphery, and there will be a focus on the relation between this physical expansion and the factors that led to this particular land-use of the territory.

As evoked above, most of the urbanization processes are occurring in underdeveloped countries, with over 90% of the world's urban growth taking place in the Global South (UN Habitat, 2016). The Global South is a term based on socio-economic and political characteristics inherited from the 'Third World' categorization of the Cold War. It therefore excludes Western (Europe, the US and Canada, Japan, Israel, Australia and New Zealand) countries and former Soviet countries, and comprises most Asian, African and Latin American countries. Most of the world's population resides in the Global South, also labeled developing countries, and is affected by low economic development, dense population and poor infrastructure.

Indeed, most expansions of city land areas will occur in low-income countries which do not benefit from effective urban planning procedures. Urban sprawl might become a characteristic phenomenon of low-income countries in the near future:

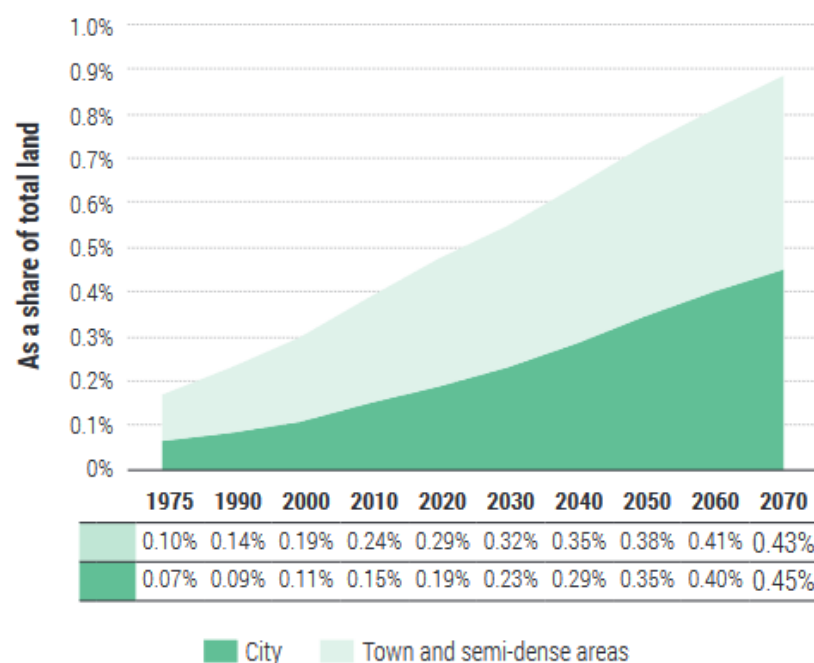


Figure 2: Land covered by cities, towns, and semi-dense areas in low-income countries, 1975–2070 (World Cities Report 2022, 2022)

1.1.1.2. Negative impacts of urban expansion

As described previously, urban expansion involves significant impacts on the environment. A large and growing body of literature has investigated this topic, and urban expansion's effects can be summarized to a loss of productive agricultural lands, lower accessibility and private transport dependency, a consistent increase of carbon emissions and increases in runoff water (Yasin *et al.*, 2021). Moreover, studies have shown that urban sprawl can have negative impacts on energy efficiency, the urban economy and social structure, but also the physical environment and public health (Peponi and Morgado, 2020).

Therefore, this process of urban expansion has a lot of consequences on land quality and on the environment in general, provoking a lot of sustainability issues to progressively appear in the city development processes of many urbanizing territories, especially in developing countries.

The main purpose of this study is to develop an understanding of the urban expansion process' impacts on a settlement during a sufficient period, in order to apprehend the small-scale effects of this phenomenon.

1.1.2. Informal settlements and informality

There are approximately one billion people living in informal settlements in developing countries, and the United Nations estimates that 3 billion people will need affordable housing by 2030 (Arora and Mishra, 2019).

Informal settlements can be defined as a form of rapid urbanization phenomenon happening under poverty conditions and with the mushrooming of substandard shelter settlements, with features such as inadequate sanitation, lack of solid waste management, insufficient water supply, scarce housing units, and basic infrastructure (Hosseini, Finn and Momeni, 2023).

Informal urbanization encompasses the actions undertaken by both impoverished settlers in their quest for a "right to the city" (Lefebvre, 1968) and well-off individuals seeking to pursue their own interests outside of ineffective statutory plans. This process is adopted by millions of people, regardless of their socioeconomic status, as they navigate the complexities of urban living and strive to shape their urban environment according to their needs and aspirations.

The notion of urban informality now forms a big part of the growth dynamics and urbanization of the cities in the global South. This type of urbanization is modifying access to employment

and shelter. Rapid population growth impacts informality and informal settlements, especially when there is a lack of suitable housing and infrastructure for residents.

According to UN Habitat, there are several indicators to identify a slum or informal settlement suffering from “household deprivations”:

- Lack of access to improved water source,
- Lack of access to improved sanitation facilities,
- Lack of sufficient living area,
- Lack of housing durability,
- Lack of security of tenure.

Slums are “the most deprived and excluded form of informal settlements characterized by poverty and large agglomerations of dilapidated housing often located in the most hazardous urban land. In addition to tenure insecurity, slum dwellers lack formal supply of basic infrastructure and services, public space and green areas, and are constantly exposed to eviction, disease and violence”

In most cities of Latin America, Sub-Saharan Africa and South Asia, between a third and two thirds of urban structures were built without any permit and on land not initially used or intended to be used for housing functions (Baumgart and Kreibich, 2011).

Rural migrants, squatters and slum-dwellers can have access to urban land easily through informal urbanization, but this process is as much the “purview of wealthy urbanites and suburbanites” (Roy 2009a: 82).

Understanding the role of the government in these processes is crucial to understanding urban informality, notably in light of inefficient use of scarce public resources and corruption, and bad governance.

Informal urban settlement growth can be associated with three prevailing regimes of urban growth regulation: state fragility, exclusion, and deregulation (Baumgart and Kreibich, 2011).

Informality due to exclusion can notably be observed in Latin America, where resourceful states deny poor rural migrants’ full access to urban amenities. Frequently, their informal settlements do not even feature in urban development and land-use plans.



Figure 3: Informal settlements of Caracas, Venezuela (Federico PARRA, AFP)

On the other hand, there are different parameters that are influencing informal urbanization, which are discussed in the following section.

1.1.3. Main parameters of informal urban expansion

After having provided the characteristics of informal urbanization, underlining the driving parameters of informal urban expansion is a key aspect to understanding the process and its main root causes.

According to urban economic theory, urban expansion across the world is a phenomenon primarily driven by different factors (Habibi and Asadi, 2011):

- population growth,
- income growth,
- low transportation and infrastructure costs,
- reduced opportunity costs for non-urban land use,
- weak urban governance and national government policies.

In addition to these primary factors, there are other forces that are associated with larger levels of urban land use. This paper focuses on the role of informal housing as a result of rapid, uncontrolled urban expansion.

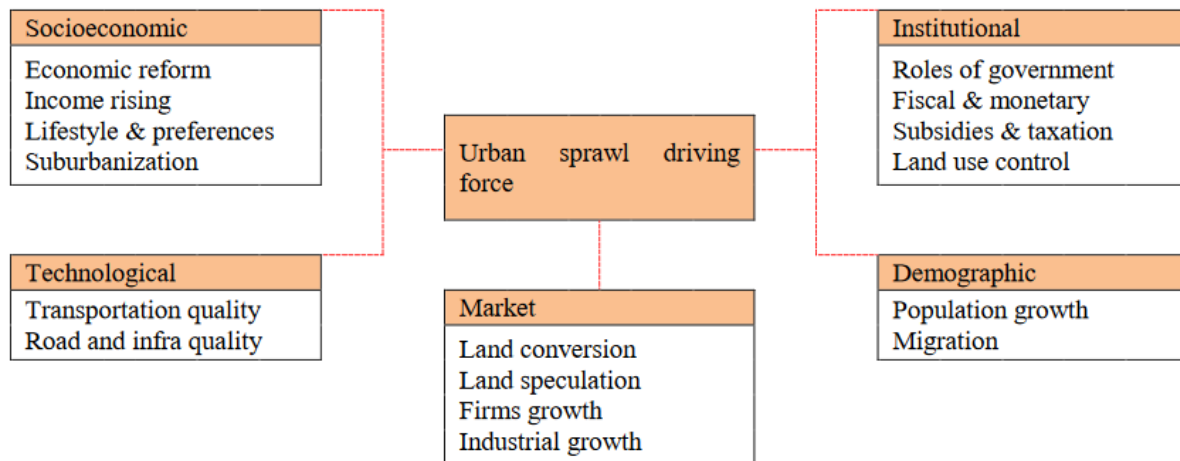


Figure 4: Urban sprawl driving parameters (Yasin *et al.*, 2021)

1.2. Identifying informal urban expansion growth

1.2.1. Main steps of informal settlements growth

Although the typology is taking different shapes and is evolving in different ways between countries across the world or between cities of the same country, there are some similar stages of development in the birth of an informal settlement.

The informal settlements growing process undergoes various stages of development, which can be separated into three main stages (Sliuzas, 2016):

- **Infancy:** in this first stage, prospective house seekers are beginning to convert the peripheral agricultural land to residential use areas.
- **Consolidation:** the second phase involves a significant increase of the initial value of land markets primarily because residential land has become attractive to high and middle-income households. At this phase of the process, the density of these peripheral residential areas is much higher than at the infancy stage.
- **Saturation (or maturity):** the final phase is a settlement growing phase, in which available land resources for house development are mostly used up and the additional housing units result mainly from the densification of existing plots and expansion on limited open space, including public areas. Living conditions for both households and slums dwellers are also progressively worsening.

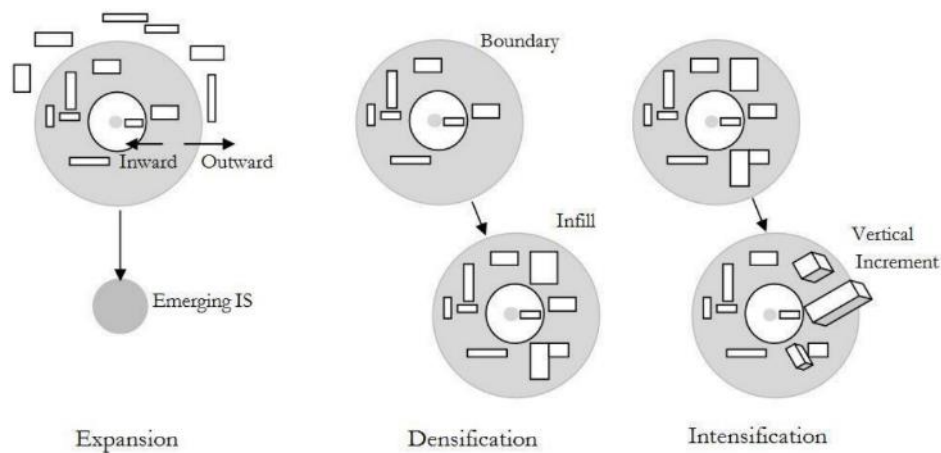


Figure 5: Concepts of informal settlement expansion, densification, and intensification (Aggarwal, 2017)

This figure shows how each phase of the informal settlement's growth can be identified as expansion, densification, and finally intensification.

This study will particularly focus on analyzing the expansion phase of a particular settlement in the city of Arequipa in Peru, to understand how a city can evolve through informal urban sprawl.

1.2.2. Informal urbanization spatial patterns

Informal urbanization can have different patterns in terms of physical shape, but also different legal properties. It is possible to characterize four types of urbanization patterns according to the study of Alvaro Espinoza and Ricardo (Rosati, Moretto and Teller, 2022)Fort of 2020:

	Type	Physical and legal characteristics	Subtype	typical promoter	Proportion
I N F O R M A L	Type 1 : Illegal occupation	<ul style="list-style-type: none"> - No services or infrastructure - Narrow streets - Irregular layout - Unaligned lots - No property rights 	1.1: Low density	Land trafficking	10%
			1.2: High density	Leader (invasion)	36%
	Type 2 : Informal lot allocations	<ul style="list-style-type: none"> - No (or partial) services and infrastructure - Regular layout - Aligned lots - Partial property rights 	2.1: No infrastructure	Owners, informal real estate	41%
			2.2: Partial infrastructure	Informal real estate	5%
F O R M A L	Type 3 : Formal Urbanizations	<ul style="list-style-type: none"> - With full services and infrastructure - With green areas - Regular layout, with parameters - Full property rights 	No subtype	Formal real estate	6%
	Type 4: Social housing	<ul style="list-style-type: none"> - With services, infrastructure and housing complete - With green areas - Regular layout, with parameters - Full property rights. 	No subtype	Formal real estate	1%

Figure 6: Urbanization typology and proportions in the urbanization process of Peru (Espinoza, A. & R. Fort, 2020)

The differentiation between formal district development and informal occupation carries significant importance as it encompasses distinct features pertaining to various services and infrastructure. This typology will prove valuable in the examination of informal neighborhoods within the context of this project.

1.3. Incremental urbanism: a new approach for informal settlements

1.3.1. Incremental urbanization, a close relation with informality

In order to study the informal urbanization process, there are several concepts that can be linked to the notion of managing informality. Indeed, the concept of incremental urbanism is a key factor in understanding informality.

Incremental urbanization can be defined as the *“Study of the relationship between incremental changes in the urban fabric (urban typologies and morphologies) and the forms of adaptations of coproduced water and sanitation services (WSS)”* (Rosati, Moretto and Teller, 2022).

This concept shows that it is necessary to take into consideration the participation of communities in processes of formation and consolidation of urban settlements in the Global South.

The concept of **incrementalism** in urban studies correspond to the improvisations, accretions and learning processes that characterizes the production and consolidation of the urban space. Coproduction processes (WSS) are an incremental learning process in which urban dwellers participate in making their cities (McFarlane 2011; Silver 2014).

Furthermore, the concept of ‘**intensive multiplicity**’ developed by Deleuze and Guattari (1987), understands the city as the result of a step-by-step process leading to consolidation over time, through new spatial additions and reconfigurations that combine social and material activities.

Incrementalism can be summarized as a theoretical notion for understanding how residents can drastically improve their water supply and sanitation through hybrid infrastructure and incremental socio-technical development. It is also how urban dwellers engage with existing spatial conditions, reconfigure their urban space and seek to adjust and maintain the circulation of water on a very local scale to respond to increasing density.

According to Joshi and Moore (2004) , **institutionalized service co-production** is ‘the provision of public services (broadly defined to include regulation) through a regular long-term relationship between state agencies and organized groups of citizens where both make substantial resource contributions’.

There are 3 main aspects to read co-production as **incremental spatial practice**:

- the role of the state and its changing relationship with society
- logistical or technical drivers (distance to the urban core, etc.)
- unfinished nature of infrastructure networks

There is a relationship between “the form and structure of this built environment and the territorial boundaries of coproduced practices” (Ostrom 1990; Habraken and Teicher 1998).

Local factors, such as **available resources** or **dwelling typologies**, shape the evolution of different co-production options along path-dependent trajectories (Schramm, 2011).

Nowadays, progressive housing is associated with emerging cities in which rapid growth in urban population occurred faster than in the formal sector, resulting in a fragmented, informal housing stock. Incremental housing has also become an urban design strategy allowing for sustainable urban growth and development characteristic of growing cities in the Southern hemisphere.

Potential solutions exist in dealing with informal urbanization, which will be presented in the following part of this report.

1.3.2. Potential solutions to sustainability problems

The many disruptions resulting from the COVID-19 crisis, rising inflation, climate change, armed conflicts and revolts are indicators that urbanized areas need to be better prepared for an unpredictable future, especially in developing countries such as Peru.

In light of the various negative externalities of urban expansion, it is necessary to develop policies to decrease these effects. Many policies exist, each focusing on a different aspect of this issue, as suggested by Habitat Report 3_ (*Issue Papers*, 2023):

Surveys indicate that one of the primary strategies for controlling urban sprawl is to decrease private vehicle ownership. Taxation, particularly through toll gates, is recognized as a significant component of this approach.

By implementing toll gates, cities can discourage private vehicle use and incentivize alternative modes of transportation, such as public transit, walking, or cycling. The imposition of tolls aims to reduce traffic congestion, improve air quality, and promote sustainable mobility options.

Creating urban boundaries is an effective way to control and manage a city's urban expansion. By establishing clear limits at the edges of cities, construction is restricted to the inner districts, preventing uncontrolled growth. This approach promotes compact and efficient urban development, utilizing existing infrastructure and resources more effectively.

Additionally, controlling urban sprawl and promoting sustainable development require residents to participate in covering infrastructure costs. Surveys indicate that sprawl costs significantly more than normal growth, as it necessitates the construction of new roads, schools, housing, and public services. By increasing residents' contribution to these expenses, urban expansion can be effectively managed.

Enhancing the living conditions of low-income households is crucial, especially considering that a significant portion of suburban residents relocate in search of better opportunities for their families. Implementing measures such as providing financial assistance, facilitating access to affordable housing, and offering regional subsidies can effectively improve their living conditions while also curbing migration.

Revitalizing inner-core regions often leads to a rise in urban land prices. To address this, various strategies can be employed, including optimizing land utilization, repurposing abandoned industrial areas, developing vacant commercial plots and metro station spaces, and rehabilitating abandoned properties and historic buildings. These initiatives serve as examples of policies aimed at promoting redevelopment while effectively managing the impact on land prices.

Furthermore, managing growth and safeguarding land resources is essential. Assigning higher tax values to open spaces can act as a deterrent for changing land uses, potentially reducing the rate of land conversion. By implementing this approach, the goal is to promote the preservation of open spaces and discourage activities that could lead to their loss or degradation.

Urban consolidation is a strategy aimed at maximizing the efficient utilization of land and infrastructure in the built-up areas of cities. It involves implementing restrictions on land use, reducing infrastructure costs, and promoting the use of public transportation. The goal is to optimize existing urban resources, foster sustainable development, and create compact and connected urban environments. By concentrating development within already developed areas, urban consolidation seeks to improve efficiency and minimize the need for expanding into undeveloped land.

Finally, supporting smart growth strategies involves prioritizing compact development and the redevelopment of built-up areas within a city. Smart growth strategies typically encourage mixed-use development, walkability, and access to public transportation, with an emphasis

on creating vibrant and cohesive neighborhoods. By adopting smart growth principles, cities can enhance quality of life, protect natural resources, and foster economic vitality in a more sustainable and environmentally conscious manner.

1.4. Conclusion of the state of the art

As a conclusion for this part of the report, having a clear definition of informal urban expansion and the key concepts related to this notion provides us with a general overview of the process, and potential solutions to the mismanagement of the territory for developing cities. As mentioned previously, informal urbanization can be related to a multitude of different factors, from governance to economic and population growth, with even the quality of the transportation network and water access having an impact on this process.

Having explored the scientific literature on this topic enables us to have a common ground for studying this process in a specific case study, the city of Arequipa in Peru.

Moreover, this process had several definitions, hence why a lot of different points of view exist with both positive and negative inputs on the concept of informal urbanization. This lack of a common methodology to measure the urban phenomenon can lead to several questions. How can urban expansion and informal urbanization be understood and estimated? What are the factors that influence this urban expansion process?

As touched upon in light of the process' prominence in the Global South, informal urban expansion is one of the main challenges for a sustainable urban planning and urbanization, and properly tackling it will prove crucial in the following decades.

II. Methodology of the project

This section of the report focuses on the overall project methodology, followed by a detailed description of how it was implemented to comprehend the operations of informal districts in Arequipa. Additionally, it explores the selection process for the specific area of informal settlement under study, considering various criteria and parameters. The different limitations of this approach are also provided at the end of this section, in order to understand the points to keep in consideration in the interpretation of results.

2.1. Overall methodology

As visible from the figure below, methodology was structured in four different phases. The initial phase of the project involved adopting a comprehensive methodological approach to study the city of Arequipa. The approach followed a sequential process, beginning with an exploration of theoretical concepts related to urban expansion and informality. Subsequently, the focus shifted towards investigating the urbanization and demographic dynamics within Peru, followed by a thinner examination of the province and city of Arequipa. This sequential approach aimed to provide a contextual understanding of the city and its patterns of urban expansion, in order to evaluate its different informal settlements on a consistent basis.

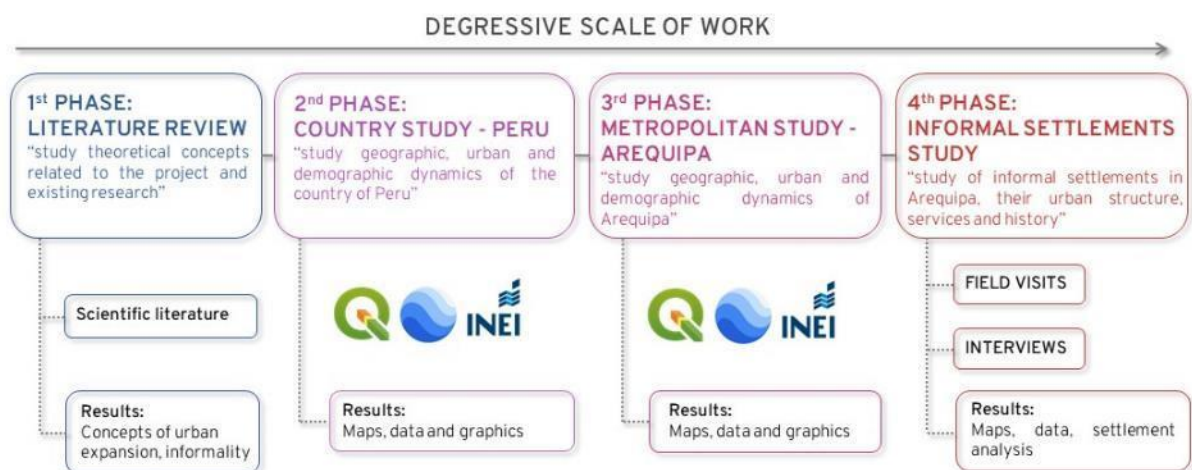


Figure 7: Overall methodology of project

First of all, gaining a thorough understanding of informal urban expansion is a crucial initial step in this study, and it can be achieved through an examination and comprehension of existing scientific literature on the subject. It is important to note that the topic of informality is relatively new, and there is limited research available on it. Furthermore, there is still a lack of established criteria for determining informal neighborhoods. Consequently, it is imperative to undertake scientific research projects focused on this theme to support effective territorial management and the urbanization of such areas. By conducting these studies, it becomes possible to develop a coherent and well-adapted approach to understanding and addressing the challenges posed by informal urban expansion.

The project methodology covered several surveys that aimed to capture key statistical population data such as population density, urban and rural distribution, as well as the number of dwellings. These surveys used data collected by the Peruvian National Institute of Statistics and Informatics (INEI), providing valuable information on the scope and scale of the study.

To visualize and analyze the urban development of Arequipa, maps and graphs were predominantly generated using satellite images sourced from the Landsat database. These images facilitated an examination of the city's urban landscape evolution over time, allowing for an exploration of its relationship with topography and the extent of its urban expansion. This utilization of satellite imagery provided valuable insights into the dynamics and patterns of urban growth in Arequipa.

Finally, to enhance the methodology, a comprehensive study of a specific informal neighborhood within the city of Arequipa was conducted to gather a complete database. This detailed study involved establishing interviews with residents and leaders of the neighborhood association and conducting site visits to obtain a comprehensive understanding of the neighborhood's functionality across different scales. Furthermore, a typological analysis of housing buildings was conducted to gain insights into the construction methods and materials commonly employed in informal neighborhoods. This additional study provided valuable information to support the formulation of a complete functional plan for the neighborhood, considering its specific characteristics and dynamics.

2.2. Arequipa urban expansion study

The following diagram illustrates the implementation of phases 2 and 3 in the overall project methodology. These phases primarily focus on data collection and subsequent processes involving map production using QGIS and graph creation through Excel. The ultimate objective is to derive estimates for the population and housing figures for both the entire country and the specific city of Arequipa. This comprehensive approach ensures reliable and informative results for the study.

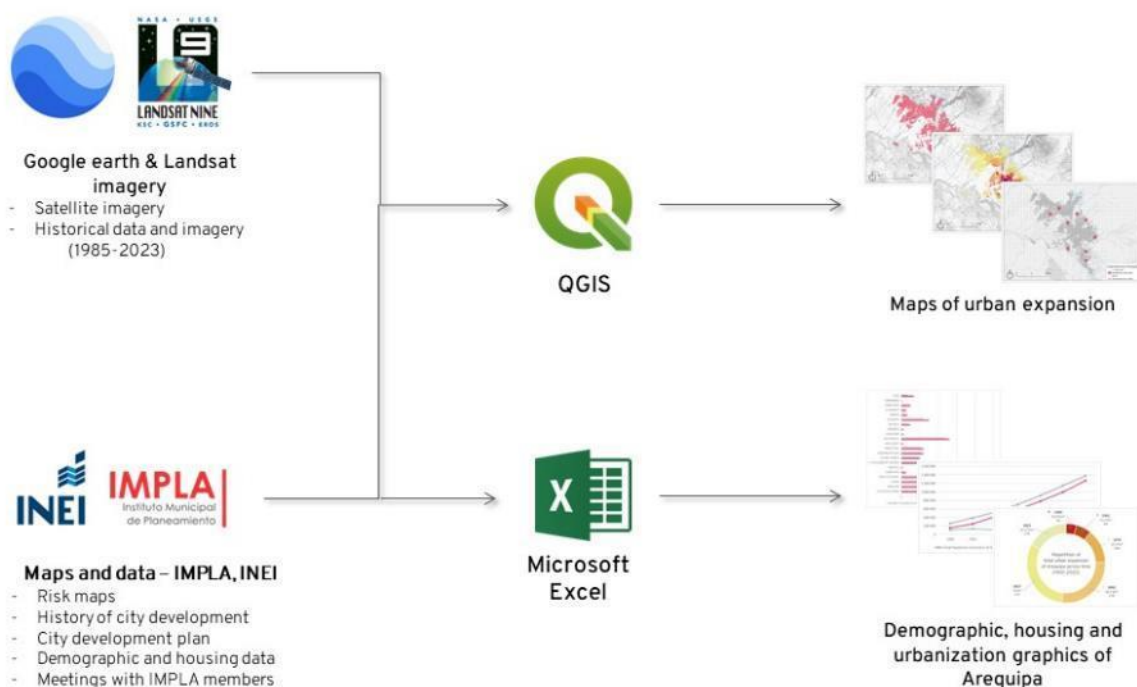


Figure 8: Methodology on urban expansion study of Arequipa (Phase 2 and 3 of overall methodology)

To conduct a complete examination of urbanization and the evolving patterns in demographics and housing developments in Arequipa, it is essential to rely on multiple sources and well-organized information. This approach ensures the production of maps and graphs that closely represent reality and are backed by reliable data. Consequently, local engagement with the Arequipa Municipality Land Use Planning Authority (IMPLA) was crucial for obtaining pertinent information, data, and the current as well as future plans for urban enhancements.

Moreover, the utilization of various population and housing censuses conducted by the Peruvian national statistics agency (INEI), at district, city, and provincial levels, has facilitated the identification of distinct demographic trends in the city accurately, with data available from different time periods.

2.3. Informal settlements study

The final phase of the study in Arequipa focuses on the area most susceptible to urban expansion, the city's periphery, and particularly on the informal neighborhoods that have undergone rapid urbanization since the early 21st century. To comprehend the various urbanization patterns that have occurred in the vicinity of Arequipa, a map (figure 9) was created which highlights different potential sites for investigation. These sites are characterized by challenging factors that hinder the sustainable development of the city in those areas, including steep terrain, geographical remoteness from the city center, inadequate or complete absence of essential services, and insufficient infrastructure.

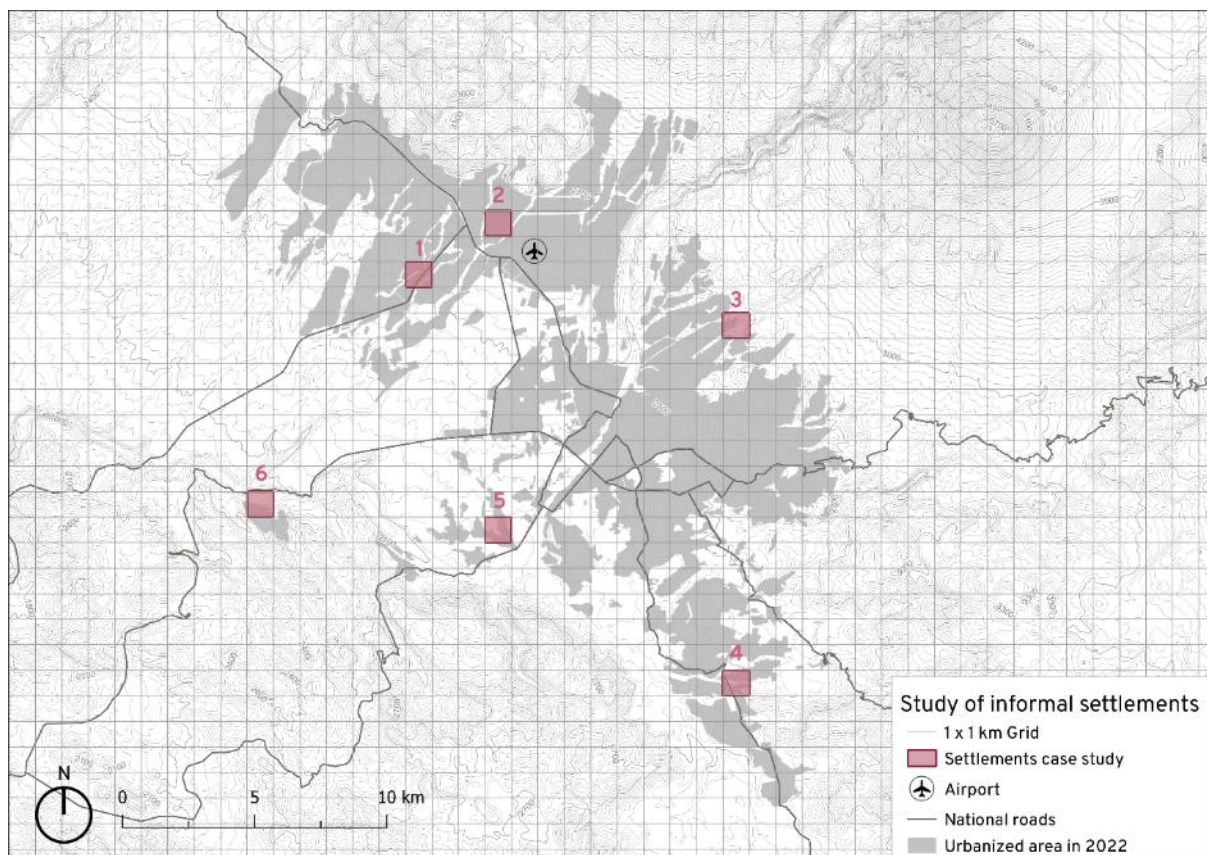


Figure 9: Informal settlements selected for case study in Arequipa (Map: H. LE VASLOT)

This map aids in identifying specific locations where in-depth analysis can shed light on the diverse urbanization processes that have unfolded in the surroundings of Arequipa. By studying these areas, a comprehensive understanding of the challenges posed by high relief and unfavorable conditions can be obtained, contributing to informed decision-making and potential interventions for sustainable development in these regions.

- Site selection:

The selection of sites in the map was conducted based on a grid system, with each site covering an equal area of 1 square kilometer. This approach ensures uniformity in surface area across the selected sites, facilitating accurate comparisons and analysis. Several parameters were considered when choosing each site, including the district's development history, its unique urban framework, topographical relief, geographical positioning, available resident services, and the current level of development.

In considering these parameters, a comprehensive and representative sample of sites was obtained, allowing for a detailed examination of each location's characteristics and the urbanization patterns observed. This systematic approach ensures that the selected sites adequately capture the diverse factors influencing urban expansion and development in the periphery of Arequipa.

Furthermore, chosen sites are strategically located in areas of the city that have experienced the most rapid urbanization phenomena, particularly in the northern, southern, and eastern regions. These areas have witnessed significant growth and transformation, making them ideal for studying the dynamics and patterns of urban expansion. By focusing on these high-growth zones, the study aimed to gain insights into the specific challenges, opportunities, and impacts associated with the accelerated urban development in Arequipa's north, south, and east. This targeted approach ensures that the analysis captures the areas that have undergone the most pronounced changes, and provides valuable insights into the urbanization trends in these parts of the city.

- Type of analysis:

The study employs consistent criteria for each site, with the objective of examining urban structure and its development over time within the specific district under investigation.

The analysis focuses on several key aspects, including the percentage of land occupied by built structures, the availability of various services, and the interplay between the district and the road network. Additionally, the topography of the area is considered in order to assess its influence on urban dynamics.

Ultimately, the goal is to characterize the type of occupation found within the informal districts of Arequipa. By applying these criteria and conducting a thorough examination, the study aims to gain insights into the distinctive features and evolution of informal settlements within the city. This research provides a deeper understanding of the patterns of land utilization, service provision, and the relationship of these districts with their surrounding urban environment.

2.3.1. Field visits and interviews – settlement of Virgen del Rosario

The study of informal neighborhoods entails conducting a comprehensive analysis, including an in-depth examination of a specific site. Fieldwork lasted for three months, from March to May 2023. Field visits were conducted to facilitate a more detailed study of one particular site, in this case the neighborhood of the "Virgen del Rosario" association (site no. 6). This neighborhood is situated to the west of Arequipa, at the metropolitan boundary of the city.

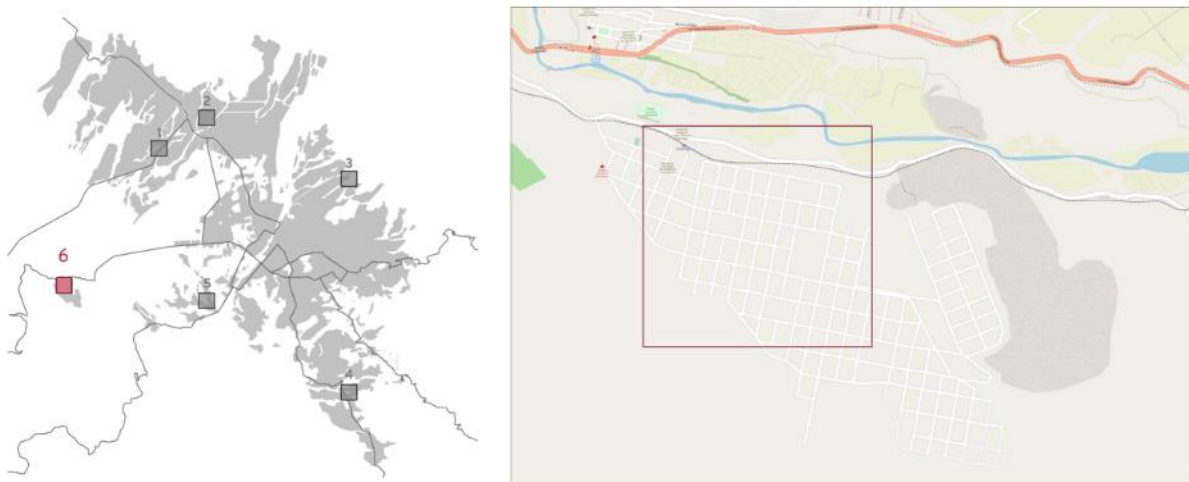


Figure 10: Location of site n°6 - Settlement of Virgen del Rosario

By conducting field visits to this specific site, the study aims to gather first-hand information and conduct on-site observations.

This approach allows for a more nuanced understanding of the characteristics, dynamics, and challenges faced by the "Virgen del Rosario" informal settlement. The detailed study of this site provides valuable insights into the specific context of informal settlements and contributes to the overall understanding of the urban landscape in Arequipa.

- Interviews during field visits:

Furthermore, the study of the neighborhood incorporates interviews with both the residents of the neighborhood and the leaders of the association responsible for oversight and advocacy in favor of the formalization of the neighborhood. These interviews serve multiple purposes. Firstly, they aimed to profile the neighborhood by assessing the level of services available to the residents. This includes examining the existing infrastructure within the neighborhood. Additionally, the interviews sought to understand the social organization of the community, particularly the role and interactions of the association with neighborhood residents.

Moreover, the interviews delved into the reasons behind the establishment of the neighborhood and explored the extent of its formalization in terms of recognition and collaboration with the city's governing organizations. By conducting these interviews, the study seeks to gain a comprehensive understanding of the neighborhood's dynamics, including its social structure, the level of services provided, and the relationship between the association and the residents. This information is crucial for evaluating the current state of the neighborhood and informing potential strategies for its future development and formalization.



Figure 11: Field interview with residents in Virgen del Rosario settlement

The interviews carried out within the neighborhood focused on a range of topics with the aim of comprehending the organization and functioning of the neighborhood.

The appendix provides a list of the various questions posed during these interviews. Each interview revolved around several key themes concerning the informal neighborhood:

- Availability and quality of services
- Social structure and dynamics within the neighborhood
- Formation and historical background of the neighborhood

By conducting these interviews, valuable insights were gained into the operational challenges faced by such neighborhoods and the criteria required for their formalization from the city's perspective. Additionally, the interviews shed light on the numerous disadvantages faced by the neighborhood's residents, including limited access to services and its remote geographical location.

2.3.2. Typology study of Virgen del Rosario settlement

In addition to the previous analysis and interviews led during field visits, the exploration of the Virgen del Rosario informal district was enhanced by conducting a typological analysis of the residences, considering the construction techniques and materials employed. It is worth emphasizing that this neighborhood exhibits a diverse range of housing styles, making this kind of analysis valuable in assessing development levels within the area. Through this study, distinct types and subtypes of dwellings can be identified, each possessing its own unique characteristics.

- Type 1 - prefabricated building (Precarious construction)

The first identifiable building type in the Virgen del Rosario settlement is the prefabricated type, which can be further divided into two subtypes: prefabricated dwellings (type 1.1) and prefabricated cabins or huts without housing functionality (type 1.2). These buildings are precarious and unsustainable due to their primary construction materials, which predominantly consist of wood, occasionally supplemented by stone or sheet metal for walls and roofs.



Type 1.1 – Prefabricated house



Type 1.2 – Prefabricated cabin/shed with no living purpose

Figure 12: Type 1 – prefabricated housing in Virgen del Rosario settlement (Photos: H. LE VASLOT)

This type of building is limited to single-story structures due to the poverty of the materials used and the lack of structural strength preventing vertical expansion. Additionally, buildings occupy minimal space on each plot, indicating low land utilization and a lack of long-term residential commitment to the neighborhood.

The first type of buildings in the Virgen del Rosario district, the prefabricated type, presents significant challenges in terms of access to basic services such as water and electricity. This lack of access prevents these buildings from constituting a genuinely sustainable residential presence in the neighborhood, particularly prior to the formalization of the area.

- Type 2 – Intermediate housing

The second identifiable building type in the Virgen del Rosario district is the intermediate type, which can be further classified into two subtypes: intermediate dwellings (type 2.1) and densified intermediate dwellings with two or more levels (type 2.2). This type of construction represents a higher level of development compared to the first type. It incorporates brick or block walls, steel-framed windows and openings, and more durable roofs that can withstand various weather conditions.



Type 2.1 – Intermediate housing construction



Type 2.2 – Densified intermediate construction (2 levels or more)

Figure 13: Type 2 – Intermediate housing in Virgen del Rosario settlement (Photos: H. LE VASLOT)

The materials predominantly used for the intermediate type of buildings in the Virgen del Rosario district include bricks, cinder blocks, and a distinctive local construction material known as volcanic rock or sillar. This volcanic rock, known as sillar, is highly durable and offers excellent structural advantages. Abundant presence of volcanic rock in the area is a result of the geographical location of the city of Arequipa, which is characterized by its volcanic context. Sillar availability in the area contributes to its extensive use in the construction of buildings, providing a unique and characteristic feature to local construction methods.

Additionally, this type of building includes structures with multiple floors, indicating a progression towards densification and an informal development of the neighborhood. Importantly, these dwellings offer access to basic water and electricity services, making them suitable for long-term residential occupation within the neighborhood.

- Type 3 – Concrete modern housing

The last identifiable type of housing in the Virgen del Rosario district is characterized by concrete construction with a modern structural design. This represents the wealthiest form of building within the neighborhood, featuring a modern framework using sail or beam post structures. These homes utilize highly resilient materials, such as concrete and reinforced concrete for walls and roofs, as well as steel for window frames equipped with comprehensive glazing systems.



Type 3.1 – Modern housing construction



Type 3.2 – Densified modern housing construction (2 levels or more)

Figure 14: Type 3 - Concrete modern housing in Virgen del Rosario settlement (Photos: H. LE VASLOT)

Furthermore, these houses benefit from water and electricity services, often equipped with high-capacity drinking water tanks. In some cases, this type of housing also exhibits vertical densification with multiple floors. These buildings occupy a significant amount of space on their respective plots and are aimed to establish sustainable housing structures in the neighborhood. However, it is important to note that these types of houses only exist in minority within the neighborhood.

2.4. Methodology limitations and quality criteria

There are several limitations to the analysis of urban expansion using historical satellite imagery, as well as to conducting fieldwork over a limited period of time, with three months spent on-site. Below are some of the key limitations.

- Time spent on-site:

As part of the project, a significant portion of the research was conducted on-site in Arequipa. The purpose was to engage with intermediaries and experts in spatial planning and to conduct field visits and interviews in informal neighborhoods. This approach aimed to ensure reliable results and a realistic assessment of informal urbanization while understanding the local dynamics of urbanization within the city.

The project's on-site duration spanned three months. Due to instabilities and a political crisis affecting the entirety of Peru, the originally planned start of the trip in January 2023 had to be postponed to March 2023. Considering visa requirements and logistical constraints, time spent on-site was limited to three months. This necessitated efficient procedures for conducting interviews and visits, in light of departure and arrival deadlines.

Despite time constraints, the work carried out was sufficient to maximize interactions with the residents and local experts, gather essential data, and gain valuable insights into the informal urbanization process in Arequipa. The project strived to overcome challenges and ensure that the research conducted during the on-site period was as comprehensive and informative as possible.

In fact, conducting on-field studies within a short time frame limits the sample size and representativity of the study. It is in turn not be feasible to cover many urban areas or capture the diversity of urbanization processes within a limited timeframe, leading to potential biases or limited generalizability of findings.

- Urban expansion study with satellite data:

In addition to the challenges of fieldwork conducted within a limited time frame, urban expansion analysis with satellite imagery also presents its own limitations. Historical satellite imagery has lower resolution and accuracy compared to more recent images. Older satellite sensors may not capture fine details or distinguish between smaller urban features. This can result in potential inaccuracies or limitations in identifying specific urban growth patterns or changes over time.

Historical satellite imagery may not be readily available for certain time periods or locations. Depending on the area of interest, there may be gaps in the availability of imagery, making it challenging to analyze urban expansion comprehensively. The temporal resolution of historical satellite imagery refers to the frequency at which images were captured over time. If the time intervals between images are too long, it may be difficult to capture short-term urban changes or understand the dynamics of rapid urban expansion.

Analyzing historical satellite imagery requires interpretation, and there can be subjective biases or limitations in the interpretation process. Different analysts may have varying interpretations of urban features, boundaries, or growth patterns, leading to inconsistencies in the analysis.

Urban expansion is a complex process influenced by various socio-economic, political, and environmental factors. Historical satellite imagery alone may not provide a comprehensive understanding of the underlying drivers or social and economic implications of urban growth.

Satellite imagery alone may lack contextual information about urban expansion, such as demographic data, land use regulations, or infrastructure development. Without such information, it can be challenging to analyze the factors driving urban expansion or its impact on the surrounding areas.

To mitigate these limitations, it is often beneficial to complement satellite imagery analysis with other data sources, such as historical maps, census data, aerial photography, or ground surveys, in order to gain a more comprehensive understanding of urban expansion patterns and dynamics.

- Access to informal areas:

The access to informal neighborhoods is often restricted due to their location outside the official city limits and their potential insecurity, making them relatively inaccessible to outsiders. Consequently, this type of study and fieldwork are limited to analyzing neighborhoods that are accessible, notably through local contacts. It is important to acknowledge that not including certain neighborhoods in the analysis may introduce disparities in result findings. Unvisited areas will not be represented in this study, and their characteristics and dynamics cannot be examined first-hand.

- Language:

During the on-site period of the project, communication in Spanish was necessary due to being the primary idiom spoken locally. This shift in language occasionally presented challenges to the researcher when exchanging data with local experts during interviews or discussions. However, thanks to prior experience from multiple long-term experiences in Latin America, it was possible to carry out discussions and collect data in Spanish smoothly without any significant issues. Familiarity with the Spanish language and previous exposure to Latin American cultures facilitated effective communication and data gathering during the project. This linguistic adaptability allowed for a more seamless interaction with local experts, ensuring that valuable insights and information were effectively exchanged. Overall, these experiences and language proficiency played a crucial role in navigating the language barrier and conducting successful interviews and data collection activities on site.

III. Peru and Arequipa: an overall context of urban expansion

In order to understand urban expansion processes taking place in Arequipa and the informal urbanization in the area, it is necessary to provide an overall context about the country situation in terms of demography, politics and urban dynamics over the last decades, as well as being familiar with the different geographical parameters that drive and impact the urbanization of the city territory.

This contextualization provides the relevant information to studying the city's development phases and understanding the formation of informal settlements on a smaller scale. Context is firstly provided about the country of Peru in general, then on the city of Arequipa.



Figure 15: Arequipa center and the volcano Misti (Source: Getty Images)

3.1. Peru

3.1.1. Geographical context

Peru is a country located on the western side of South America, between Chile and Ecuador. It also shares borders with Bolivia, Brazil, and Colombia and has a coastline along the South Pacific Ocean. The country is on the south of the equator and on the western side of South America. Its diverse topography includes a coastal plain in the west, rugged high mountains at its center (known as the Andes), and a lowland jungle in the east (Amazonia) that extends into the Amazon River basin. Finally, the country's highest peak is Nevado Huascarán, which rises to 6 768 m above sea levels.



Figure 16: Peru map location (Source : britannica.com)

Peru's climate is influenced by its diverse landscapes, ranging from tropical climate in the east to desert in the west and temperate in the Andes. The capital city of Lima, located on the coast, experiences an average high temperature of 26.5°C in February and a low of 14°C in August.

Peru is located in the northern part of the Southern hemisphere, with an extension of 1 285 220 km², making it the sixth largest country in the Americas and third in South America, after Brazil and Argentina (World Population Review 2019).

Finally, Peru has a total of 25 local regions, which are divided into second level administrative subdivisions amounting to a total of 196 provinces in the country.



Figure 17: Peru administrative map (Source: geology.com)

3.1.2. Historical and political context

Historically, Peru formed the center of the Inca empire, established in the 11th century with the city of Cuzco as its capital. In 1533, the region was conquered by Spanish adventurer Francisco Pizarro, and it thereafter was dominated by Spain for almost 300 years as the Viceroyalty of Peru.

Peru declared its independence in 1821, and by 1824, remaining Spanish forces were defeated. After a period of twelve years of military rule, Peru transitioned back to democratic leadership in 1980. However, the country has faced economic challenges and the emergence of a violent insurgency over the past decades.

Peru has experienced a tumultuous political history characterized by a chaotic blend of military dictatorships, coups d'état, and ineffective civilian governments, which led to frequent periods of instability. Notably, in the 1980s and 1990s, the country gained notoriety for instances of corruption among high-ranking government officials, resulting in the forced ousting and subsequent exile of two former presidents, as well as widespread concerns about domestic terrorism.

3.1.3. Demographic and urbanization context

Concerning demographic dynamics, Peruvian population and housing censuses have been registered from the period of republican governance. Since that date, 12 population censuses and 7 housing censuses have been carried out. The country's last census, the 12th National Census of Population, took place in October 2017. According to its results, census population was 29 381 884 and total population, that is, the census population plus the omitted population, was estimated to 31 373 385:

Year	Total population	Annual average growth rate	Urban population and % of total population		Rural population and % of total population	
1940	7 023 111	1,90%	2 486 181	35,4%	4 536 930	64,6%
1961	10 420 357		4 939 249	47,4%	5 481 108	52,6%
		2,80%				
1972	14 121 564	2,58%	8 402 331	59,5%	5 719 233	40,5%
1981	17 762 231	2,04%	11 580 975	65,2%	6 181 256	34,8%
1993	22 639 443	1,59%	15 870 250	70,1%	6 769 193	29,9%
2007	28 220 764	1,02%	21 419 560	75,9%	6 801 204	24,1%
2017	31 237 385		24 771 246	79,3%	6 466 139	20,7%

Table 1: Total, Urban and Rural population in Peru (Data source: INEI, 2017)

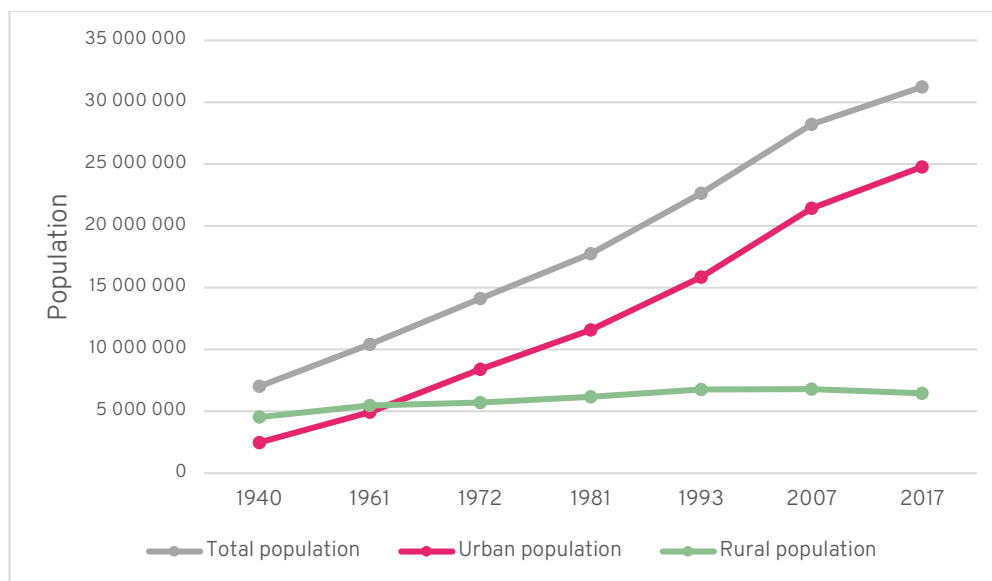


Figure 18: Demographic evolution of Peru with urban and rural population (Data source: INEI, 2017)

Since 1940, the population of Peru has experienced a consistent rise, as indicated by Figure 10 with the INEI National Census of 2017. The 20th century witnessed a decline in rural population and a consequent trend of rural exodus, resulting in an increase in the urban population from 70% in 1993 to over 79% in 2017. This upward trend has been especially prominent since the 2000s.

According to the data of the National Institute of Statistics and Informatics, in the year 2022, Peruvian population reached 33,396,700 inhabitants, more than double the population registered in the year 1972.

Peru, like all Latin American countries, has experienced major changes in the distribution of its population throughout the 20th and early 21st centuries. The main mechanism behind these changes was internal migration, which caused growth effects and redistributed the population spatially. Indeed, massive transfers of rural population to the cities, the emigration of the Sierra region from the center of the country to the coast and the progressive occupation of the Selva region (east of the country), are based on complex processes of formal and informal colonization. These changes in the spatial distribution of the Peruvian population, induced by internal migration, interact with other structural transformations affecting the country at the social, economic, cultural, and political levels.

Internal interregional migration has increased since the middle of the past century, with many Peruvians having left their place of origin in search of better opportunities in departments with greater economic potential, a phenomenon that has continued throughout generations.

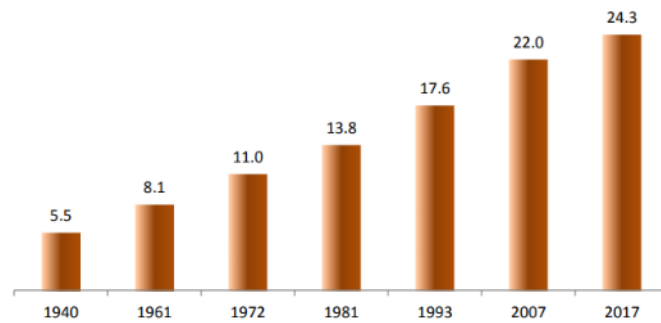


Figure 19: Population density (residents/km²) evolution in Peru between 1940 and 2017 (Source: INEI)

By analyzing the Peruvian population density indicator over the years, based on the INEI (National Institute of Statistics and Informatics of Peru) databases, a clear increase is observed in the number of inhabitants per square kilometer. These changes can be associated with demographic changes in fertility, but also with the process of urbanization and internal migration that has taken place within the country since the 20th century.

3.2. City of Arequipa

3.2.1. Geographical context: region, province and city

As specified in the previous section, the country of Peru is subdivided into 25 regions, and the region of Arequipa is located on the south of the country.

The Arequipa region is the sixth largest area in Peru, covering over 63,345 km² and sharing borders with Ica, Ayacucho, Apurímac, Cusco, Puno, and Moquegua. As of 2017, the region had a population of 1,465,132 inhabitants (INEI, 2017), making it the most populated region in the country. The region has a total of eight provinces, with Caylloma and Caravelí being the largest in size, but Arequipa having the highest population density.

The region boasts a diverse topography and abundant natural resources. Its coastline extends over 528 km and contains numerous fertile valleys. Despite its diversified economy, which includes mining, agro-export, services, fishing, and tourism, among others, the region has a high incidence of poverty, ranging from 9.6% to 12.0%, according to INEI's 2018 report.



Figure 20: Map of region of Arequipa in Peru (Source: Wikipedia)

The province of Arequipa, situated within the larger region of Arequipa, is positioned in the Quilca-Chile basin at the eastern edge of the region. It shares borders with the adjacent provinces of Caylloma, Camaná, and Islay, as well as the regions of Puno and Moquegua. Covering an area exceeding 9 609 km², this expansive province contains a diverse geography, abundant in natural resources, economic opportunities, and tourism potential. However, it is characterized by rugged topography and a prominent volcanic mountainous backdrop.

Politically, the province is divided into 29 districts, geographically grouped into five territorial units. These units share similar environmental conditions, geomorphology, basic resources, and population clusters that ascend from the coastal areas to the high plateaus. The five territorial units are the Arequipa Plateau, the Barroso Volcanic Chain, the Arequipa Peninsula, the Western flank of the Andes, and the Southwestern alluvial plain of the subtropical desert.



Figure 21: Map of provinces of Arequipa (Source: INEI)

The city itself, Arequipa, is the second largest city in Peru after the capital Lima, both in terms of population and area, and plays a major role in the surrounding region, having a strong influence on neighboring cities like Tacna, Juliaca, Puno, but also Cusco.

Indeed, the capital city of the province of Arequipa is divided into 21 districts, with a total area of 3 900 km², but the metropolitan limit of Arequipa extends only over 360 km². Most of these districts contain urban and agricultural areas, and only a few of them are completely urbanized, such as the Miraflores, Mariano Melgar and Arequipa districts.

District	Area (km ²)
ALTO SELVA ALEGRE	6,98
AREQUIPA	12,80
CAYMA	246,31
CERRO COLORADO	174,90
CHARACATO	86,00
CHIGUATA	460,81
J.L. BUSTAMANTE Y RIVIERO	10,83
JACOBO HUNTER	20,37
MARIANO MELGAR	29,83
MIRAFLORES	28,68
MOLLEBAYA	26,70
PAUCARPATA	31,07
QUEQUENA	34,93
SABANDIA	36,63
SACHACA	26,63
SOCABAYA	18,64
TIABAYA	31,62
UCHUMAYO	227,14
YANAHUARA	2,20
YARABAMBA	492,20
YURA	1 942,90
TOTAL	3 948

Table 2: Districts of city of Arequipa and their area (Data Source: INEI, 2017)

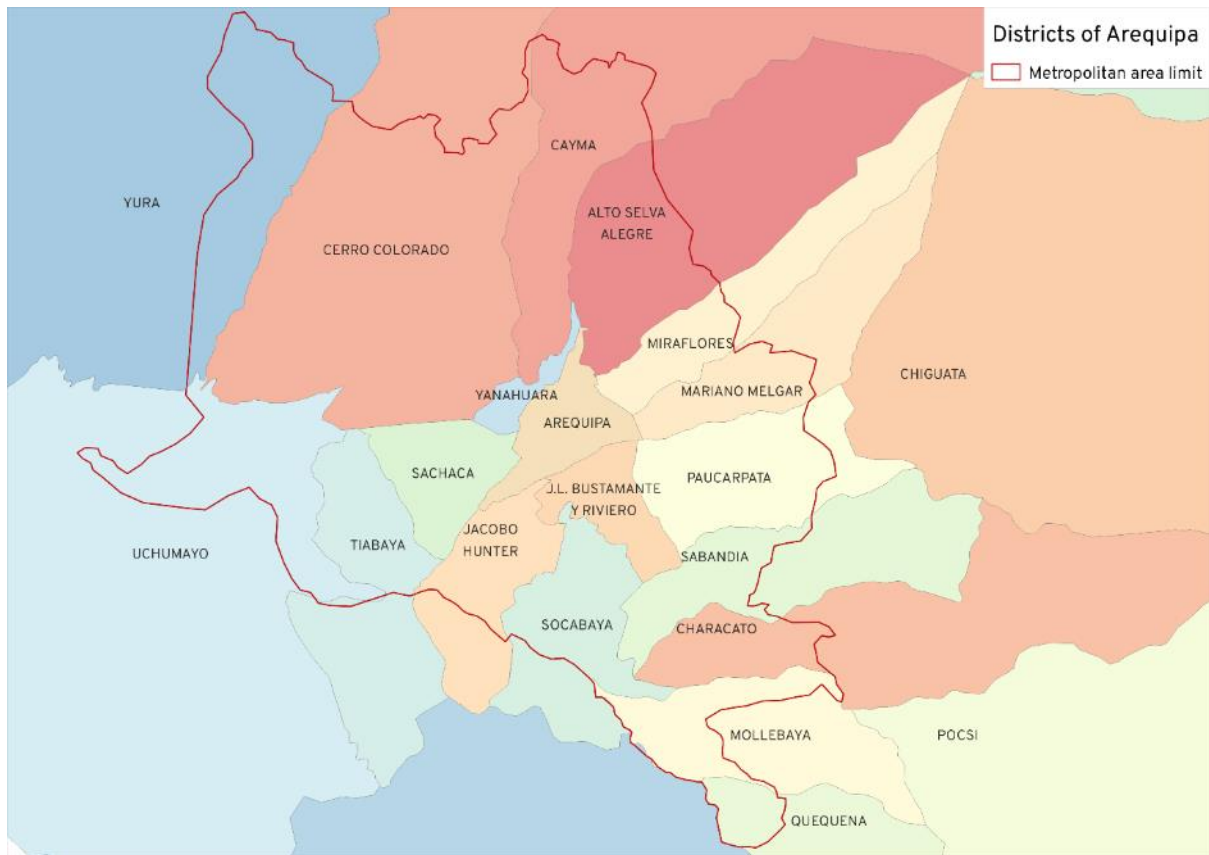


Figure 22: Districts and metropolitan area limit of Arequipa (Map: H. LE VASLOT)

Despite having a monocentric urban structure, the city of Arequipa relies on surrounding provinces and regions to meet its essential needs for items like food, water, and energy. In other words, the city is not self-sufficient and depends on external sources for these basic goods and services.

3.2.2. Historical and political context

According to research tracing back to 7500 BC, the earliest signs of housing in Arequipa can be found, indicating the presence of hunter-gatherer groups in the region. During the pre-Incan era, the area was under the influence of Wari culture, based in Ayacucho, and the Tiwanaku civilization located on the Bolivian side of Lake Titicaca. By the year 1000, Arequipa had its own distinct cultures, such as Churajón and Chuquibamba. Arequipa's strategic location played a crucial role in facilitating the exchange of goods between different regions, making it a significant hub for trade. Moreover, the city served as a vital source of agricultural supplies for the Inca Empire, providing sustenance and essential resources to support their economy.

In 1350, the city was conquered and became part of the Inca Empire. Spanish arrival in 1530 recognized the significant agricultural potential of Arequipa, which became one of the prominent hubs of the region.

During the country's historic colonial era, in 1540, Garcí Manuel de Carbajal established the city of Arequipa with a grid-like street pattern that was rotated approximately 20° in relation to the North, under the commission of Francisco Pizarro. This urban design, characterized by a central square, was chosen for both functional and symbolic reasons. It followed the model proposed by Francisco Eximeniç, who drew inspiration from the biblical book of Revelations to theorize about an ideal city with a grid layout, in which the main square was associated with the throne of God. This design aimed to create a visually appealing and symbolic urban environment, reminiscent of the heavenly Jerusalem (C. Zeballos, 2020). Arequipa was founded as a geopolitically strategic center to collect silver extracted from mines in Chivay and Potosí and deliver it to the port in Quilca.

The urban layout of Arequipa was carefully aligned with the Chili River and rotated diagonally in relation to the topography. This intentional design aimed to facilitate the efficient drainage of rainwater during heavy rainfall. Urban planners ensured that excess rainwater could easily flow and be evacuated, minimizing the risk of flooding.

Furthermore, the central square served as the focal point for key religious, political, and administrative functions. Important institutions and buildings associated with these functions were strategically located around the main square, emphasizing its significance as the heart of the city.

During the colonial period, the urban landscape of Arequipa was defined by its horizontal and homogeneous nature, predominantly shaped by the grid layout. The regularity of the grid pattern created a sense of uniformity throughout the city, with streets sharing the same spatial hierarchy and cross-section.

The map below, created in 1784 by Antonio Álvarez and Jiménez, provides a fascinating colonial document depicting the uniformity of the urban landscape during that time. The map highlights the prominence of churches as the most important landmarks, underscoring their significant role in the city's identity. The central square, or main square, occupies a central position, emphasizing its importance as a focal point for civic and social activities.

The map also includes representations of temple gardens and agricultural plots, reflecting the significance of agriculture in the region's economy. Notably, the area adjacent to the river appears empty, suggesting a lack of significant development in that zone.

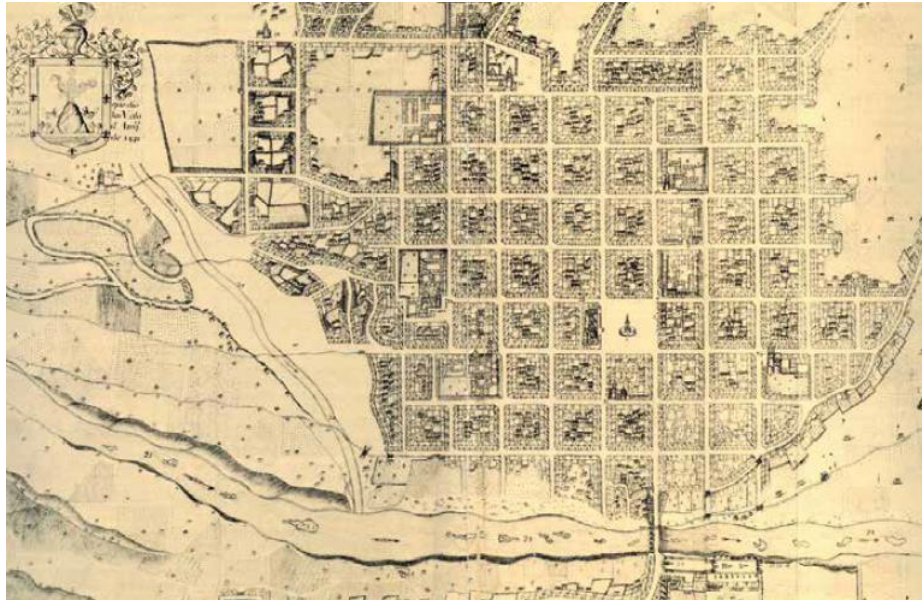


Figure 23: Map of city of Arequipa in 1784 made by Antonio Álvarez y Jiménez (Source: Atlas Ambiental de Arequipa)

Following Peru's independence in 1821, Arequipa entered its Republican era and quickly became the leading urban center in southern Peru. It surpassed the city of Cusco in terms of economic importance, particularly in commercial exports. Architecturally, the city embraced a new and more contemporary style known as neoclassical style, while the overall urban layout remained largely unchanged from the colonial era.

During this period, Arequipa witnessed a notable urban expansion, which was characterized by vertical growth rather than horizontal sprawl. The city experienced a progressive densification of the built environment, with an increasing number of structures erected within the existing urban fabric in order to accommodate its growing population and economic activities.

In the 1870s, two significant events brought about a complete reorganization of the urbanization in Arequipa. Firstly, the devastating earthquake of September 1868, with a magnitude of 9, resulted in the destruction of most of the city's buildings. This catastrophic event required the reconstruction of the entire city and the implementation of a new urban model that emphasized wider streets while maintaining the orthogonal pattern characteristic of the city's layout.

Additionally, the construction of a railway in December 1870, which connected Arequipa to the Peruvian coast and to Lima, played a crucial role in the city's development. This railway link contributed to Arequipa's emergence as the primary economic hub in the region, by facilitating trade and the transportation of goods and solidifying its position as a key economic

center. The railway connection played a significant role in shaping the city's growth and establishing its prominence within the regional economy.

In the 20th century, particularly from 1940 onwards, the centenary of the Spanish foundation of Arequipa, several neighborhoods began to emerge around the city center. These new residential areas were developed to accommodate the growing population and urban expansion. However, two major earthquakes struck the region in 1958 and 1960, both with a magnitude of 7, causing significant damage and destruction to parts of the city.

As a result of these destructive earthquakes, Arequipa had to undertake measures to address the housing needs of affected populations. Certain agricultural areas were transformed into residential zones with the aim of providing housing for those in need. These areas were repurposed to support the growing population and offer a solution to housing challenges resulting from the earthquake damage.

In the 1980s, Arequipa experienced significant urbanization, marked by both urban expansion and the densification of the historic center with the introduction of modern buildings. Towards the end of the 20th century, the city witnessed further urban expansion in the north, east, and south, but this process also brought along negative consequences. These included the destruction of green areas and the unhealthy and chaotic development of certain areas or neighborhoods due to rapid urbanization.

In 2000, UNESCO declared the historic center of Arequipa as a World Heritage Site. However, the following year, the city faced a devastating magnitude 8 earthquake, resulting in significant damage to both the historic center and the cathedral, and the destruction of numerous residential areas. Unfortunately, Arequipa continued to lose its remaining green spaces over time, and no dedicated program for protecting its natural heritage was implemented. Instead, these areas were gradually replaced by residential or commercial developments.

One of the characteristics of the city of Arequipa is the ashlar, volcanic ash stone and lapilli used for the construction of buildings. The white color of the stone gave Arequipa the appellation of White City. This uniqueness of its architecture was one of the determining factors for the historic center of the city to be declared UNESCO cultural heritage of humanity.

3.2.3. Urbanization context

Urban expansion and growth in the country can be attributed to multiple factors and causes, with the primary driver being rural-to-urban migration. Indigenous and highland populations have been migrating from the countryside to the cities, seeking better opportunities and living conditions. However, many of these migrants lacked the necessary resources to establish their own homes or sustain themselves adequately. Consequently, informal settlements emerged as a result of this migration wave starting from the 1960s, where people formed informal settlement groups, facing challenges in terms of housing and livelihood.

The consequence of this migration process and the prevalence of informal settlements it creates, is rapid and unregulated urbanization, particularly evident in the periphery of Arequipa since the early 21st century. These areas face significant challenges to achieving sustainable urbanization due to their severe topography and various obstacles such as volcanism, landslides, and flood risks. Additionally, thriving agricultural activity in the city of Arequipa has compelled people to settle in areas beyond designated agricultural zones. Therefore, the city has expanded disproportionately, extending its boundaries to the north, south, and east, resulting in an increased overall size of the urban area.

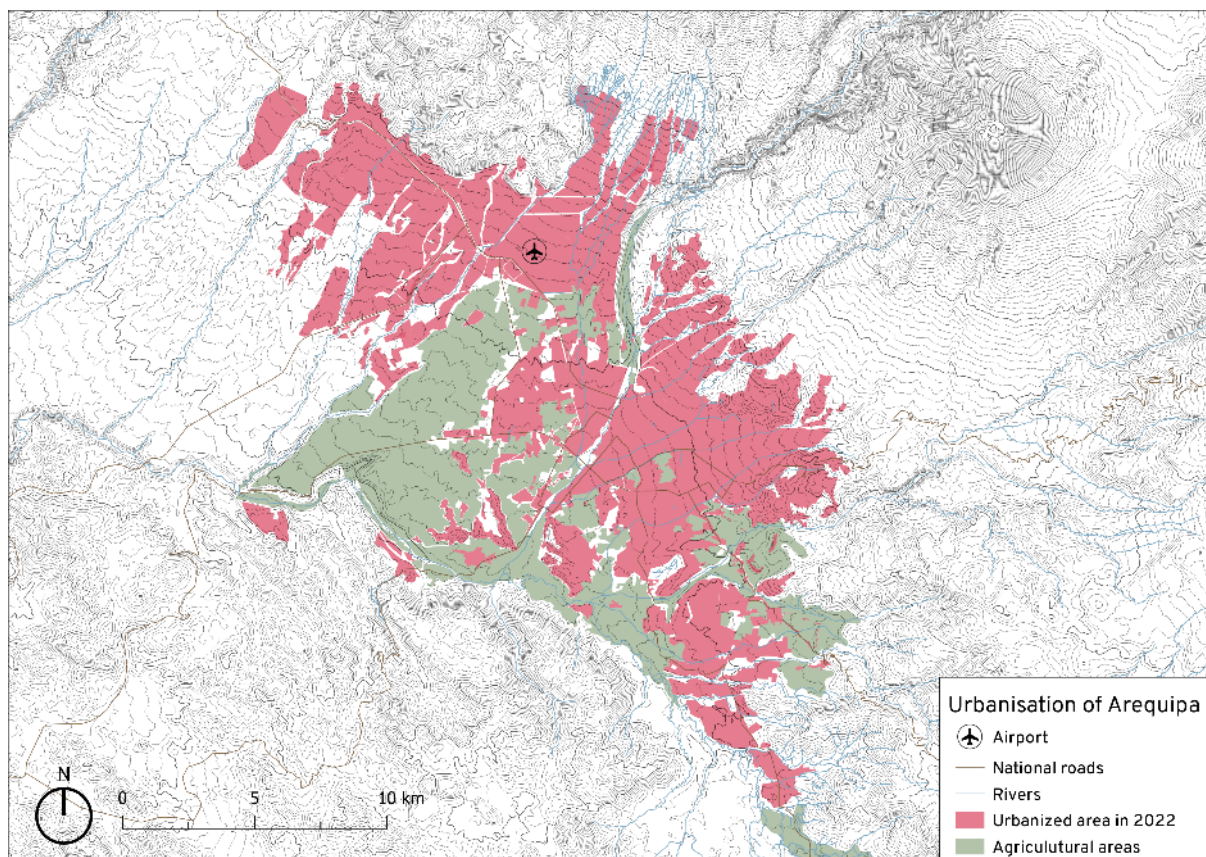


Figure 24: Map of Arequipa and relation of the urban areas with the topography (Map: H. LE VASLOT)

The present urban layout of Arequipa proves an uneven pattern of urbanization, showing a monocentric city design. This configuration highlights the significant influence of the city's topographical relief, which acts as a hindrance to its urban expansion. The topography of the area plays a crucial role in shaping the city's development, imposing limitations on the extent and direction of urban growth, as shown on the previous map.

The growth of Arequipa has led to soil speculation, resulting in the rise of informal social groups, including land sale mafias, particularly in the northern part of the city (Dirección de Ambiente y Cambio Climático, 2018). These groups take advantage of the demand for land and engage in illegal activities. This issue emphasizes the need for measures to address informal practices and ensure transparent urban development.

In order to obtain a deeper understanding of the urbanization process in the city, it is essential to analyze this phenomenon from a historical perspective. By examining the historical phases and events, it is possible to establish connections between specific urbanization zones and their corresponding historical contexts and get valuable insights into the city's growth patterns and identify key factors driving urbanization.

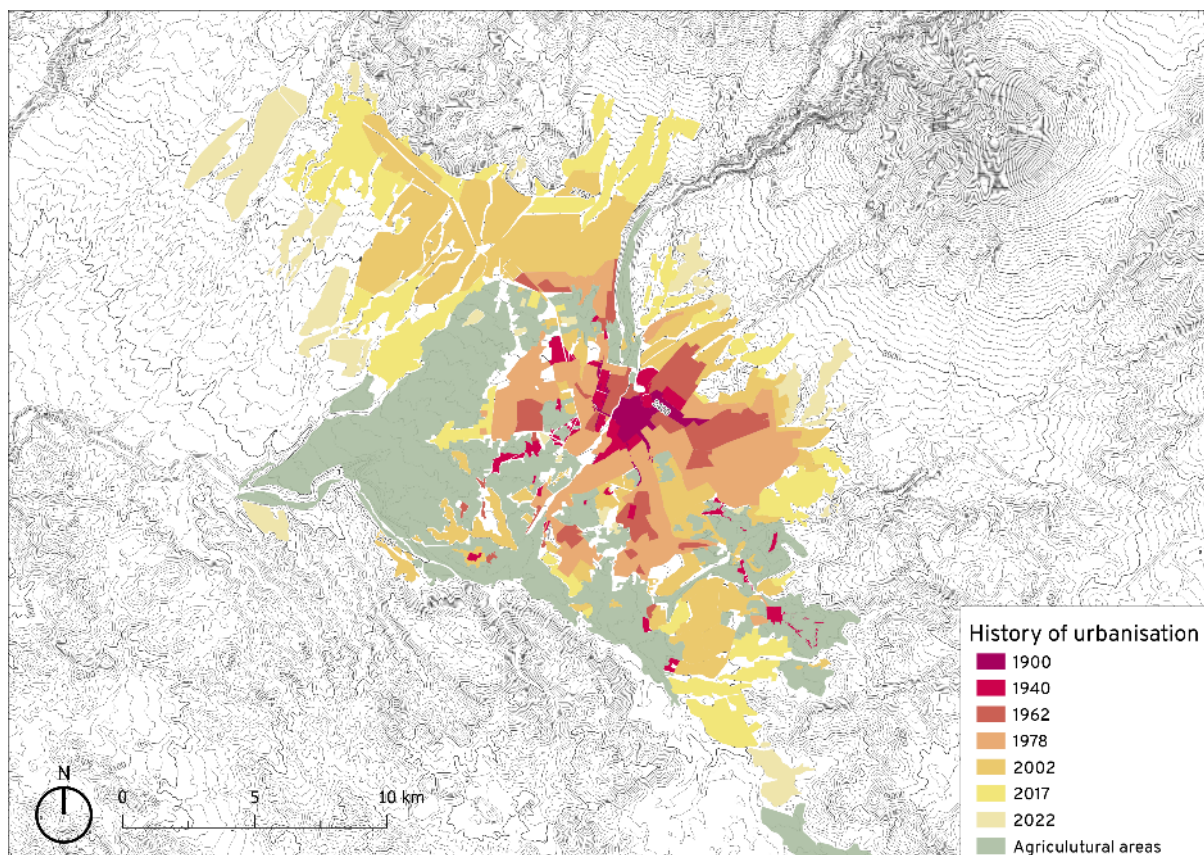


Figure 25: Evolution of urban area of Arequipa (Data Source: Landsat Satellite imagery, IMPLA)

Between 1940 and 2022, Arequipa experienced a remarkable urbanization process. Based on satellite images and historical maps, the urban area of the city expanded 19-fold, growing from 13 to over 250 square kilometers. This significant growth was driven by urban expansion and a substantial increase in population. Notably, for the first time in its history, urbanized areas of Arequipa surpassed agricultural areas within the city. The above map provides a visual representation of these changes, highlighting the transformative nature of Arequipa's urban landscape over the years.

The growth of Arequipa since 1940 can be attributed to several factors, including its 400 years of existence, which led to significant urban developments such as Selva Alegre. Additionally, the construction of the airport, initially located in the north far from the city, played a role in driving growth towards that area. During this period, traditional villages existed as rural settlements connected to the city through road networks. These factors contributed to the expansion and development of Arequipa during that time.

In the 1960s, earthquakes in Arequipa triggered the migration of middle-class households from the historic center to nearby agricultural areas in the west, primarily to the Paucarpata and Yanahuara districts. This forced relocation resulted in the urbanization and development of these previously rural regions. The earthquakes served as a catalyst for the expansion of urban areas into formerly agricultural lands, leading to significant demographic and spatial changes in these areas. Additionally, droughts in the departments of Cusco and Puno have triggered a significant migration wave, causing the population of Arequipa to triple in just 20 years. This influx of migrants has resulted in the urbanization of areas east of the historic center, particularly in the districts of Miraflores and Mariano Melgar.

During the 1970s and 1980s, the existing neighborhoods in Arequipa became more established and witnessed a strengthening of urban expansion towards the eastern areas. Additionally, a gradual expansion tended towards districts in the north, particularly Cayma. From 1980 to 2000, a significant and rapid urban growth occurred in the northern part of the city, encompassing the airport area as well as the districts of Cayma, Cerro Colorado, and Yura. This newly urbanized area developed a distinct urban structure, closely connected to the road network and running parallel to the airport.

Between 2005 and 2015, there was a significant increase in real estate prices and land inflation. This was influenced by restrictions imposed by the 2001 city development plan, which led to the densification of the formal city and its center. At the same time, there were speculative invasions and informal occupations, with various informal groups acquiring multiple plots of land. This situation highlights one of the major challenges of urban

development in the city. The continuous expansion of the city is not sustainable and poses difficulties in terms of providing services, infrastructure, and preserving natural areas.

Using satellite image data, it is possible to estimate the urban areas constituting the city of Arequipa over each period studied, and thus obtain the percentage of urban expansion between 1900 and 2022, but also to determine the average rate of intercensal urban expansion:

Year	Urban area of Arequipa (km ²)	Urban expansion (km ²)	% of total urban expansion (1900-2022)	Urban expansion intercensal rate (%)
1900	2,94	-	-	-
1940	13,5	10,56	4,3%	3,88%
1962	28,7	15,2	6,2%	3,49%
1978	62,9	34,2	14,0%	5,03%
2002	129,1	66,2	27,1%	3,04%
2017	205,104	76	31,1%	3,13%
2022	247,274	42,17	17,3%	3,81%

Table 3: Evolution of urban expansion of the city of Arequipa (Data source: Landsat Satellite imagery)

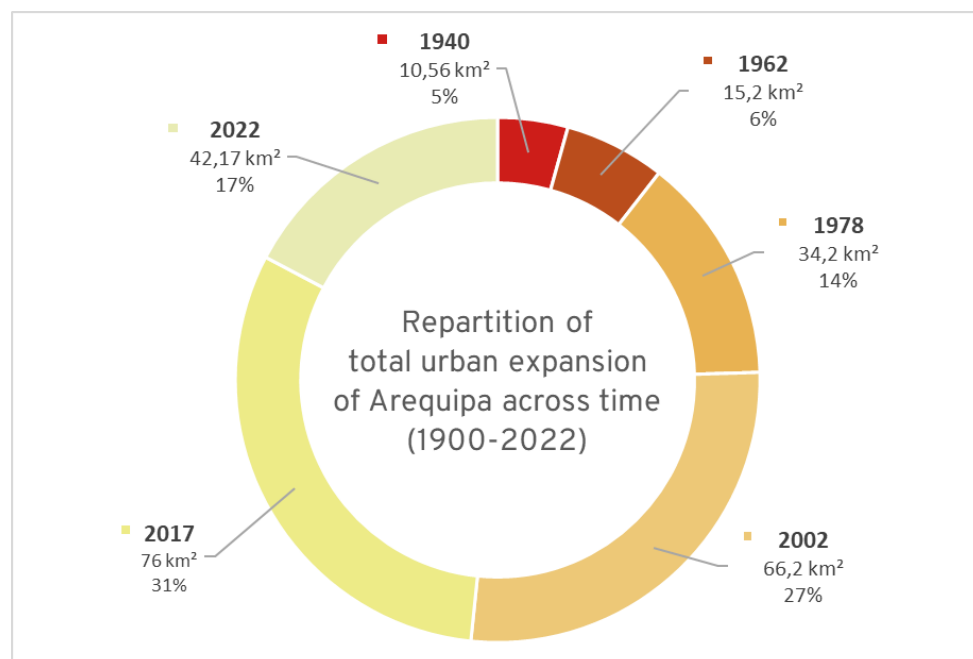


Figure 26: Repartition of urban expansion of city of Arequipa across time

The city of Arequipa has experienced significant urban expansion primarily in the 21st century, as visible on figure 18, mainly driven by migration and population growth within the city. Additionally, the intercensal rate of urban expansion indicates that the most substantial expansion occurred during the early 1980s, with an annual growth rate exceeding 5% at the city level.

Overall, the combination of migration, population growth, and bad territorial management policies has contributed to the substantial urban expansion of Arequipa, with the early 21st century appearing as a critical period for the city's transformation.

The significant expansion of Arequipa and informal urbanization which characterized it from 1980 to 2020 has raised concerns regarding the quality of life in newly developed areas. The comfort and well-being of residents in these regions depend on the availability of adequate infrastructure and services. Regrettably, this growth has resulted in the loss of green spaces in districts like Cayma, Cerro Colorado, Mollebaya, Quequeña, Sachaca, Socabaya, and Yura. These districts have had to sacrifice their natural areas to accommodate the city's expansion, potentially impacting the overall environmental balance and sustainability of these areas.

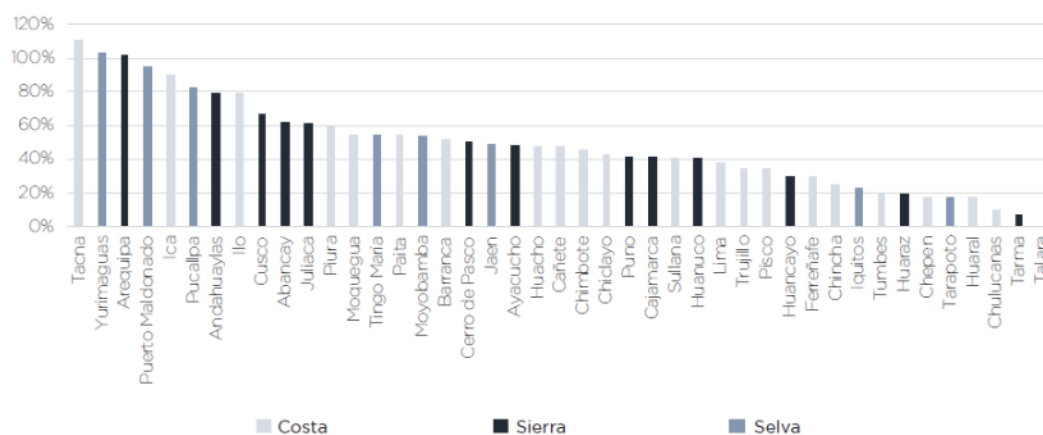


Figure 27: Accumulated urban expansion in Peruvian cities between 2000 and 2018 (Source: Mapeo y tipología de la expansión urbana en el Perú, 2019)

To conclude the urbanization study, between 2000 and 2018, the city of Arequipa experienced the third highest relative urban expansion among Peruvian cities, with a growth rate surpassing 102%. This rapid doubling of the city's surface area indicates a lack of effective management and planning in urban development. It highlights the need for better strategies to regulate and guide the city's growth.

3.2.4. Demography and Housing in Arequipa

In the province of Arequipa, similarly to the overall trend in Peru, the population experienced a significant increase in the second half of the 20th century. During this period, there was a notable shift as rural population gradually declined while urban population in cities, particularly in Arequipa, saw a steady rise. This population shift can be attributed to the migration of people from neighboring small towns and rural areas towards Arequipa in search of better employment and housing opportunities. The city's urban environment offered greater accessibility to jobs and improved living conditions, attracting individuals from surrounding areas.

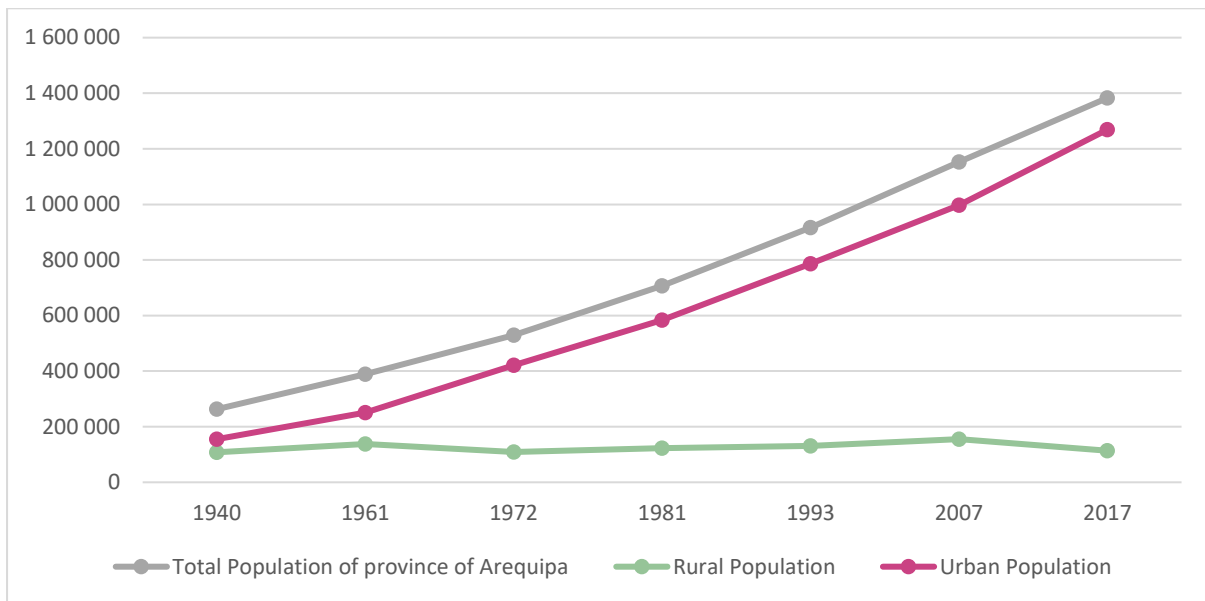


Figure 28: Demographic evolution in province of Arequipa with urban and rural population (Data source: INEI)

The province of Arequipa witnessed a notable rural exodus during the second half of the 20th century. The urban population in the region increased from 59% in 1940 to over 86% in 2017, reflecting a significant trend of rural exodus, leading to a significant rise in urbanization within the province.

Besides, the INEI censuses of 2007 and 2017 offer valuable information to examine the demographic trends within the city of Arequipa. By analyzing this data, it becomes possible to gain a detailed understanding of the population distribution across different districts of the city and observe demographic changes and trends that occurred over a decade.

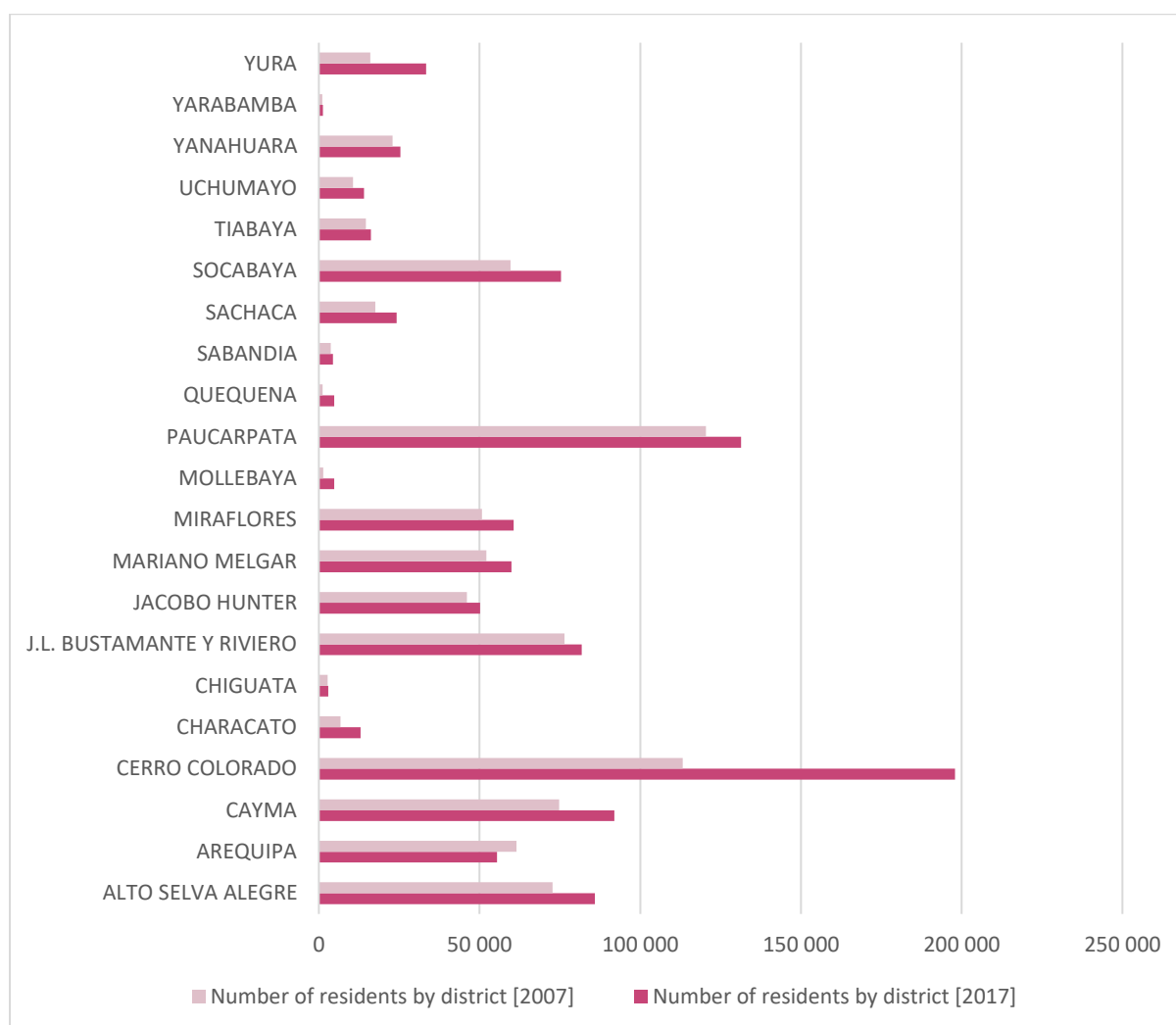


Figure 29: Population in districts of Arequipa in 2007 and 2017 (Data source: INEI)

Between 2007 and 2017, the total population of Arequipa city increased from 826 202 to over 1 034 736 inhabitants, resulting in an annual population growth rate of 2.28% for the entire municipality. Examining population trends by district, Cerro Colorado and Paucarpata emerged as the most populous districts, with 197 954 and 131 346 inhabitants respectively in 2017. However, the Arequipa district itself experienced a decline in population, dropping from 61 519 to 55 437 residents between 2007 and 2017. This trend suggests that despite the overall high population growth rate in the city, the historic center, which is densely urbanized, has gradually seen a decrease in residents. In contrast, more affordable residential areas in the northern, southern, and eastern parts of the city have attracted population over the past decade.

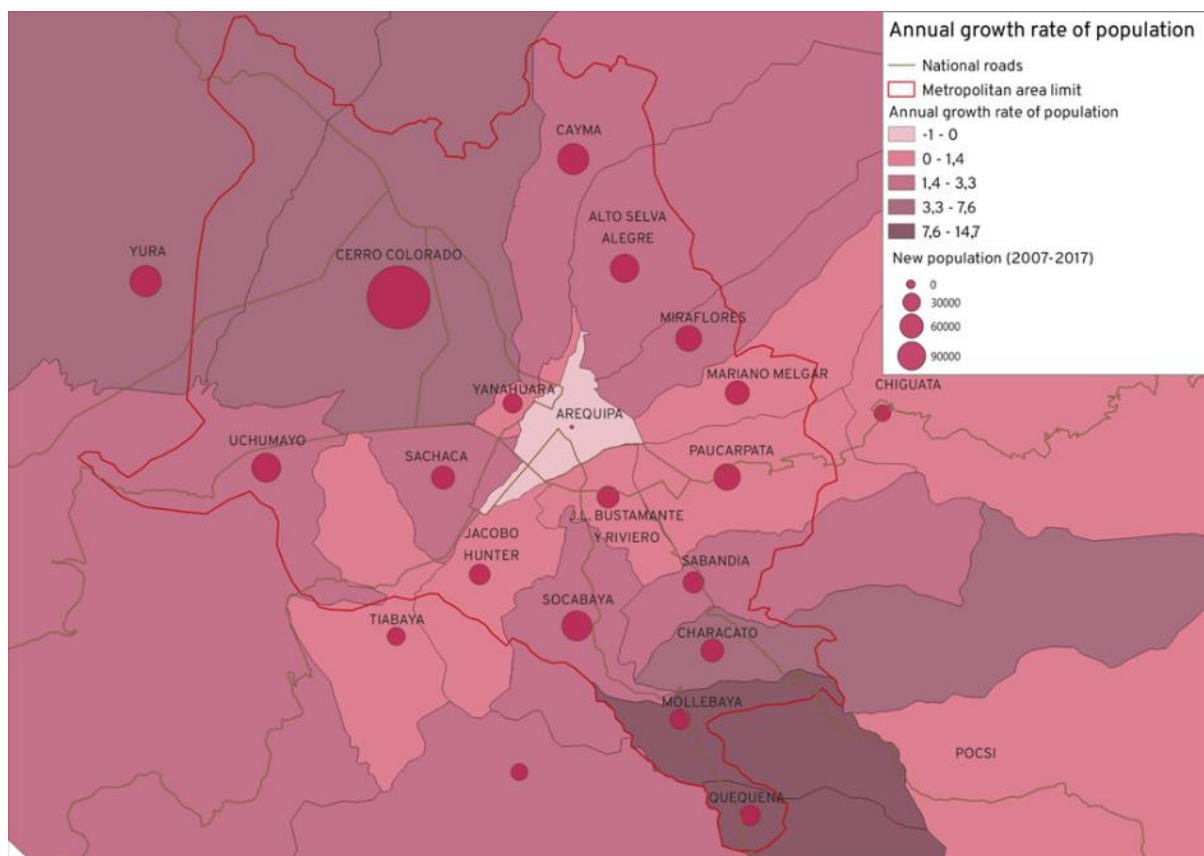


Figure 30: Map of annual growth rate of population by district of Arequipa between 2007 and 2017 (Data source: INEI)

The intercensal population growth rate map of Arequipa city reveals significant population growth in the northern districts (Cerro Colorado, Yura) and southern districts (Characato, Mollebaya, and Quequena). This indicates a trend of population expansion towards the periphery of the city, driven by informal urbanization and the establishment of new neighborhoods in vulnerable areas.

Furthermore, the neighboring districts near the city center are experiencing population growth, although at a slower rate compared to the areas of informal urbanization. However, the historic center district is witnessing depopulation, with a negative annual population growth rate of -1.04% between 2007 and 2017. This trend highlights a decline in the residential attractiveness of the historic center, while underscoring the concentration of population growth in the peripheral areas.

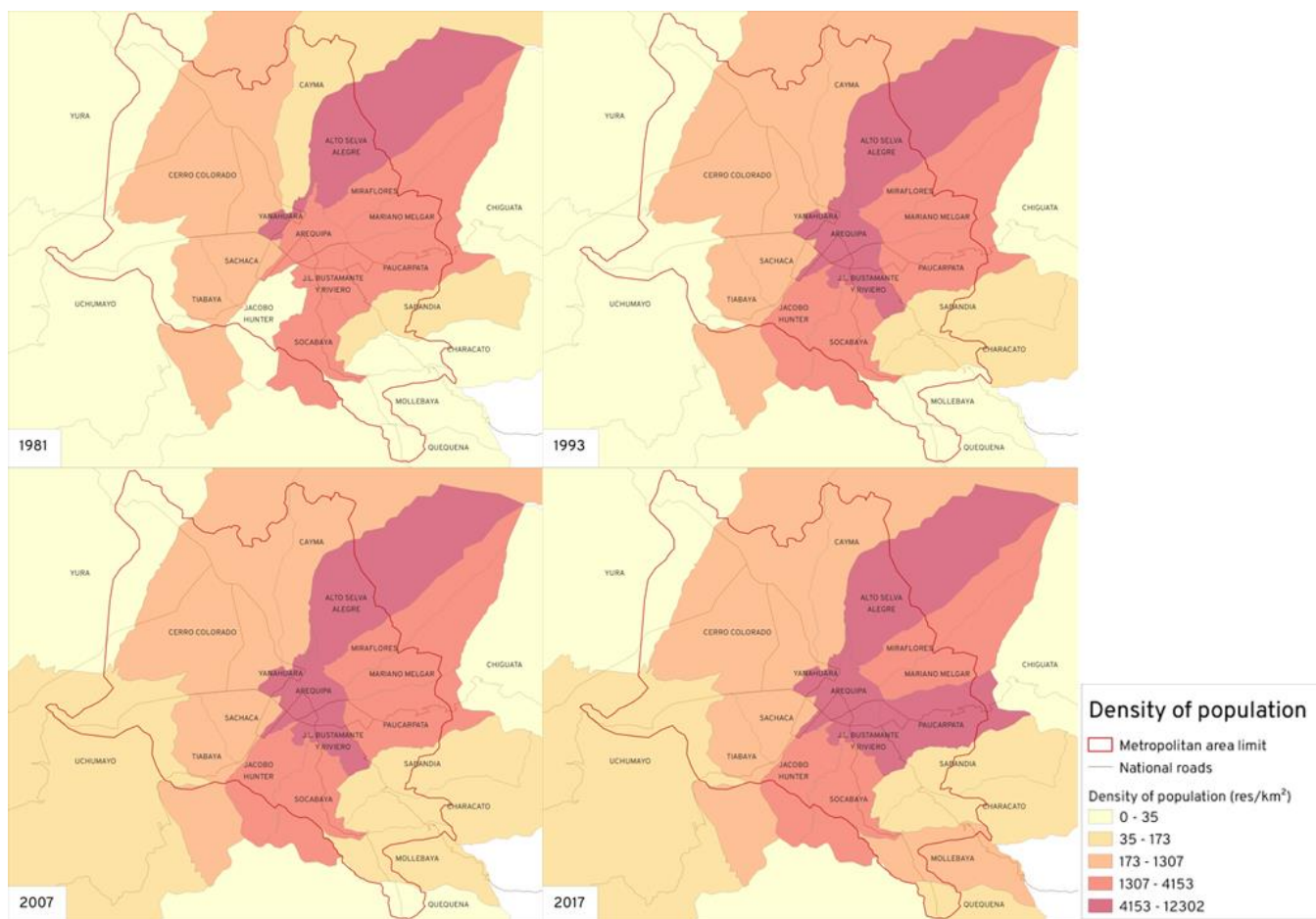


Figure 31: Historical evolution of density of population (res/km²) in districts of Arequipa (Data source: INEI)

Population density trends in the districts of Arequipa have been influenced by significant historical events since the 1960s. Initially, from 1981 to 1993, the historic center and its neighboring districts experienced a higher population density. This can be attributed to a large influx of migrants and rapid population growth in these areas. Moreover, during this period, the northern districts of Cayma and Cerro Colorado saw an increase in population, primarily due to urban expansion and the establishment of new neighborhoods around the newly constructed airport in 1980. These districts developed unique urban structures and characteristics specific to them.

Subsequently, between 1993 and 2007, the eastern and southern districts of Arequipa witnessed a higher population density. This was a result of the relocation of populations affected by the 2001 earthquake, leading to the creation of new residential areas either planned by the city or informally established.

Furthermore, between 2007 and 2017, the districts located on the outskirts of the city center experienced significant population growth. This was primarily driven by ongoing urban expansion, accompanied by the emergence of informal settlements in the southern districts of Mollebaya and the eastern district of Paucarpata, where the population density exceeded 4000 inhabitants per square kilometer.

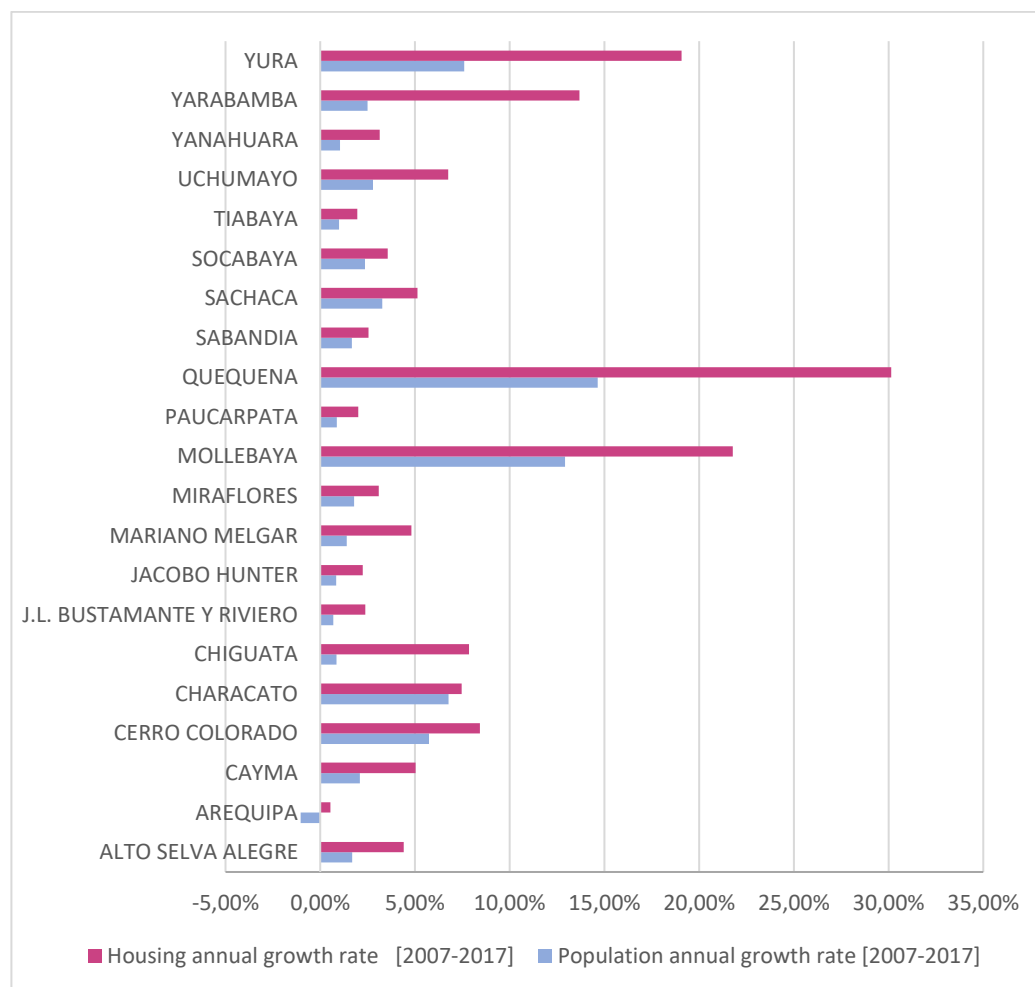


Figure 32: Intercensal growth rate of housing and population in Arequipa between 2007 and 2017

The disparity between the intercensal growth rates of dwellings and population can be attributed to several factors. Firstly, planned urban development plays a significant role. Urban development projects are implemented to anticipate future population growth, resulting in the construction of new dwellings in alignment with projected needs. Additionally, over a 10-year period, there may be a time lag between the creation of new housing units and population growth.

Secondly, real estate speculation has been a contributing factor since 2005. Investors often build housing in anticipation of future increases in real estate prices, leading to an excess supply of housing compared to the actual demand from the population. This phenomenon is further compounded by informal groups that occupy and attempt to profit from multiple land plots.

Lastly, the presence of vacant or unoccupied dwellings also contributes to the disparity. Even as the number of dwellings increases, a portion of them may remain unutilized, creating an imbalance between supply and the actual demand for housing.

In sum, the divergence between the growth rates of dwellings and population can be attributed to planned urban development, real estate speculation, and the presence of vacant or unoccupied dwellings. These factors collectively contribute to the housing supply exceeding the immediate needs of the population.

3.2.5. Mobility

The urban growth of Arequipa city is involvedly connected to its existing road network, as numerous informal neighborhoods emerged along national roads, particularly in the northern and southern regions of Arequipa. However, this road network exhibits several drawbacks attributed to the city's gradual expansion. Indeed, the roads are struggling to cope with the escalating and swift development, inhibiting their ability to accommodate the growing demands of the city.

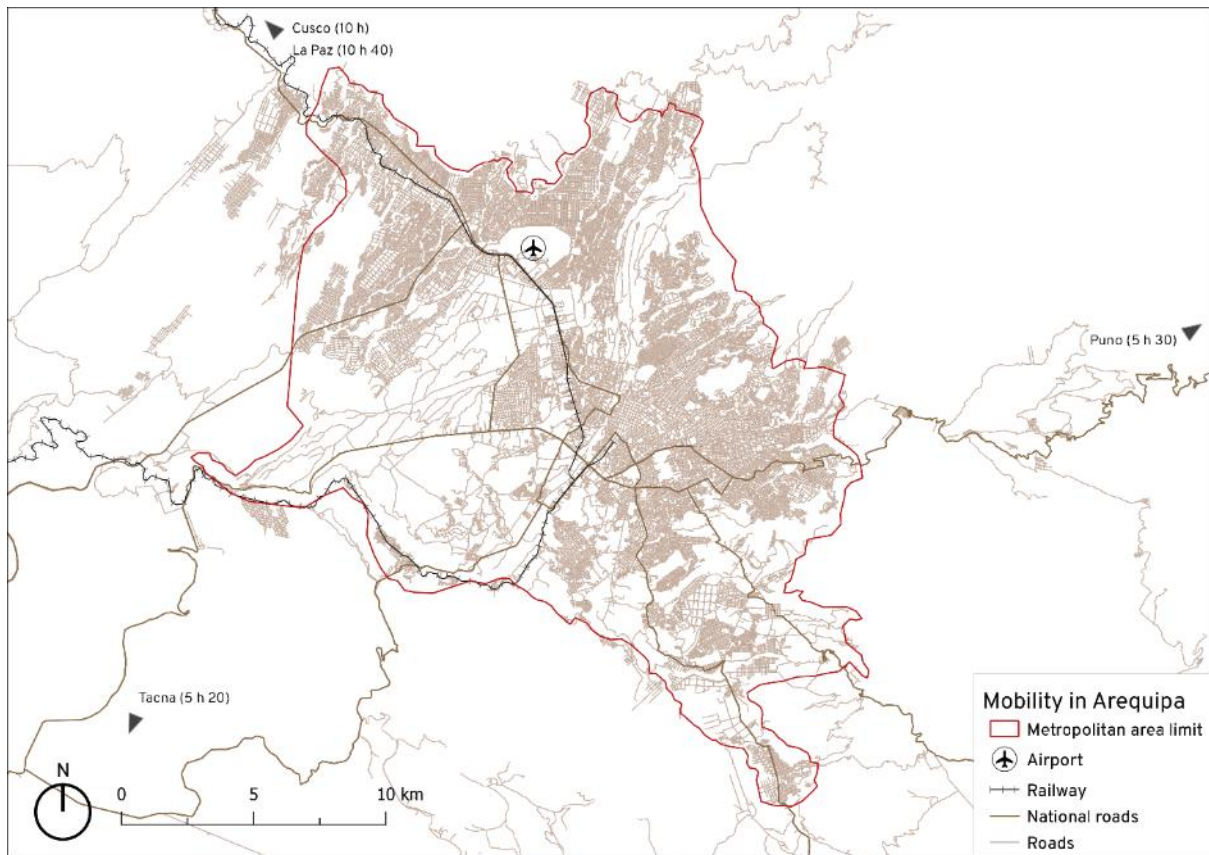


Figure 33: Mobility network of Arequipa (Map: H. LE VASLOT)

One of the primary drawbacks is the inadequate infrastructure to support the city's mobility needs and expanding urban areas. The road network, particularly in the outskirts and peripheral areas, is poorly developed, leading to congestion, traffic bottlenecks, and delays. This can result in increased travel times and frustration for commuters.

Furthermore, the public transportation system in Arequipa is facing a lot of challenges. There is a lack of sufficient and reliable public transport options, such as buses or trains, to cater to the growing population. This issue is leading to overcrowding, discomfort, and inconvenience for transportation in Arequipa, especially during peak hours.

The underdeveloped state of the public transport network in Arequipa has led to a predominant reliance on vehicles of lower capacity, such as combis, which can navigate the city's congested traffic more effectively.



Figure 34: Example of combi vehicle in Arequipa (Source: La Republica)

However, this inadequate public transport system has given rise to a surge in private transportation services, including taxis and ride-sharing platforms like Uber and InDrive. Consequently, the growing number of vehicles on the roads exacerbates traffic congestion, compounding the challenges faced by the city in terms of transportation services.

The integration between different modes of transportation, such as buses, taxis, and cycling infrastructure, is clearly insufficient. This lack of coordination and connectivity between various modes of transport makes it challenging for residents to switch seamlessly between different modes, hindering the efficiency of the overall mobility network.

Moreover, the management of traffic flow and enforcement of traffic regulations may be suboptimal, which result in chaotic traffic conditions, disregard for traffic rules, and an increased risk of accidents. Inadequate traffic management measures, including the absence of effective traffic control systems and police presence, can further compound the mobility challenges in the city.

Finally, the city of Arequipa misses sustainable transportation alternatives. Insufficient emphasis on promoting and developing cycling lanes, pedestrian-friendly infrastructure, and eco-friendly transportation options such as electric vehicles could contribute to environmental concerns and increased reliance on private vehicles, exacerbating traffic congestion and pollution.

3.2.6. Drawbacks of Arequipa's location

The urban expansion of Arequipa city is influenced not only by demographic and territorial management factors but also by various natural phenomena and disasters associated with its geographical location. Earthquakes, tsunamis, floods, landslides, and the presence of nearby volcanic activity all play significant roles in shaping the city's growth patterns and development. These natural events have direct implications for urban planning, infrastructure resilience, and the overall management of the city's expansion in the face of such geophysical challenges.

- Volcanic activity

Concerning the volcanic context of Arequipa's region, southern Peru has a total of 16 active volcanoes, namely Sabancaya, Misti, Ubinas, Coropuna, Yucamane, Tutupaca, Huaynaputina, Ticsani, Chachani, Sara Sara, Casiri, Quinsachata, Purupuruni, Andahua, Huambo, and Auhuato. These volcanoes have demonstrated activity within the past 500 years, making the region highly prone to volcanic events. Misti Volcano, the closest from the city of Arequipa, towering at an elevation of 5 822 meters above sea level, experienced its most recent eruption during the period of 1984 to 1985. Presently classified as dormant, Misti Volcano is situated merely 17 kilometers (approximately 10 miles) away from the city of Arequipa.

Peru's Institute of Geology, Mining, and Extraction has revealed significant findings regarding Arequipa's vulnerability to volcanic activity, placing it as the third most susceptible city globally. Notably, the looming threat of an eruption from Misti Volcano presents a grave concern, as it could result in the rapid influx of ash, rockfall, and molten lava towards the city center, here is the hazard map of the Misti volcano and city of Arequipa:

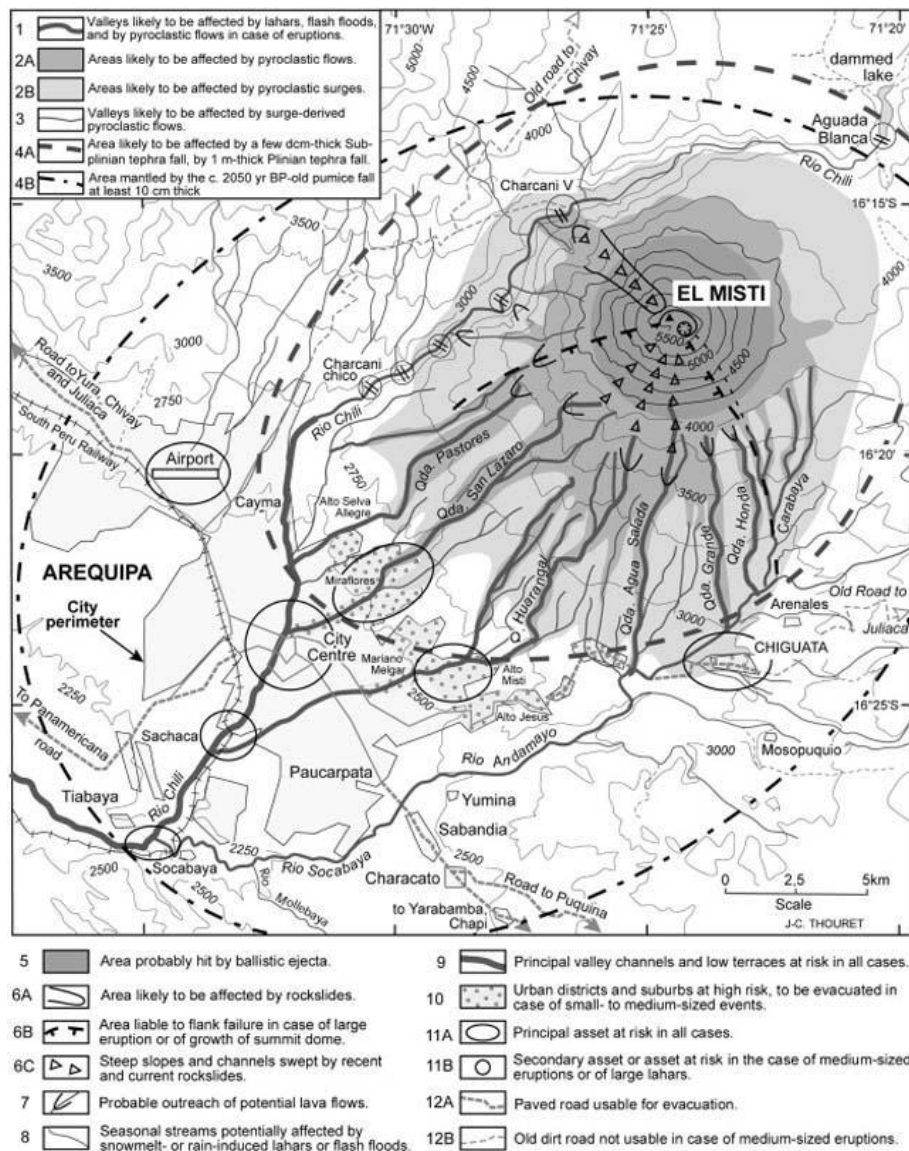


Figure 35: Hazard-zone map for El Misti and city of Arequipa (Source: <https://volcano.si.edu/volcano.cfm?vn=354010>)

The hazard map reveals a concerning pattern, indicating that a significant volcanic hazard threatens most urban areas and settlements situated to the east of the city center of Arequipa. Specifically, the districts of Miraflores, Mariano Melgar, and Paucarpata are particularly exposed to this hazard. Consequently, the ongoing informal urban expansion occurring in these districts gives rise to sustainability challenges.

Volcanic eruptions pose a multitude of hazards and threats that can result in loss of life, extensive property destruction, and even have global climate implications. The detrimental impact of eruptions is particularly pronounced in economically disadvantaged countries,

where the recovery process can extend over months or even years. Consequently, volcanic activity poses a significant and enduring danger for the city of Arequipa.

- Earthquakes

In addition to this volcanic context, Arequipa, as a region, is situated in a zone with high seismic activity, and its urban areas have been expanding without adequate control from authorities or the responsibility of the population. Consequently, in the event of an earthquake, a high level of destruction and loss of life is expected, similarly to the earthquakes that have damaged the city several times, notably in 1600, 1868, 1958, 1979, and 2001.

The southern region of Peru has a recurring history of significant earthquakes due to the continuous movement of tectonic plates. Although earthquakes of the same magnitude can generate similar ground vibrations, the level of damage in urban areas can vary considerably. This variation is primarily attributed to population growth and the unregulated expansion of cities into high-risk areas, with inadequately constructed housing in terms of design and materials used. Essentially, the construction of high-risk cities underscores the importance of comprehending natural hazards and implementing suitable measures to mitigate and prepare for these potential threats.

- Flooding risks

The rugged geomorphology of the Arequipa volcanoes region contains numerous micro-basins, many of which have been urbanized with streets and avenues that serve as pathways for rainwater. Among these micro-basins, the largest are ravines that carry substantial hydraulic flows, often accompanied by mud and stones during torrential episodes, earning them the name "torrents."

The encroachment of urbanization into these torrent channels poses significant risks to the population residing along their banks. The sealing of the natural absorption areas amplifies the inflow of water. Consequently, water that used to permeate the ground now floods the streets and avenues, exacerbating the absence of a proper storm drainage system in the city. The increased volume of water entering these channels during heavy rainfall events leads to destructive consequences, including property damage and, in some cases, the loss of human lives. One notable event occurred in February 2013 in the Mariano Melgar torrent.

The invasion of these torrent channels and the absence of adequate stormwater management measures highlight the urgent need to address these risks for the safety and well-being of the population in Arequipa.

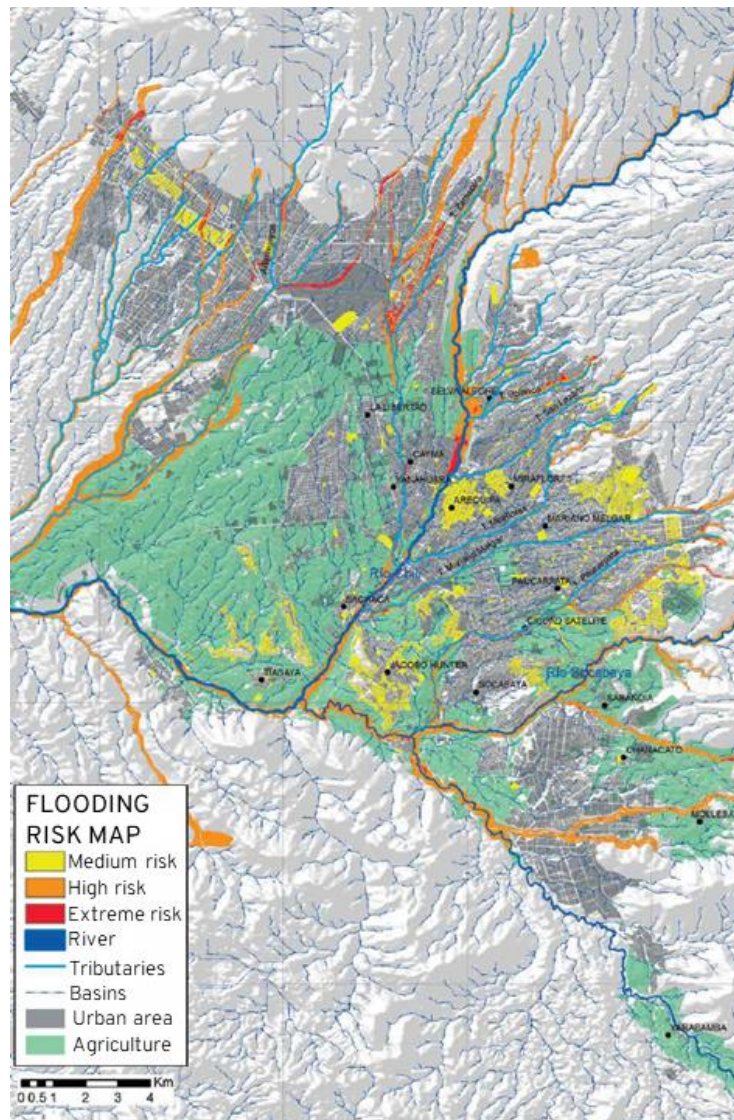


Figure 36: Flooding risk map (Source: Atlas Ambiental de Arequipa)

The flood risk map reveals that numerous areas within the city of Arequipa are highly susceptible to flooding and related phenomena. The excessive urbanization of riversides, particularly in the city center of Arequipa, as well as in the eastern and northern regions, has significantly increased the vulnerability to such disasters. Of particular concern are the poorer informal neighborhoods that lack the necessary preparations to effectively confront this type of disaster.

The concentration of urban development in these at-risk areas has amplified the potential for flooding and its associated impacts. It is crucial to address the existing vulnerabilities and implement appropriate measures to enhance resilience and mitigate the adverse effects of flooding in Arequipa.

3.3. Informal settlements case study in Arequipa

3.3.1. Location and urbanization context of settlements

The areas under study are informal districts situated in regions that have undergone significant urban growth since the start of the 21st century in Arequipa city. Consequently, these locations have witnessed rapid and inadequately regulated urbanization.

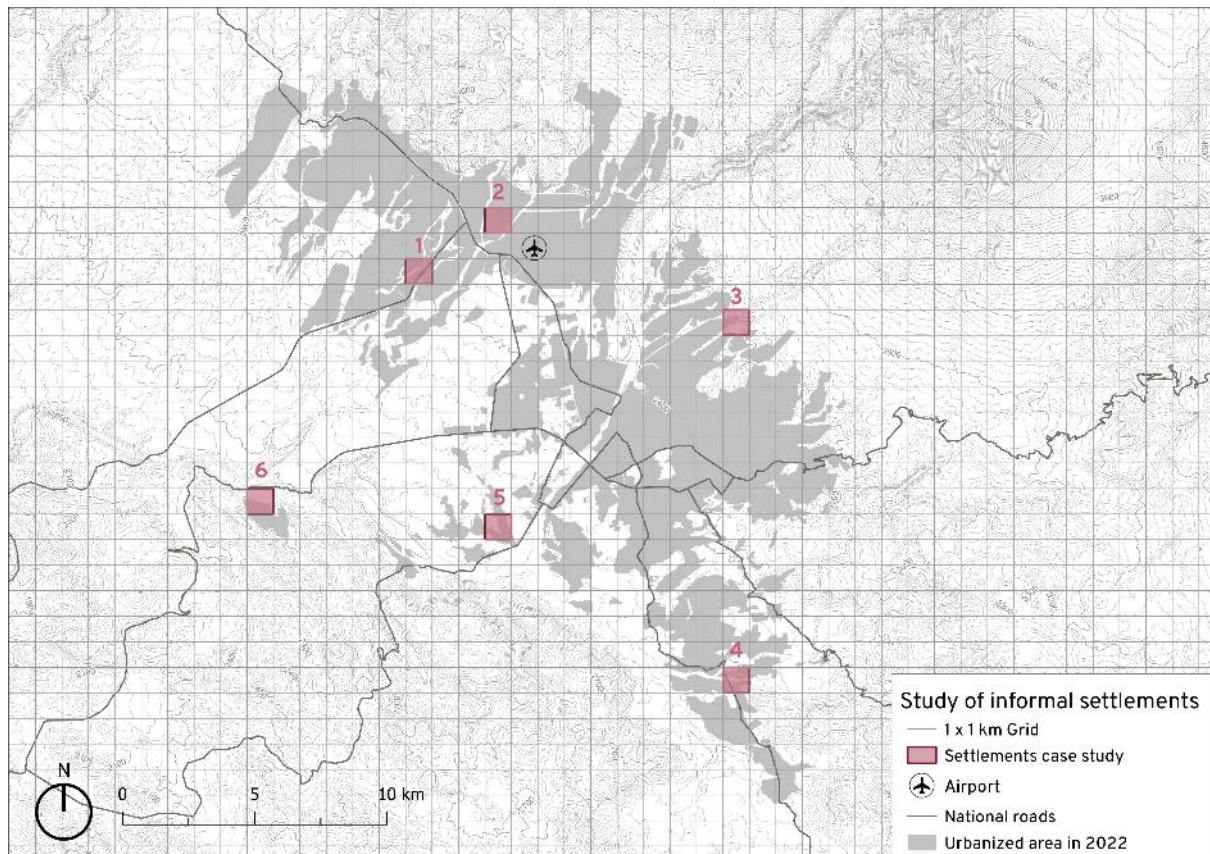


Figure 37: Location of informal settlements case study in Arequipa (Map: H. LE VASLOT)

The emergence of informal settlements in Arequipa city primarily occurred through the unlawful occupation of land by informal groups in previously vacant regions, particularly in the northern, southern, and eastern outskirts of the city. These areas, characterized by significant topographical variations, present numerous challenges for the future development of these neighborhoods. The geographical remoteness of these sites, coupled with the absence of essential services and road infrastructure within them, further exacerbates the issues they face.

- Site 1 – north of Arequipa:



Figure 38: Site 1 location and local map

The initial site under investigation is situated to the north of Arequipa city, an area that experienced significant urbanization following the 2001 earthquake. The rapid growth of the city and the incremental occupation of land by various informal groups led to a scattered built environment without a coherent and consistent urban pattern. Moreover, the national highway axis was established on the site after the initial neighborhoods had already been developed, resulting in a lack of harmony between the road network and the existing built framework. This lack of cohesion hinders the sustainable development of the neighborhood.



Figure 39: Site 1 satellite map – 2022 (Data source: Landsat imagery)

- Site 2 – north of Arequipa and airport context:

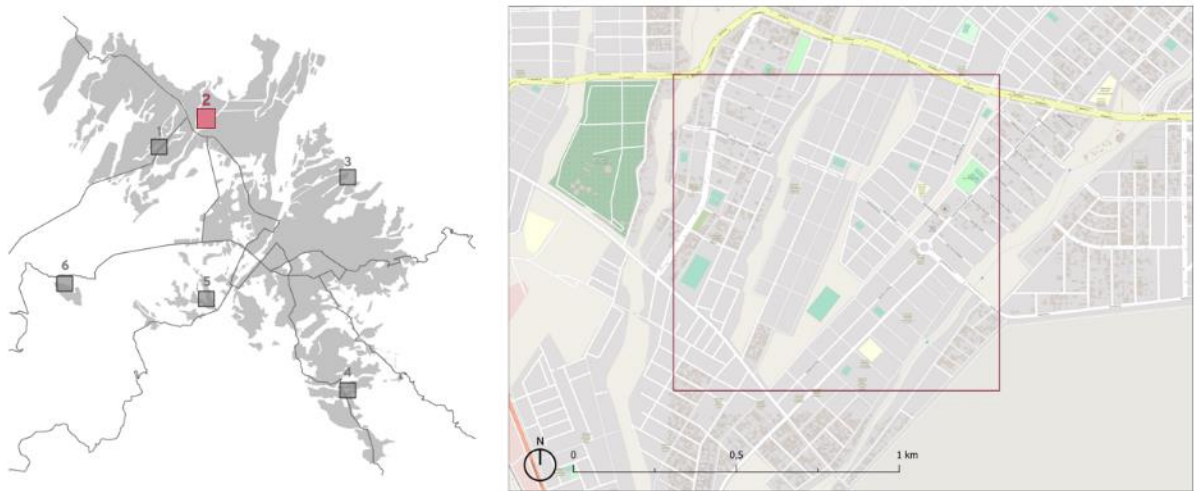


Figure 40: Site 2 location and local map

The second site, situated in the northern part of Arequipa near the city's airport, experienced urbanization concurrently with the establishment of the airport in the 1980s through the establishment of residential districts. As a result, the development of this site was designed to adhere to an urban framework. Compared to the first site, the development of this area is more advanced. Since the 2000s, the informal neighborhoods in this region have undergone a significant process of formalization. They have adopted a development scheme that considers the local topography, and multiple areas within these neighborhoods have already experienced substantial densification.



Figure 41: Site 2 satellite map – 2022 (Data source: Landsat imagery)

- Site 3 - east of Arequipa:



Figure 42: Site 3 location and local map

The third site under study is situated in the east part of Arequipa, characterized by its elevated terrain and the presence of surrounding mountains and volcanic features, including the nearby Misti volcano. The topographical relief in this area has compelled informal groups to settle in the limited available spaces with moderate slopes. As a result, the land utilization on this site is very low, and the absence of a recognizable urban layout is apparent.

This site poses significant challenges for neighborhood development and the formalization of existing infrastructure. It is located in areas prone to landslides and falls within protected areas designated by the province of Arequipa, such as natural reserves and the vicinity of the volcano. Consequently, the urbanization of this site follows a varied framework and is complex, shaped by the topography and lacking uniform development patterns.



Figure 43: Site 3 satellite map – 2022 (Data source: Landsat imagery)

The topographical features in the neighborhood present substantial challenges to its development. Notably, the informal groups located at the bottom of the valley face considerable vulnerability to erosion, landslides, and floods due to the rugged mountainous terrain. These geographical constraints pose a serious risk to the stability and safety of the settlements in the area.



Figure 44: Local topography on site (Source: Google earth)

- Site 4 - south of Arequipa:



Figure 45: Site 4 location and local map

The fourth site examined is situated in the southern part of the city and experienced rapid and unregulated urbanization during the early 21st century, similar to the northern area of the city. This site, once again, features significant variations in its topography. As a result, the development of the site is characterized by a stark contrast between two distinct areas.

In the northern part, there is a more structured development with a classical orthogonal urban grid, connected to the national road network. This portion of the site follows a planned layout and exhibits a more organized urban form.

In contrast, the southern part of the site showcases an informal neighborhood that has gradually emerged on the mountainous terrain. The development in this area is fragmented and lacks a clear development pattern. The informal settlement has expanded in a disparate manner, reflecting the challenges posed by the rugged terrain and the absence of planned urbanization.



Figure 46: Site 4 satellite map – 2022 (Data source: Landsat imagery)

- Site 5 – southwest of Arequipa:



Figure 47: Site 5 location and local map

The fifth site is situated in the southwestern region of Arequipa, which is primarily designated for agricultural purposes. This agricultural land use has limited the urban expansion on the western side of the city, as there is minimal available space for informal groups to establish new settlements. However, this site represents a unique case where informal groups have managed to colonize the land, despite the challenging topography that restricts the utilization of new agricultural areas. Since the beginning of the 21st century, there has been a gradual occupation of the hill on this site, resulting in increased urbanization in recent years.



Figure 48: Site 5 satellite map – 2022 (Data source: Landsat imagery)

Nevertheless, this type of occupation is not sustainable for the future development of the district. The significant relief in the area makes it impractical to construct viable road infrastructure, and the absence of an existing urban fabric poses challenges for future densification. Moreover, the occupation of such terrain carries a high risk of landslides, and the unstable soil hampers the construction of multi-story buildings.

Overall, the site's topographical constraints, absence of proper urban planning, and geotechnical risks present significant obstacles to its future development.



Figure 49: Local topography of the settlement (Source: Google earth)

3.3.2. Virgen del Rosario settlement – site 6

3.3.2.1. Historical context, location and topography

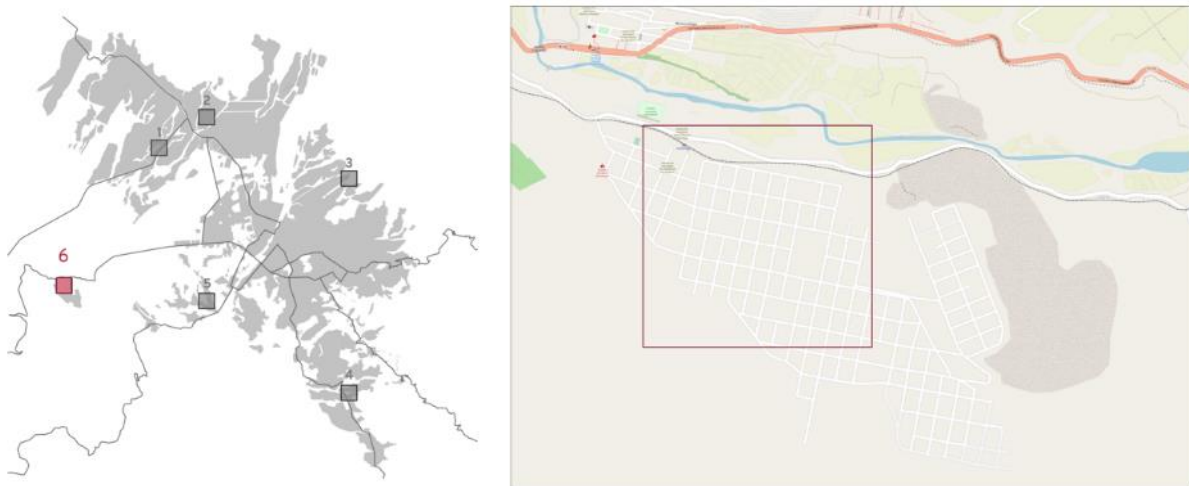


Figure 50: Site 6 location and local map

The final site under study provides a rich array of elements for analysis, as extensive on-site visits and interviews with residents and leaders of the Virgen del Rosario Housing Association have been conducted. These interactions have facilitated an in-depth examination of the neighborhood's urbanization, its available services, and its overall level of development.

The district is situated on the outskirts of the metropolitan area of Arequipa, specifically within the Uchumayo district near its corresponding municipality. This location within the broader urban context of Arequipa offers valuable insights into the dynamics and characteristics of the neighborhood, as well as its relationship with the surrounding area.

To give an historical context, the establishment of the Virgen del Rosario Housing Association and the creation of the settlement can be traced back to 2001. The catalyst for its formation was the earthquake that occurred in September of that year, which affected the southern region of the country, including the city of Arequipa. The earthquake prompted the district authorities to identify the Uchumayo area as a potential urban expansion zone.

Given the lack of available expansion areas within the main town and considering the need for demographic expansion to accommodate the local population and the surrounding communities, the authorities turned their attention to this location. Thus, the Virgen del Rosario settlement was conceived in response to the earthquake, to support the growing population and fulfill the demand for housing in the area.



Figure 51: Site 6 satellite map – 2022 (Data source: Landsat imagery)

The neighborhood is established in close proximity to mountain ranges and agricultural plots, which poses significant limitations for its future development. The nearby terrain and the presence of agricultural areas restrict any possibility of extending the neighborhood further. This geographical constraint restricts the neighborhood's potential for future growth and expansion, emphasizing the importance of utilizing the available space effectively and sustainably within the existing boundaries.



Figure 52: Local topography of the Virgen del Rosario settlement (Source: Google earth)

3.3.2.2. Local services and urban grid

- Urban grid and development plan:

The layout and plan of the Virgen del Rosario district were informally established by the Virgen del Rosario informal housing association, with the assistance of an architect and a topographer. Their objective was to define the essential urban framework for the development of the district. The plan took into consideration various aspects, including the allocation of spaces for specific purposes.

Natural areas such as parks and green spaces were integrated into the plan to provide recreational and environmental amenities for the residents. Educational and medical facilities were also considered and designated within the district to cater to the educational and healthcare needs of the community. Meeting areas, such as the civic square, were included to serve as spaces for communal gatherings and events.

A significant focus was placed on residential plots and islets, as the primary aim of the district was to provide housing for the residents. The plan outlined the allocation of residential spaces and determined the distribution of housing units within the district. Although the plan was developed informally, it aimed to establish a functional and well-organized framework for the district, considering the various requirements and needs of the community.

Furthermore, it is crucial to highlight the significant topographical relief and unstable soil conditions within the neighborhood. This situation sets a considerable risk of landslides and soil erosion, particularly in the outer areas of the neighborhood. These geological factors play a crucial role in determining the feasibility and sustainability of the neighborhood's development. They present significant challenges for both the residents and the Virgen del Rosario association, who are actively working towards formalizing the settlement. The need to address these development constraints and mitigate the risks associated with the topography and soil instability becomes a priority in ensuring the long-term safety and stability of the neighborhood.



Figure 53: settlement parcels in landslides risk (Photo: H. LE VASLOT)

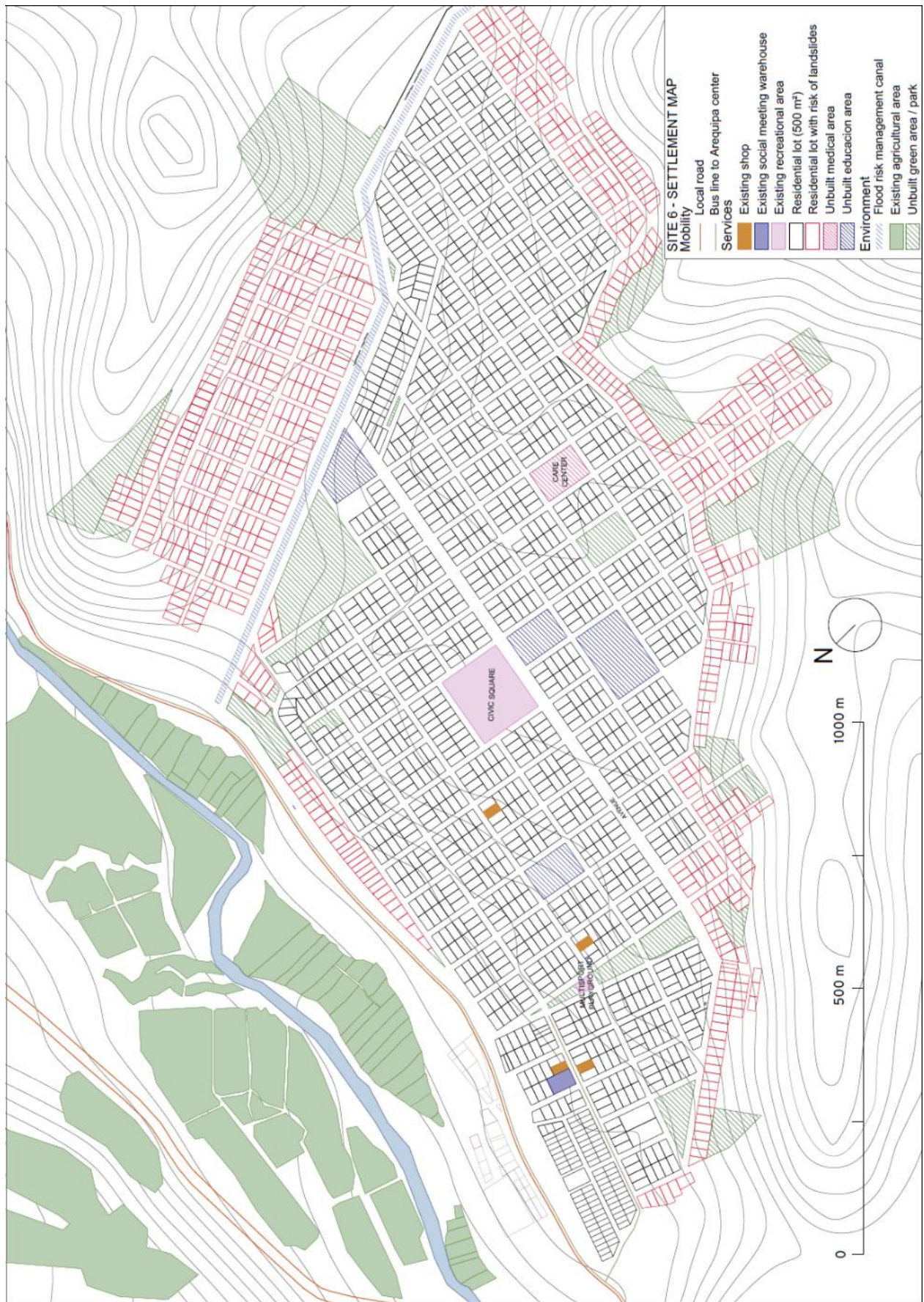


Figure 54: Map and services of Virgen del Rosario settlement with local topography (Map: H. LE VASLOT)

- Services and quality of services:

Despite the well-organized distribution of space within the neighborhood plan, it is important to acknowledge that most planned services, such as natural park areas, educational facilities, and medical centers, have not been developed as initially intended. As a result, the current state of the neighborhood only provides housing and a limited number of shops, without offering these essential services to the population.

The absence of these services can be attributed to the limited resources of the informal group responsible for the settlement's development. Creating and developing areas for parks, education, and healthcare require significant financial investment and ongoing maintenance costs. Unfortunately, the informal group has faced constraints in securing the necessary resources to implement these planned services.

The only activity areas currently available to residents are a multi-sport area and a children's playground in the neighborhood's central civic square.



Figure 55: Multisport area and children playground in Virgen del Rosario settlement (Photos: H. LE VASLOT)

Concerning the more basic services, the settlement relies on an informal water network provided by a private company (JAAP). Currently, there are over 700 connections to this network, without including the illegal connections by residents. Each resident has limited access to water for approximately two hours per day. Some wealthier residents have installed water storage tanks to meet their needs outside the designated access hours. However, access to water remains problematic within the neighborhood, as interviews with residents indicate a significant level of water contamination. Additionally, access to water is restricted during the day.

Regarding electricity, residents have continuous access to electricity, with individual consumption meters installed on each plot for monthly billing. The settlement also has a network of public lighting to illuminate the streets at night, although the installation of this lighting system is still relatively precarious.



Figure 56: Public lighting network and electrical consumption meter in Virgen del Rosario settlement (Photos: H. LE VASLOT)

However, the neighborhood is currently in the process of formalization with the city's COFOPRI organization. This process entails integrating the settlement into the formal urban framework, which may open up opportunities for accessing resources and funding for the development of planned services. According to the leaders of the Virgen del Rosario association, they anticipate that the neighborhood will gradually be equipped with the intended services in the coming years, once the formalization process is complete.

- Mobility:

The site is located at a considerable distance of over 20 kilometers from the city center of Arequipa, resulting in a significant geographical separation between the neighborhood and the city center. This distance presents a challenge for residents, as they must contend with the effects of being located far from the central urban area.

Currently, the mobility services available in the district consist of a bus line that connects the neighborhood to the city center. This bus service operates with a frequency of approximately every 20 to 30 minutes, aiming to provide residents with a means of transportation for commuting to work primarily in the city center. However, due to the numerous stops along the route and the congested traffic conditions in the city throughout the day, the journey duration exceeds an hour and 30 minutes.

The geographical position of the informal Virgen del Rosario district, coupled with the limitations of the public transportation service, presents significant constraints to mobility for the residents. The lengthy travel time and the challenges associated with the public transport system make it difficult for residents to conveniently and efficiently connect with the city center.

The neighborhood also lacks paved roads and sidewalks, both for vehicle and pedestrian traffic, causing challenges in terms of mobility. The absence of proper infrastructure contributes to dust accumulation whenever vehicles pass through the unpaved areas. Furthermore, the neighborhood is situated on a relatively steep slope, making it even more challenging for residents to navigate on foot or by vehicle. The combination of these factors hampers mobility within the neighborhood and creates difficulties for both pedestrians and vehicles.

- Social organization:

The Virgen del Rosario Association plays a crucial role in managing the formalization process of the neighborhood and facilitating communication between the residents and city services. The association is a non-profit organization dedicated to meeting the needs of the residents and ensuring the development of the neighborhood. Regular meetings are held between the association leaders and the residents, providing updates on the progress of the neighborhood's development and discussing ways to improve the community.

These meetings take place in a social room where leaders and one representative per household gather to address various aspects, including the current formalization process. This process involves visits from the COFOPRI (Formalization and Land Registry Authority) to assess the infrastructure and equipment of each plot and determine their eligibility for formalization according to the city's standards.



Figure 57: Social meeting warehouse and association of Virgen del Rosario panel (Photos: H. LE VASLOT)

3.3.2.3. Residential parcel organization



Figure 58: Residential block map analysis (Map: H. LE VASLOT)

The neighborhood is structured into several residential blocks, with each block consisting of 12 parcels of approximately 500 square meters each. The blocks are organized in an orthogonal street layout, allowing for better understanding and facilitating future formalization efforts.

One particular block, Block Number 16, located at the entrance of the neighborhood, was analyzed. This block comprises 12 plots of equal size. It benefits from the proximity of a bus line that connects it to the center of Arequipa, making it relatively well-served compared to other areas that lack easy access to public transportation.

Residents of Block Number 16 also enjoy close proximity to the local social area and a few existing shops within the neighborhood. This grants them convenient access to essential services. To the south of the block, there is a designated vegetated area intended to be part of the neighborhood's service infrastructure. However, at present, no construction has taken place, and only a few fruit tree plantations can be found in that area.



Figure 59: Fruit tree plantation area - start of development of a natural area (Photo: H. LE VASLOT)

Once the analysis of the blocks and islets was conducted, it became important to study the organization of the neighborhood at the scale of individual plots. Field visits and interviews allowed for the inquiry of insights into how residents navigate and adapt within the informal neighborhood.

These visits provided valuable information about the daily lives of residents, their living conditions, and their experiences. Interviews allowed researchers to understand the challenges and opportunities residents face, as well as their strategies for coping with the limitations of the informal settlement. By examining the organization of the neighborhood at the plot level, it became possible to understand the social interactions among residents, and the ways in which they navigate the lack of formal infrastructure and services. This detailed examination shed light on the resilience and resourcefulness of the residents and provided a comprehensive view of life within the informal neighborhood.



Figure 60: Residential parcel map analysis in Virgen del Rosario settlement (Map: H. LE VASLOT)

In this group of plots, the level of development varies, with some dwellings having access to the electricity and water network that runs through the streets. Each plot has its own electricity meter to track monthly consumption, allowing residents to pay for their usage.

During a visit to plot number 10 and an interview with the owner, it was observed that residents organize their plots according to their own preferences and level of wealth. In this particular case, the functions of the kitchen, bathrooms, and bedrooms were separated into different spaces. However, other residents combine these functions within a single dwelling.

Furthermore, there is significant variation in the building materials used in the neighborhood, largely influenced by the resources available to each resident. Commonly used materials include wood, sheet metal for roofing, bricks or blocks, and sillar, which is a local volcanic rock commonly used in traditional construction in the center of Arequipa. In more developed dwellings, concrete is also used.

A typological study will be presented on the following sections to analyze and determine the distribution of different construction modes within the neighborhood.

In some plots, such as parcel number 10, residents have additional amenities such as fruit trees and small animal farms. These resources provide residents with an opportunity for personal consumption, including fresh fruits and potentially eggs or dairy products from their

animals. The presence of these resources within the neighborhood adds to the self-sustainability and resilience of the residents, allowing them to supplement their food needs and potentially generate additional income.



Figure 61: Animal farming, fruit trees and wooden dwelling with sheet metal roofing on residential parcel (Photos: H. LE VASLOT)

Due to the limited and intermittent water supply, residents have to rely on storage solutions. In the case of the resident interviewed on plot number 10, they have installed two tanks with a total capacity of 4000 liters (2000 liters each). These tanks are equipped with a motorized pump device to ensure access to water throughout the day.



Figure 62: Water tank storage with motorized pump for individual consumption (Photos: H. LE VASLOT)

This type of installation highlights the precariousness of the services provided within the neighborhood, as residents must adapt to limited resources and find their own ways to secure a consistent water supply. The variability in access to basic services demonstrates the challenges faced by residents and the need for improved infrastructure and support in the informal settlement.

3.4. Process of formalization in Peru

The city of Arequipa, as well as Peru as a whole, employs three primary mechanisms to formalize districts that have been illegally occupied, based on information from IMPLA. Once a neighborhood has been informally and illegally occupied for at least 30 days, a legal process is initiated in accordance with Peruvian national law.

To access temporary services from the city, these neighborhoods have the option to request proof of possession, which grants them access to services for a period of three years. It is important to note that these services are temporary and not definitive, as they are provided with the expectation of eventual formalization. The provision of temporary services through the proof of possession is intended to support the neighborhood during the formalization process. While these services are temporary, they demonstrate the city's commitment to eventual formalization and provide assistance to the community during the transition.

The three main mechanisms to formalize the neighborhoods already occupied illegally are those that will follow.

- COFOPRI:

In Peru, the National Commission for the Formalization of Informal Property (COFOPRI) is the governing body responsible for the formalization of settlements. As a government agency under the Ministry of Housing, Construction, and Sanitation, COFOPRI's primary mandate is to oversee the formalization process and grant legal recognition to informal settlements across the nation.

COFOPRI fulfills its role by implementing the legal framework established by the Peruvian government to address the issue of informal settlements. The agency's responsibilities encompass various aspects of formalization.

Regarding land regularization, COFOPRI is tasked with identifying and regularizing informal settlements by establishing clear land tenure and property rights. This involves conducting surveys, mapping land, and performing other cadastral activities to determine the boundaries and ownership of occupied land. Once the land is identified and ownership is established, COFOPRI issues property titles or land concessions to the occupants of informal settlements. These titles provide legal recognition and secure tenure to residents, enabling them to access formal services, sell or transfer the property, and invest in their homes.

COFOPRI is also involved in urban planning activities related to the formalization process. It collaborates in the development and implementation of urban plans and zoning regulations for the settlements, ensuring proper allocation of land for housing, infrastructure, and public

spaces. The organization provides technical support, training, and capacity-building programs to local governments, community organizations, and other stakeholders involved in the formalization process. This strengthens their ability to carry out necessary tasks and implement sustainable development practices effectively.

In terms of social integration and upgrading, COFOPRI promotes social integration by working with other government entities and organizations to provide social programs, services, and infrastructure improvements in formalized settlements. This includes ensuring access to basic services such as water supply, sanitation, and electricity, as well as developing community facilities like schools, healthcare centers, and recreational areas.

Finally, COFOPRI collaborates with local governments, regional authorities, and other relevant institutions involved in the formalization process. It facilitates dialogue, cooperation, and coordination among these stakeholders to ensure the effective and efficient implementation of formalization initiatives.

Overall, COFOPRI plays a crucial role in the formalization of settlements in Peru by providing legal recognition, securing land tenure, and supporting the socio-economic development of informal communities. Through its efforts, COFOPRI contributes to improving living conditions and promoting the integration of informal settlements into the formal urban fabric of the country.

- Regional government:

The regional government, represented by the Province of Arequipa, plays a crucial role in granting property rights to informal groups residing in the area. In order to formalize the land tenure of these informal settlements, the regional government has the authority to sell the land to the occupants at its commercial value.

The determination of the land's commercial value considers various factors, with one of the key considerations being the prevailing land speculation occurring in the territory of Arequipa. Land speculation refers to the process where the value of land is influenced by expectations of future development or increased demand, leading to fluctuations in prices.

The commercial value of the land is determined based on an assessment of its market worth, taking into consideration factors such as location, accessibility, infrastructure, and potential for future development. The regional government, through a transparent and regulated process, enters into agreements with informal groups to sell the land to them at a fair and market-based price.

By granting property rights through this mechanism, the regional government aims to provide legal recognition to informal settlements and ensure the occupants have secure tenure over the land they occupy. This process not only regularizes the status of the settlements but also promotes social and economic stability for the residents.

It's important to note that the price of the land can fluctuate depending on various factors, including changes in the local real estate market, infrastructure development in the area, and the demand for land. The regional government endeavors to strike a balance between the commercial value of the land and the affordability for the informal groups, aiming to facilitate the formalization process and improve the living conditions of the residents in the Province of Arequipa.

- Provincial municipality:

The provincial municipality in Peru is responsible for the formalization of neighborhoods, particularly focusing on addressing the issue of informal settlements. They manage and implement municipal housing programs aimed at regularizing these areas, providing support and resources to communities in need. These programs include land regularization, infrastructure development, and the provision of basic services.

The municipality enforces the ground law, which outlines the necessary steps and procedures for formalization and defines the rights and responsibilities of both the municipality and the informal groups. They work to ensure effective implementation of urban planning regulations within the informal settlements, allocating land for residential purposes, public spaces, and community amenities.

Collaboration with government agencies, community organizations, and stakeholders is key for the municipality. They coordinate efforts to promote social integration and sustainable development, providing access to social services, education, healthcare facilities, and necessary infrastructure upgrades.

Overall, the provincial municipality's role in formalizing neighborhoods contributes to enhancing the well-being and legal recognition of informal settlements. Through their programs and adherence to the ground law, they aim to create inclusive, sustainable, and thriving communities for all residents in Peru.

IV. Results of informal settlements case study

4.1. Results of informal settlements urbanization process

Satellite analysis of the various neighborhoods surrounding the city of Arequipa has provided insights into the level of occupancy and the type of occupation over time since the early 21st century. Based on the established criteria outlined in the state of art section, the analysis has helped characterize the neighborhoods into different categories: illegal occupation, informal development, formal urbanization, or social housing.

By analyzing satellite imagery, it becomes possible to identify areas that have experienced illegal occupation, where residents have settled without proper authorization or legal ownership. The analysis also reveals areas of informal development, where housing and infrastructure have been established without adherence to formal planning regulations.

Furthermore, the satellite analysis helps identify areas that have undergone formal urbanization, indicating that these neighborhoods have been developed in accordance with established urban planning guidelines and regulations. Additionally, social housing areas can be identified, which typically involve the provision of affordable housing options to low-income residents.

By classifying the neighborhoods based on their occupancy type, the satellite analysis contributes to a better understanding of the urban dynamics, patterns of growth, and the varying levels of formality or informality within the different areas surrounding Arequipa.

4.1.1. Site 1 – North of Arequipa

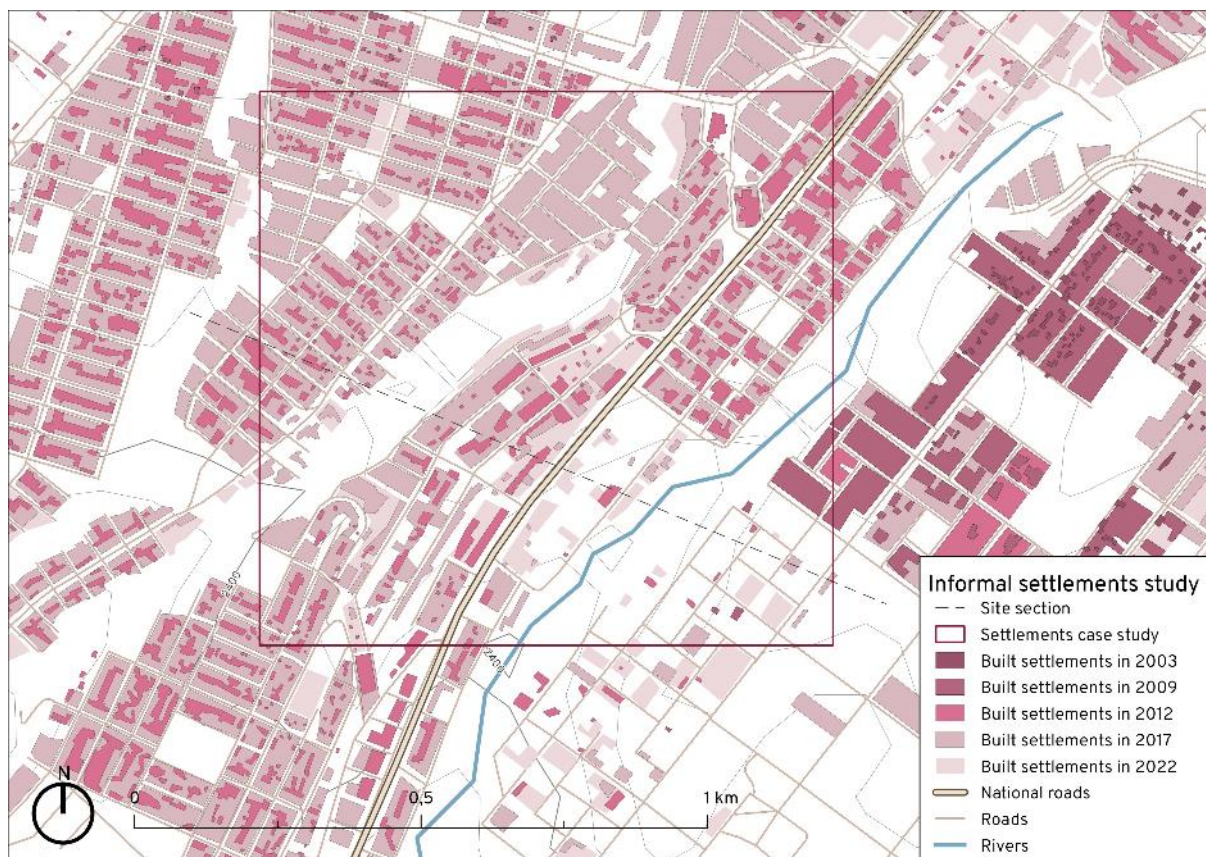


Figure 63: Development map of site 1 (Data source: Landsat imagery)

The progressive urbanization of Site 1, located in the northern region of Arequipa, reveals an illegal invasion on the land starting from 2003, initially spreading through the south of the site and ultimately covering the entire site. The invasion is clearly noticeable from the numerous clusters of small-sized structures and housings observed on the map, sparsely and heterogeneously distributed. Between 2009 and 2012, further land occupation took place, following the local topography and resulting in distinct urban patterns on each side of the national road. This situation highlights the lack of territorial management and the prevalence of informality in the site's urbanization process, as infrastructure was established after the initial informal settlements had already formed.

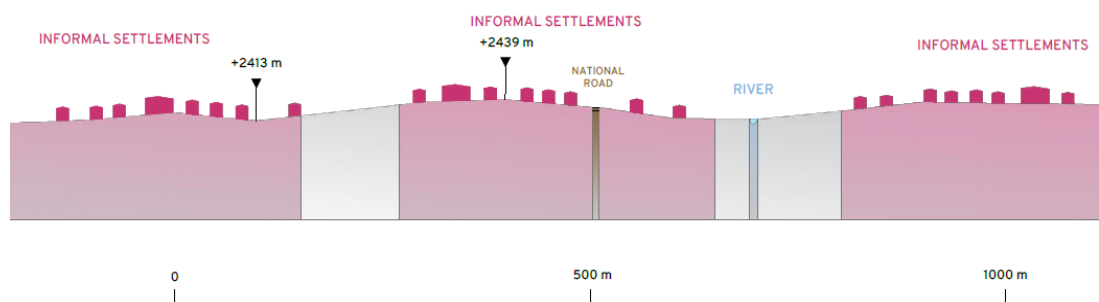


Figure 64: Transversal section of site 1 (Transect)

The structure of the site indicates a pattern of land occupation predominantly in the higher elevated regions, driven by the informal groups' intention to mitigate the risk of flooding. These areas are prioritized by the informal occupants during their initial encroachment on the land. As a result, the first infrastructure developments emerge around these elevated zones.

SITE 1	Urbanized Area (ha)	Non urbanized area (ha)	% of urbanisation	Period	Annual urbanization rate
Total site	-	100	-	2003 - 2009	-
2003	0	100	0%	2009 - 2012	155,2%
2009	0,58	99,42	0,6%	2012 - 2017	31,5%
2012	9,58	90,42	9,6%	2017 - 2022	2,9%
2017	37,72	62,28	37,7%		
2022	43,46	56,54	43,5%		

Table 4: Urbanization of site 1 in hectares and intercensal urbanization rate

Between 2009 and 2012, the urbanization rate experienced a significant surge, expanding from 0.58 to 10 hectares of urbanized land within a total site area of 100 hectares. This period coincided with substantial urban growth in the northern and southern regions of Arequipa city. The intercensal urbanization rate indicates an average annual increase of over 155% in the urbanized area on the site during this time.

Following this phase, the phenomenon of informal occupation persisted, leading to further expansion into an urbanized area exceeding 37 hectares. By 2022, there was a notable densification of buildings and occupied areas, with over 43 hectares of land being urbanized. This represented approximately 43.5% of the total 100-hectare site that had been developed.

- Urbanization pattern characterization:

The urbanization pattern observed in the first site can be described as a combination of partial infrastructure presence and a generally structured but irregular urban layout. This pattern is indicative of an urbanization process that involves the **allocation of informal lots with limited infrastructure** development. The presence of some basic services and a structured layout suggests a certain level of organization, but the irregularity in the arrangement of buildings and infrastructure points to the informality and lack of comprehensive planning in the development of the site.

4.1.2. Site 2 - North of Arequipa and airport context



Figure 65: Development map of site 2 (Data source: Landsat imagery)

The urbanization of the second site, situated north of Arequipa, occurred simultaneously with the establishment of the airport in 1980, located in the south of the site. This symbiotic relationship between the airport and urban development contributed to a more organized and structured urban framework compared to the previous site. The urbanization followed an orthogonal pattern, facilitating the connection of residential areas to a well-established network of roads, ensuring accessibility to the city center.

It is worth noting that the site already exhibited a relatively advanced level of urbanization at the beginning of the 21st century. The neighborhood's development unfolded progressively and in a structured manner over time, and this trend continues until the present day.

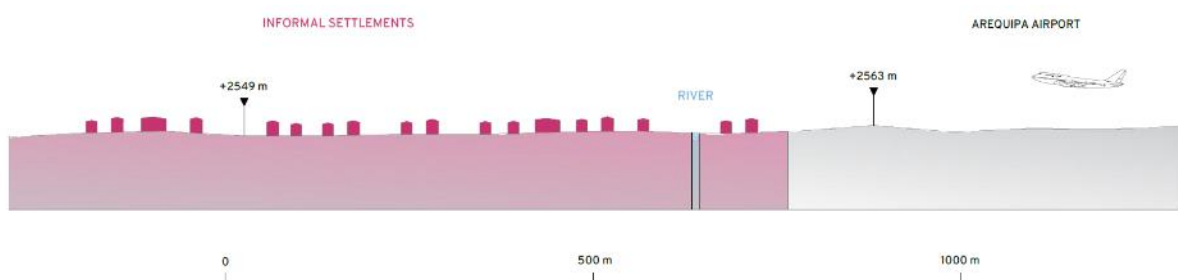


Figure 66: Transversal section of site 2 (Transect)

The site's relatively flat local topography played a significant role in facilitating its development without significant field constraints. This favorable characteristic of the terrain has contributed to the advanced development of the site and was a key factor in the city's decision to choose this location for establishing new residential areas north of Arequipa in the 1980s. The absence of major natural obstacles or uneven terrain provided an advantageous setting for urban expansion and the creation of residential neighborhoods in the area.

SITE 2	Urbanized Area (ha)	Non urbanized area (ha)	% of urbanisation	Period	Annual urbanization rate
Total site	-	100	-	2003 - 2009	10,1%
2003	23,69	76,31	23,7%	2009 - 2012	4,1%
2009	42,29	57,71	42,3%	2012 - 2017	1,2%
2012	47,65	52,35	47,6%	2017 - 2022	0,3%
2017	50,57	49,43	50,6%		
2022	51,21	48,79	51,2%		

Table 5: Urbanization of site 2 in hectares and intercensal urbanization rate

The urbanization pattern of site 2 exhibited a more structured development compared to other sites. This is evident in the annual intercensal rate of urbanization, which peaked at the beginning of the 21st century, with a high rate of 10.1% between 2003 and 2009. However, this rate gradually decreased over time due to the site already being heavily urbanized and experiencing densification within the existing neighborhoods.

Furthermore, in terms of the percentage of urban area within the 100-hectare site, site 2 reached a relatively high proportion of 51% in 2022. This percentage indicates that the site's urbanization has been comprehensive and well-structured. The significant urban coverage demonstrates the completion of the urbanization process, with the majority of the site's land being developed into urban areas.

Overall, the intercensal rate of urbanization and the high percentage of urban area on site 2 reflect its advanced stage of urban development and the successful realization of a structured and complete urbanization process.

- Urbanization pattern characterization:

Site 2 showcases a clear example of **formal urbanization**, characterized by a systematic and structured approach to development. The presence of a regular pattern in the expansion of urban areas indicates careful planning and organization. Furthermore, the provision of comprehensive infrastructure services demonstrates the site's well-developed and regulated nature. This formal urbanization process has resulted in a cohesive and efficiently designed urban framework, highlighting the success of planned development efforts.

4.1.3. Site 3 – East of Arequipa

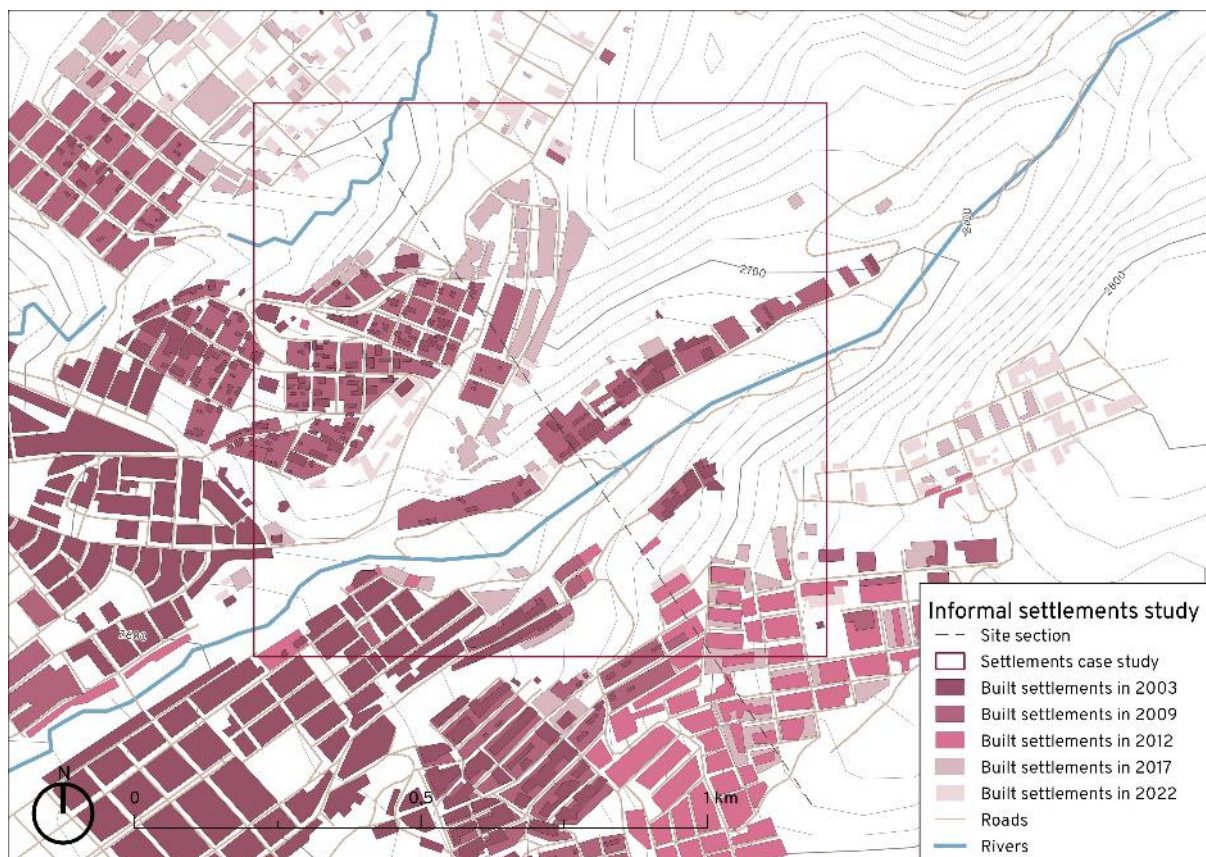


Figure 67: Development map of site 3 (Data source: Landsat imagery)

The 3rd site, located on the eastern outskirts of Arequipa, experienced a phenomenon of urban expansion characterized by an absence of a discernible development pattern and significant ground constraints. The informal groups that settled in this area faced challenging terrain, including steep slopes and low-lying valleys. This resulted in a stark contrast between the formal and structured urbanization pattern observed in the western part of the city and the fragmented and heterogeneous development pattern within the site itself.

The site's urbanization exhibited built clusters that were concentrated in specific areas, with large expanses of undeveloped land in between. This fragmented and irregular development pattern highlights the difficulties encountered in developing such challenging terrain. Moreover, the lack of a coherent and organized urban framework suggests that this site may not be viable for future development due to its inherent limitations.

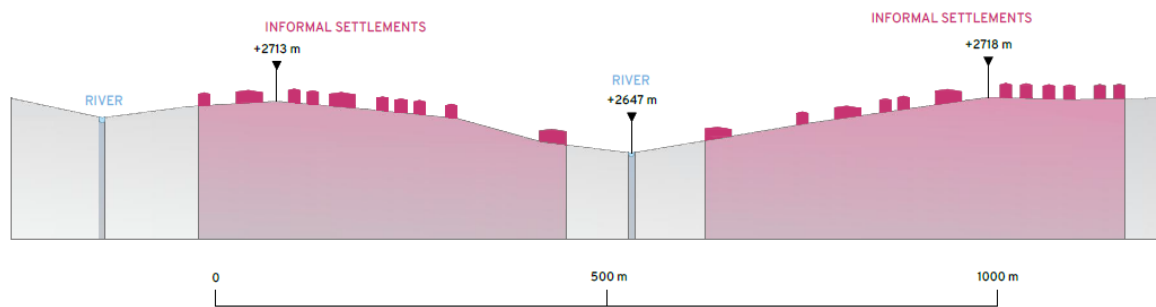


Figure 68: Transversal section of site 3 (Transect)

The elevated topography of the section indicates that the informal groups settled in an area that is highly susceptible to various risks, including landslides, erosion, and flooding. The challenging terrain poses significant hazards and makes it difficult to ensure the safety and stability of the settlements. Additionally, the steep relief of the site presents limitations for the development of sustainable infrastructure, such as roads and other large-scale facilities. The topographical constraints make it impractical to undertake extensive construction projects, further complicating the establishment of necessary infrastructure to support the community.

SITE 3	Urbanized Area (ha)	Non urbanized area (ha)	% of urbanisation	Period	Annual urbanization rate
Total site	-	100	-	2003 - 2009	17,5%
2003	5,54	94,46	5,5%	2009 - 2012	5,5%
2009	14,61	85,39	14,6%	2012 - 2017	5,0%
2012	17,15	82,85	17,2%	2017 - 2022	1,3%
2017	21,93	78,07	21,9%		
2022	23,37	76,63	23,4%		

Table 6: Urbanization of site 3 in hectares and intercensal urbanization rate

Finally, the intercensal rate of urbanization between 2003 and 2009 reveals a significant increase in the urbanized area, with an average annual growth of over 17% during this period. This rise can be attributed to the invasion of land by informal groups at the beginning of the 21st century, which led to rapid urbanization. Despite this initial expansion, the site remains relatively underdeveloped, with an urbanized area accounting for only 23% in 2022. This low level of urbanization highlights the complexity involved in occupying and developing such challenging sites. The limited progress in urbanization indicates the difficulties faced in establishing sustainable infrastructure and promoting comprehensive development in this particular location.

- Urbanization pattern characterization:

The evident absence of a structured urbanization pattern, coupled with the lack of services and existing infrastructure, supports the notion of an **illegal occupation** of the land characterized by **low-density housing**.

4.1.4. Site 4 - South of Arequipa

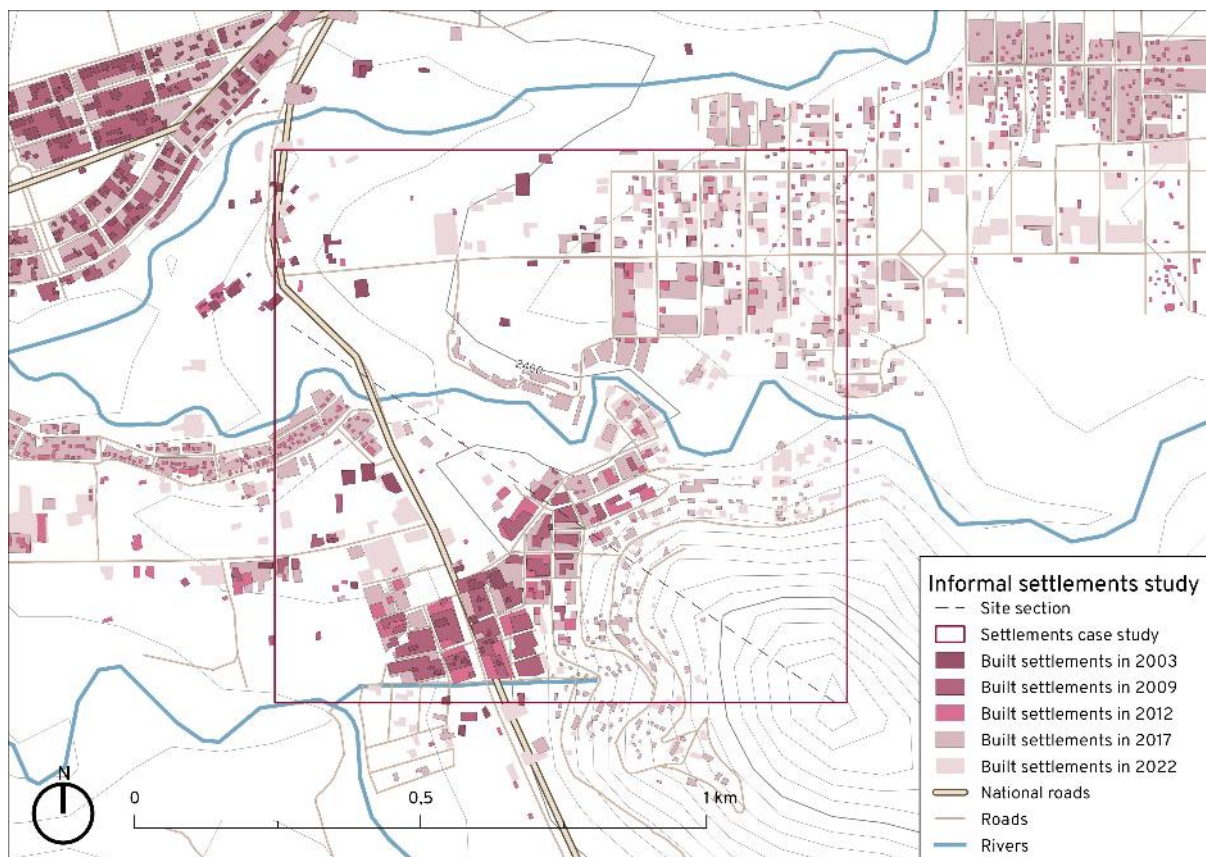


Figure 69: Development map of site 4 (Data source: Landsat imagery)

Situated at the southern end of Arequipa, site 4 reveals a contrasting pattern of urbanization characterized by the presence of a rugged mountainous terrain that has been occupied by informal groups. The distinction is evident when comparing the formal and structured urban structure in the northwest with the progressive and informal occupation in the south. In the northwestern part, a planned and organized urban framework is observable, whereas in the southern portion, numerous scattered built-up areas can be seen, distributed in response to the slope of the land. This dispersed and unregulated pattern of development highlights the informal nature of the occupation.

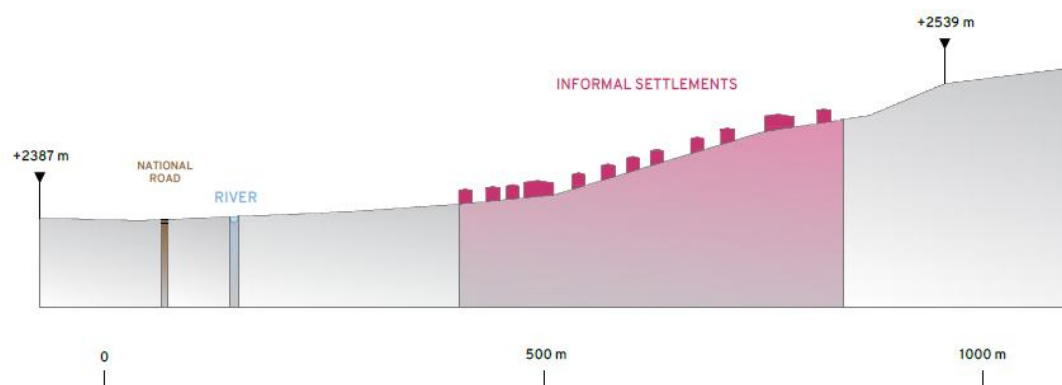


Figure 70: Transversal section of site 4 (Transect)

Similar to the previous sites, informal urbanization on site 4 primarily occurs on the elevated areas, as the constrained slopes of the land make formal urban expansion impossible. The challenging topography of the site hinders the densification of buildings, imposing limitations on its future development. The steep terrain presents significant constraints and obstacles for constructing and expanding infrastructure. As a result, the site's potential for further urbanization and development is significantly restricted.

SITE 4	Urbanized Area (ha)	Non urbanized area (ha)	% of urbanisation	Period	Annual urbanization rate
Total site	-	100	-	2003 - 2009	30,3%
2003	0,81	99,19	0,8%	2009 - 2012	15,9%
2009	3,96	96,04	4,0%	2012 - 2017	17,6%
2012	6,17	93,83	6,2%	2017 - 2022	6,8%
2017	13,87	86,13	13,9%		
2022	19,26	80,74	19,3%		

Table 7: Urbanization of site 4 in hectares and intercensal urbanization rate

The rapid occupation of the site by informal groups in the early 2000s is evident from the intercensal rate of urbanization. Between 2003 and 2009, the urbanization rate reached 30%, remaining relatively high at 16% between 2009 and 2012, and 17% between 2012 and 2017. These rates indicate a continuous influx of population settling on the site over a span of more than 20 years. However, despite this ongoing occupation, the urbanized area on the site remains limited, accounting for only 19% of the total area as of 2022. This low level of urbanization suggests that the site is not well-suited for residential development. The presence of significant topographical relief and its geographical distance from the city center of Arequipa contribute to its unsuitability for becoming a residential area.

- Urbanization pattern characterization:

Based on the observed urbanization pattern and the low occupancy of the site's urbanized area, it can be concluded that site number 4 is characterized as a **low-density illegal occupation site**. The challenging ground constraints have compelled informal groups to settle in this area, impeding the development of sustainable infrastructure and proper housing. The lack of structured urbanization and limited occupancy highlight the informal and unauthorized nature of the occupation on this site. The constraints imposed by the terrain have hindered the establishment of a cohesive urban framework and prevented the implementation of sustainable development practices.

4.1.5. Site 5 – West of Arequipa

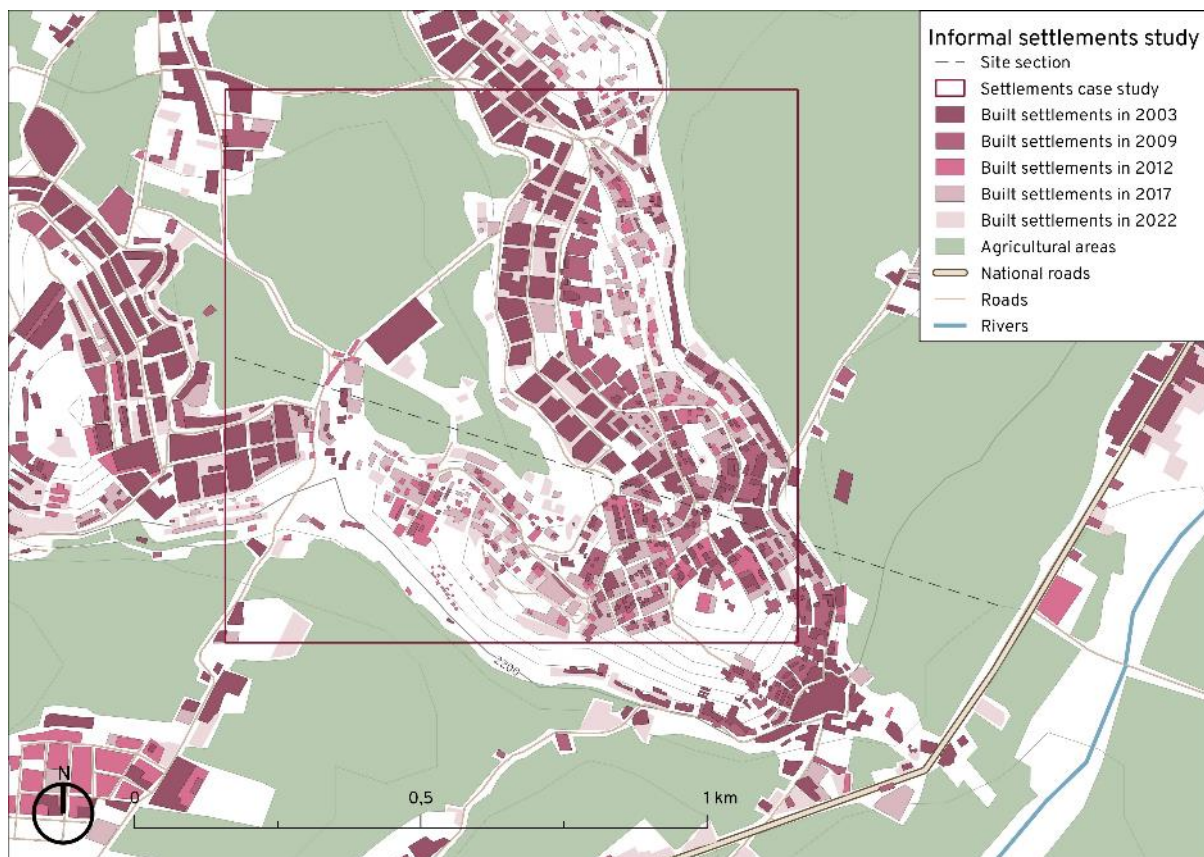


Figure 71: Development map of site 5 (Data source: Landsat imagery)

The 5th site serves as another example of informal occupation and urban expansion in the city of Arequipa. Located at the western end of the city, this site predominantly consists of agricultural land. However, certain areas with high relief, like this site, have witnessed the settlement of informal groups in the early 2000s. These groups have subsequently developed informal urbanization without the approval of city authorities.

The urbanization map of this site depicts a development pattern devoid of a structured framework or prominent axis that would enable the coherent arrangement of housing. This lack of organization can be attributed to the absence of effective land management practices and the inherent challenges posed by the hilly terrain. The presence of steep slopes and uneven topography further compounds the difficulty of establishing infrastructure in this area.

As a result, the urbanization on this site lacks a cohesive plan or systematic layout, reflecting the informal and unregulated nature of its development. The absence of a structured framework and the geographical constraints imposed by the hilly terrain have hindered the implementation of comprehensive urban planning and infrastructure development.

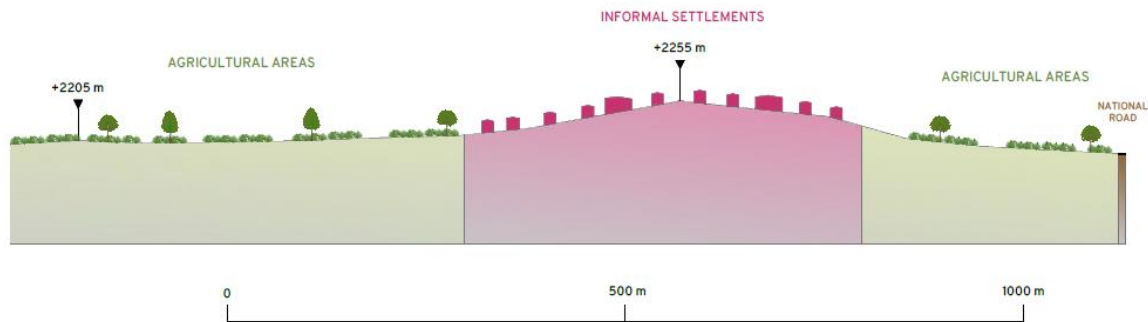


Figure 72: Transversal section of site 5 (Transect)

Upon examining the site's section, it becomes evident that the informal housing is positioned on the only available portions of land that are not exploited for agricultural operations. The presence of steep slopes further complicates the prospect of developing a future neighborhood in this area. These factors collectively indicate a high probability that the neighborhood may never be formalized by the city in the future.

SITE 5	Urbanized Area (ha)	Non urbanized area (ha)	% of urbanisation	Period	Annual urbanization rate
Total site	-	100	-	2003 - 2009	6,7%
2003	9,59	90,41	9,6%	2009 - 2012	5,3%
2009	14,15	85,85	14,2%	2012 - 2017	7,5%
2012	16,54	83,46	16,5%	2017 - 2022	3,0%
2017	23,73	76,27	23,7%		
2022	27,51	72,49	27,5%		

Table 8: Urbanization of site 5 in hectares and intercensal urbanization rate

The analysis of the intercensal rate of urbanization reveals a gradual and continuous urbanization process on the site, although at a decreasing pace around 2017. The annual average rate of 3% between 2017 and 2022 indicates a slower pace of urban expansion compared to previous periods. This can be attributed to the fact that the hill area is already densely occupied by informal housing, leaving limited space for further development. The presence of neighboring agricultural plots further restricts the capacity to accommodate new housing in this area.

The relatively low percentage of occupancy, standing at 27% of the total site in 2022, underscores the informality and partial nature of the site's urbanization. Numerous constraints, such as the hilly terrain, agricultural land, and limited available space, have contributed to the fragmented and constrained nature of the urbanization process. These challenges have hindered the site from reaching its full urbanization potential and have perpetuated the informality of the housing occupation.

- Urbanization pattern characterization:

Indeed, based on the absence of essential infrastructure, the lack of a coherent and uniform urban fabric, and the clustering of housing groups on a small portion of hilly land, it is appropriate to characterize the site as an **illegal occupation** site with **high-density housing**. The absence of proper planning and the concentration of housing in a confined area further emphasize the informality and unregulated nature of the urbanization process.

The limited availability of suitable land for housing, coupled with the challenging terrain, renders it impractical to envision a formalized neighborhood emerging in this location. The absence of a viable environment for infrastructure development and the lack of planning in the area contribute to the likelihood of the neighborhood remaining informal and unregulated in the foreseeable future.

4.1.6. Site 6 – Virgen del Rosario settlement

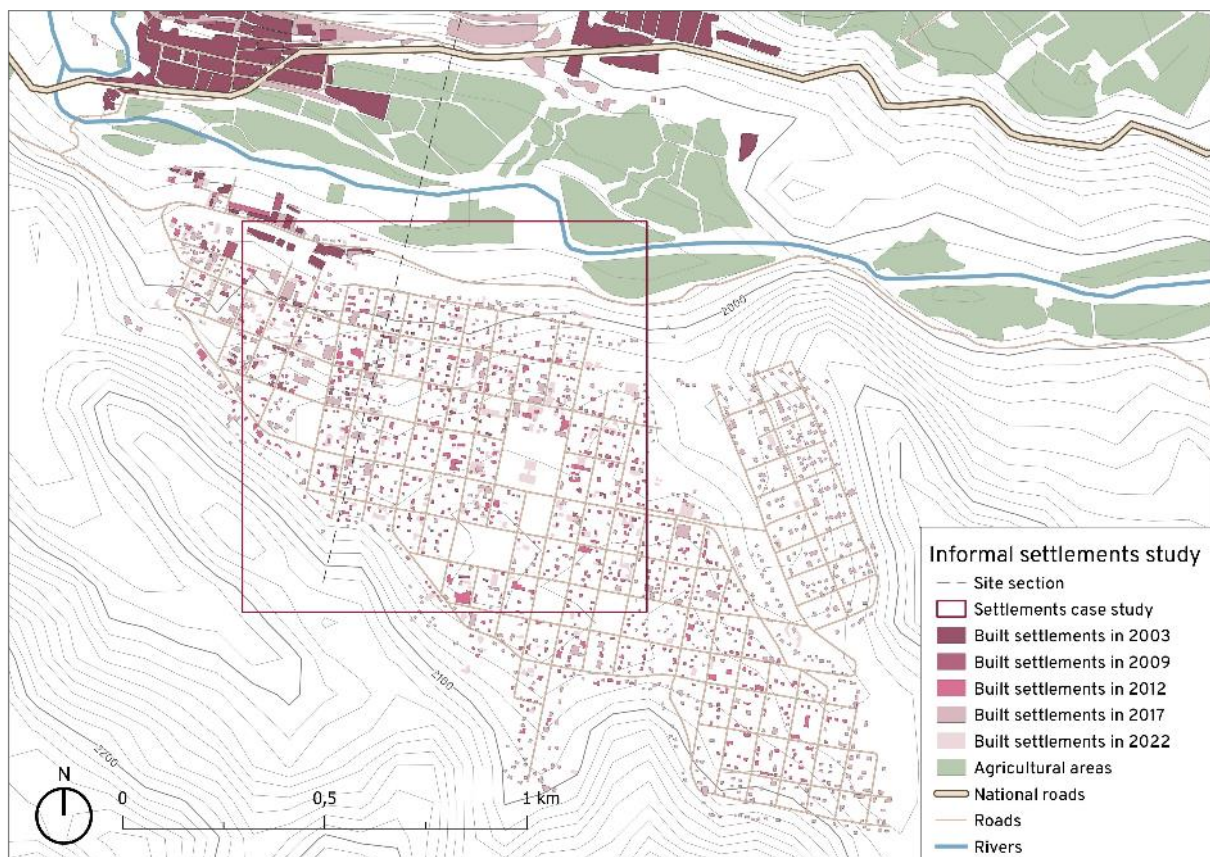


Figure 73: Development map of site 6 with local topography (Data source: Landsat imagery)

The Virgen del Rosario neighborhood, the last site studied where on field visits and interviews have been carried out, has experienced gradual development since its establishment in 2001. However, the actual land occupation within the neighborhood is minimal, as indicated by the urbanization map. Most residential lots have been occupied by makeshift housing with limited size and no legal recognition. Furthermore, there is a significant lack of facilities and service infrastructure for the neighborhood's residents. As a result, there are numerous vacant areas within the neighborhood due to the informal nature of its development. This highlights the need for improved provisions of essential services and infrastructure to support the residents and promote sustainable urban development in the area.



Figure 74: Transversal section of site 6 (Transect)

The site map and section analysis highlight several development constraints that impact the site's urbanization. The significant terrain and proximity to mountain ranges contribute to the presence of rocky, infertile, and unstable soil, making it susceptible to erosion and landslides. This poses challenges for construction and limits the potential for future development.

Furthermore, the site is surrounded by agricultural land and characterized by significant terrain, which further restricts its expansion and development possibilities. The district's location on the opposite bank of the town of Uchumayo and the national road also creates limited access to mobility and essential services from the city, further isolating the area.

These constraints collectively impede the site's urbanization and present challenges for creating a well-connected and sustainable urban environment. Addressing these issues would require careful planning, infrastructure development, and mitigation measures to ensure the safety and accessibility of the area.

SITE 6	Urbanized Area (ha)	Non urbanized area (ha)	% of urbanisation
Total site	-	100	-
2003	0,44	99,56	0,4%
2009	0,92	99,08	0,9%
2012	3,84	96,16	3,8%
2017	6,99	93,01	7,0%
2022	9,68	90,32	9,7%

Period	Annual urbanization rate
2003 - 2009	13,1%
2009 - 2012	60,9%
2012 - 2017	12,7%
2017 - 2022	6,7%

Table 9: Urbanization of site 6 in hectares and intercensal urbanization rate

Furthermore, the intercensal rate of urbanization on the site indicates a significant urbanization surge between 2009 and 2012, driven by the development and densification of housing areas. However, this rate has since reduced, reaching an annual average rate of 6% between 2017 and 2022. This decline highlights the ongoing challenges faced by the neighborhood in terms of its development, primarily due to the constraints imposed by the site itself.

The limited progress in urbanization is evident as the urbanized area of the neighborhood, even in 2022, remains below 10% of the total site. This indicates the overall weak development of the neighborhood and the failure of informal groups and residents to effectively and sustainably appropriate the area over a span of 20 years.

Considering these factors, the neighborhood faces persistent obstacles in its development, primarily related to the constraints imposed by the site's terrain and the associated limitations on expansion. The anticipated formalization of the neighborhood in the future is expected to drive a significant increase in the rate of urbanization, resulting in the development of multiple areas within the site. However, addressing the existing constraints and promoting sustainable development practices will be crucial for achieving a more substantial and successful transformation of the neighborhood.

- Urbanization pattern characterization:

Based on the context provided by the leaders of the association Virgen del Rosario and its residents, it is evident that the settlement of site 6 is characterized by **allocation of informal lots** with **limited infrastructure**. The urban pattern observed in the area further supports this assessment, with the presence of distinct residential clusters and plots of similar sizes, as previously described in the last section.

It is important to note that informal settlements like this pose challenges in terms of providing essential services, improving infrastructure, and ensuring the well-being of the residents. Efforts to address these issues typically involve initiatives for formalization, regularization, and the provision of adequate infrastructure to enhance the quality of life for the residents.

4.2. Housing typology in Virgen del Rosario informal settlement

The study of the district of Virgen del Rosario incorporates a typological analysis of construction methods and materials used in three categories: precarious, intermediate, and modern. This analysis aims to assess the level of development within the neighborhood at the housing level and evaluate the types of materials utilized.

The classification of housing into these categories provides insights into the quality and durability of construction, as well as the level of infrastructure and services available to residents.

As specified in the methodology section, the precarious category typically refers to housing structures built with temporary or substandard materials, lacking proper foundations or structural stability.

The intermediate category represents housing that shows some improvements compared to the precarious category, with better construction techniques and relatively more durable materials. However, these houses may still exhibit limitations in terms of structural integrity and access to basic services.

The modern category signifies housing that meets higher standards of construction quality, utilizing more resilient materials such as concrete and following established building codes. These structures typically offer improved living conditions, including better access to services and infrastructure.

By conducting a typological study of the construction methods and materials used in the district, it is possible to gain insights into the overall development level of the neighborhood. This assessment allows for a more comprehensive understanding of the housing conditions and helps identify areas for improvement, such as the need for infrastructure upgrades, access to essential services, and the promotion of sustainable construction practices. This study will also provide insights into the diversity of building materials and construction practices employed by residents, reflecting their individual circumstances and available resources.

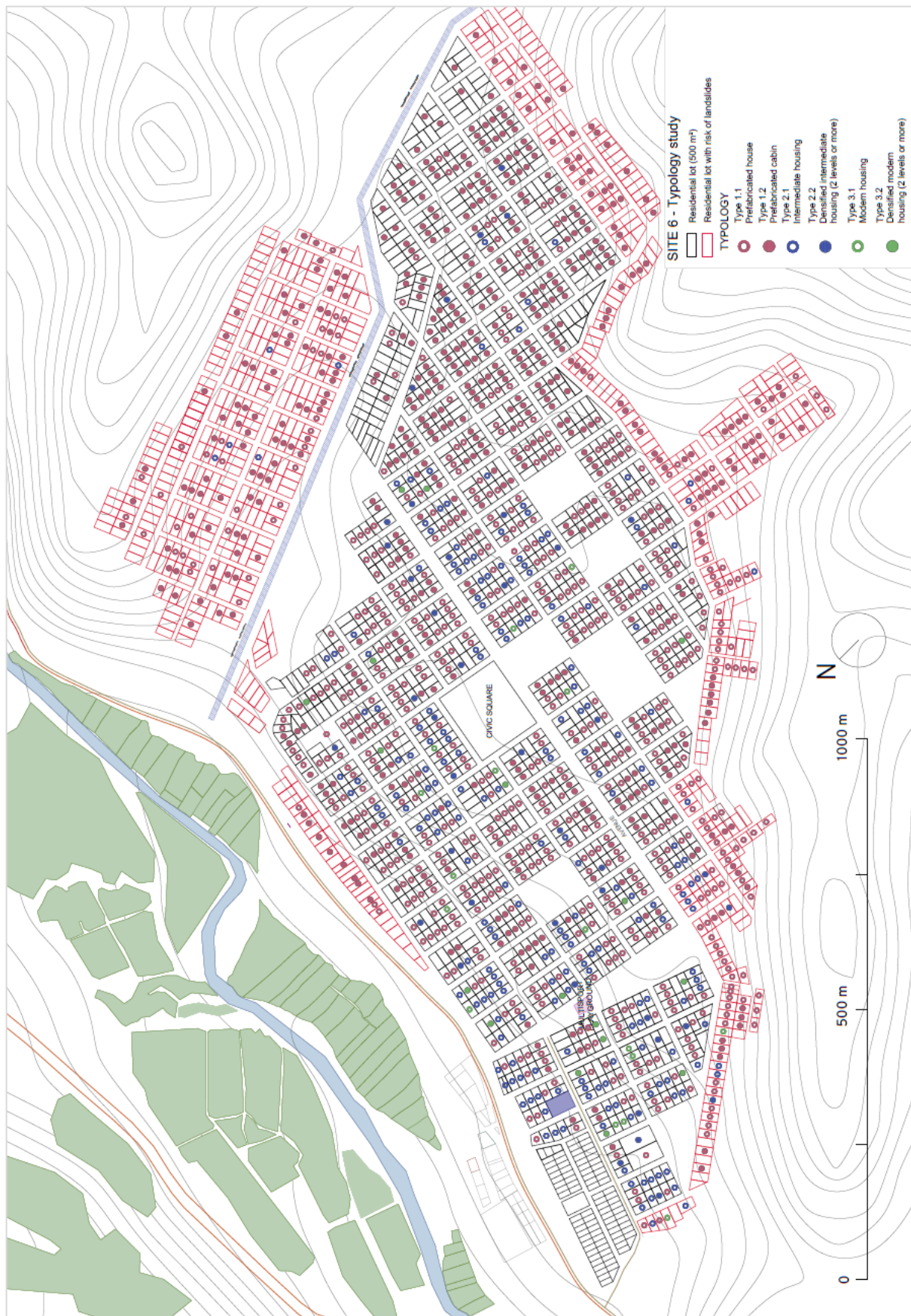


Figure 75: Housing typology study in Virgen del Rosario settlement – May 2023 (Map: H. LE VASLOT)

The typological map of housing distribution in the Virgen del Rosario neighborhood reveals a predominance of precarious housing and cabins (types 1.1 and 1.2), which reflects the prevalence of poor housing conditions in the area. This is a common typology found in informal neighborhoods in Peru, where the population often lacks the means to afford adequate housing and resorts to makeshift wooden structures.

It is worth noting that the majority of these precarious dwellings are concentrated in the lower areas of the neighborhood, particularly in the southern part where the terrain is steeper and more prone to landslides (indicated by red plots on the map). This poses challenges for development in these areas due to the unstable soil and the associated risks.

In contrast, the relatively wealthier type 2 or 3 dwellings are mainly located at the entrance and central areas of the neighborhood, close to the main internal roads. These areas tend to have better access and are more suitable for development.

Likewise, within the Virgen del Rosario neighborhood, there are a few dwellings that exhibit densification, with two or more levels. These multi-story structures indicate a relatively higher level of housing development and suggest the presence of a more affluent population within the neighborhood. However, it is important to note that these densified dwellings remain a minority within the overall housing landscape of the neighborhood.

Furthermore, a significant portion of the neighborhood's land remains unoccupied, indicating low occupancy and limited development. Many of these vacant plots are situated in areas with challenging topography and landslide risks, making them unsuitable for formalization by the COFOPRI organization.

Lastly, there are large empty spaces within the neighborhood that were originally intended for the construction of essential facilities and infrastructure such as schools, parks, and medical centers. However, these areas remain undeveloped and await the provision of services and the formalization of the neighborhood by the municipal authorities.

In conclusion, the analysis reveals that the Virgen del Rosario settlement is still in its early stages of development, both in terms of housing and the provision of services and infrastructure. The challenging conditions related to the neighborhood's location and terrain significantly influence the process of urbanization, limiting it to specific areas within the neighborhood. The heavily constrained topography poses significant obstacles to the expansion and development of the neighborhood.

V. Interpretation and discussion of the results

5.1. Study of informal settlements results

The study of informal neighborhoods in Arequipa sheds light on the urban expansion phenomenon occurring in specific areas of the city. It reveals a pattern where informal groups initially occupy the land, followed by a process of regularization and formalization of these settlements in the eyes of the city authorities. By examining the main findings of this study, it is possible to get a better understanding of the overall phenomenon of informal urbanization.

One key result is the identification of specific areas within the city that have experienced significant informal occupation. These areas demonstrate the initial attraction of informal settlers to available land and their ability to establish communities despite the lack of formal infrastructure and services. The process of regularization involves the municipality recognizing and legitimizing these settlements, providing them with basic services and infrastructure, and integrating them into the city's urban planning framework.

- Urbanization results:

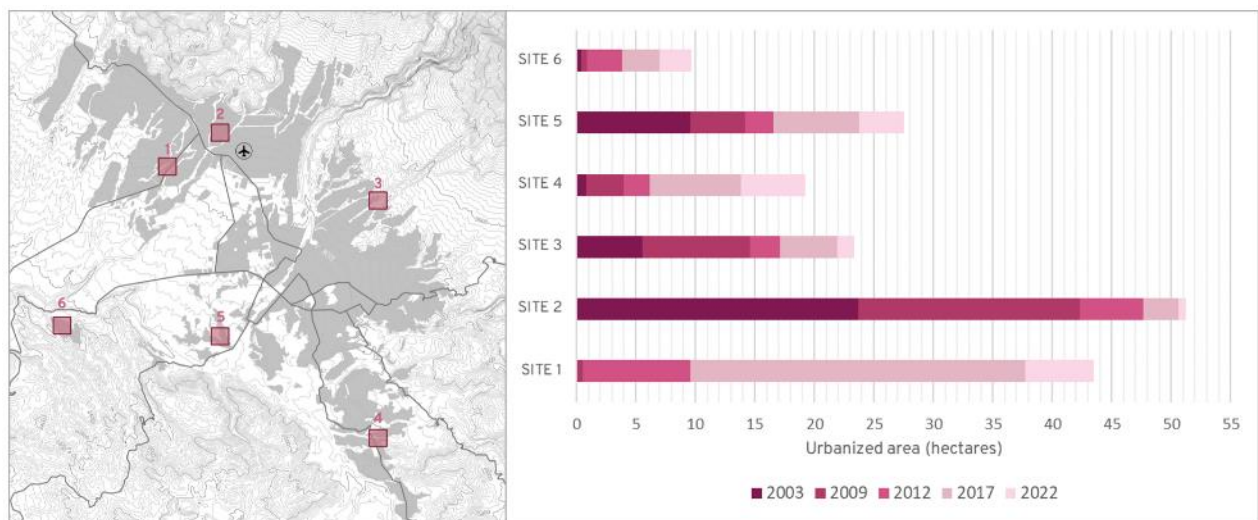


Figure 76: Informal settlements location and urbanization in hectares over the 21st century

Based on the findings regarding the level of urbanization of each location, it is possible to compare the data among them because the selection of a 100-hectare area for each site allows for straightforward comparisons.

The two sites situated to the north of Arequipa exhibit the highest degree of urbanization. In 2022, site 1 had 43% of its area urbanized, while site 2 had 51%. These figures indicate that the northern region of the city experienced earlier and denser development compared to its peripheral areas. Notably, the establishment of the airport in the 1980s compelled the creation of residential neighborhoods nearby, contributing to the accelerated growth of this particular zone. However, it is important to note that these two sites display distinct characteristics and patterns of urbanization.

Site 1 primarily underwent informal development through the invasion of land by informal groups in the early 2000s. Subsequently, the road infrastructure was created in the settlement, and the area became more densely populated over time. On the other hand, the second site was planned and developed in conjunction with the construction of the adjacent airport earlier than the first site with a much more structured urban fabric, demonstrating a more formal mode of urbanization.

The third site, situated east of the city, exhibits a low level of urbanization, with only 23% of its area being urbanized in 2022. The development of informal neighborhoods in this area has been relatively slow, mainly due to the challenging terrain and topographical conditions. These physical features have significantly restricted the pace of development, resulting in the site being only half as urbanized as the previous sites characterized by plateau urbanization.

Furthermore, it is important to note that the informal neighborhoods located at the eastern outskirts of the city are unlikely to be formalized. This is primarily due to the high risks posed by volcanic activity, landslides, and erosion in these areas. Given the hazardous nature of these locations, formalizing these neighborhoods is not considered a viable option in the city's overall development plan.

Since the 1970s, the southern region of Arequipa has been a major direction for the city's urban expansion, as revealed by the earlier sections of this report. However, it is important to note that numerous sites in the southern area have experienced settlements by informal groups on the elevated sections of the mountainous terrain. Site 4 exemplifies this situation. Unfortunately, the site has shown limited progress in terms of urbanization, with only 19% of the land being urbanized in 2022. This low rate of urbanization indicates a lack of effective territorial management during the site's development process and the various natural restrictions related to the site's position and its important relief.

In contrast to other sites, Site 5 displays a relatively average rate of urbanization, with more than 27 hectares being urbanized in 2022. This area, located to the west of Arequipa, stands out as one of the few regions in this side of the city where urban expansion is occurring, primarily because the steep terrain makes it unsuitable for agricultural purposes. Consequently, informal housing settlements proliferated in Site 5 at the beginning of the 21st

century, followed by a subsequent increase in housing density on the hill in the following years.

However, the illegal occupation of this site does not present an opportunity for the city to establish a residential area and provide necessary services. The local topography poses significant limitations, making it impractical to develop the area for residential purposes.

Lastly, Site 6 is characterized by an informal subdivision scheme, and extensive visits to the area have confirmed its remarkably low level of urbanization. In fact, as of 2022, the urbanized area of the site does not surpass 10%. This indicates a lack of development in the neighborhood since its inception, with slow urbanization attributable to the absence of local services and the substandard housing conditions.

Site 6 stands out as the least occupied site among all six locations, underscoring the numerous constraints imposed by the terrain and the geographical remoteness of the area. These limitations significantly hinder the site's development potential.

- Demographic data of the sites:

Understanding the process of urban expansion and informalization is crucial by examining local demographic data. Indeed, a rapid population growth and prevalent poverty are key factors that contribute to the emergence of informal groups and the occupation of peripheral areas in the city of Arequipa.

Site	District of Arequipa	Intercensal population growth rate		
		1981 - 1993	1993 - 2007	2007 - 2017
1 & 2	Cerro Colorado	2,8%	4,4%	5,8%
3	Miraflores	0,4%	0,02%	1,8%
4	Mollebaya	2,0%	4,3%	12,9%
5	Sachaca	3,6%	2,0%	3,3%
6	Uchumayo	2,1%	2,6%	2,8%

Table 10: Intercensal population growth rate in each site's district (Data source: INEI)

Initially, the INEI conducted censuses on various dates (1981, 1991, 2007, and 2017) to gather population data for each district where the informal sites were studied. Using this information, the intercensal rate of population growth was calculated between each date, representing the average annual population growth rate for each period. Instead of focusing on the exact number of residents per district, the rate of population growth was considered as a significant criterion for this study.

The findings reveal a significant increase in the average annual population growth rate for sites 1 and 2, located north of Arequipa. This rate escalated from 2.8% between 1981 and 1993 to over 5.8% between 2007 and 2017. This demonstrates a migration phenomenon towards the northern region of the city since the 1980s, and the subsequent urban expansion can be attributed to the substantial population growth in this area during the 21st century.

On the other hand, the district of Miraflores, situated east of Arequipa where the 3rd site is located, exhibits low rates of population growth since 1981 (ranging from 0.8% to 1.8% currently). This indicates a stagnation of the population in this area, which is heavily constrained by mountains and challenging terrain, hindering its development.

In contrast, the district of Site 4, located in the southern part of the city, demonstrates the highest increase in population growth rates among all areas. It witnessed a rise from 2% between 1981 and 1993 to more than 12.9% between 2007 and 2017. This substantial growth during these periods indicates the relocation of populations to the southern region of the city and a gradual urban expansion of this district.

Lastly, the districts of sites 5 and 6, situated to the west of the city of Arequipa, exhibit relatively average characteristics. The district of Sachaca, located near the city center, experienced a relative decrease in the rate of population growth, declining from 3.6% between 1981 and 1993 to 3.3% between 2007 and 2017. This indicates that there has been limited population movement towards these areas of the city, as the phenomenon of urban expansion primarily occurs in the north, south, and east regions.

The Uchumayo district, situated on the western outskirts of the city, demonstrates a slight increase in population over the years. However, it remains below 3% between 2007 and 2017, indicating a relatively modest growth rate compared to other areas of the city.

Site	District of Arequipa	Density of population (res/km ²)			
		1981	1993	2007	2017
1 & 2	Cerro Colorado	255	354	647	1 132
3	Miraflores	6 879	7 248	7 264	8 680
4	Mollebaya	23	29	53	178
5	Sachaca	325	498	659	910
6	Uchumayo	26	33	47	62

Table 11: Density of population in each site's district (Data source: INEI)

Another significant criterion to consider at the population level is population density, which is expressed as the number of inhabitants per square kilometer within each district where the informal sites are located.

Notably, the district of Site 3, situated to the east of the city, exhibits the highest population density. It increased from 6,879 residents per square kilometer in 1981 to over 8,680 in 2017. This can be attributed to the district's small size and its historical status as one of the initial areas of urban expansion in close proximity to the densely populated city center.

The district of sites 1 and 2, located to the north of Arequipa, has experienced a substantial surge in population density. It escalated from 255 inhabitants per square kilometer to over 1,132 in 2017, further demonstrating the trend of population relocation towards the northern region of the city since the beginning of the 21st century.

In the Mollebaya District of Site 4, situated to the south of the city, the population density, while relatively average, has been increasing. It rose from 23 residents per square kilometer to over 178 in 2017. The lower density compared to other districts can be attributed to the district's larger area, which includes agricultural holdings where population occupancy is not possible. Nonetheless, this southern area is gradually being occupied by populations and informal groups.

Moving to the west, the Site 5 district exhibits high population densities, primarily due to its relative proximity to the city center.

Lastly, in the Uchumayo district, located further west, the population migration towards the western part of the city is minimal, as indicated by a slight increase in population density that remains below 62 residents per square kilometer in 2017.

In conclusion, a significant increase in population density has been observed, especially in the northern and southern regions of the city since the 1980s. There is also a growing trend of population density in the eastern and western districts of the city, which are closer to the city center. These findings demonstrate that urban expansion is accompanied by a substantial rise in population density within the districts affected by this phenomenon. In some remote areas of the city, population density can surpass 1,000 inhabitants per square kilometer, leading to the emergence of new residential centers for the population. However, this rapid growth in population density comes with various challenges and constraints in terms of housing and mobility.

- Housing data of the sites:

To complete the study of urban expansion for each site, it is valuable to analyze housing data and their evolution within their respective districts. This analysis helps in understanding the trends related to the increase in the number of dwellings in different areas of the city.

By examining housing data, it is possible to gain insights into the changing housing landscape and the corresponding implications for urban expansion. This information provides a comprehensive understanding of the growth patterns and housing needs within each district associated with the informal sites.

Site	District of Arequipa	Density of housing (h/km ²)		Number of housing		Intercensal housing growth rate
		2007	2017	2007	2017	
1 & 2	Cerro Colorado	205	460	35 805	80 385	8,42%
3	Miraflores	458	621	13 133	17 800	3,09%
4	Mollebaya	22	158	588	4 218	21,78%
5	Sachaca	180	298	4 806	7 926	5,13%
6	Uchumayo	14	28	3 280	6 304	6,75%

Table 12: Housing data in each site's district (Data source: INEI)

In terms of housing densities, it is observed that the areas with the highest densities are primarily located near the city center. The Miraflores district to the east stands out with a density of 621 dwellings per square kilometer, indicating a high concentration of housing in that area. Similarly, the West Sachaca district of Site 5 exhibits a density of 298 dwellings per square kilometer in 2017.

However, it is worth noting that the outlying district north of Cerro Colorado possesses a density of 460 dwellings per square kilometer in 2017, making it the second most densely populated district after Miraflores on that date. This finding demonstrates the emergence of numerous urban areas, both formal and informal, in the northern part of the city. This suggests a significant level of urbanization and the establishment of residential neighborhoods in that region.

When examining the annual average growth rate of housing between 2007 and 2017 in the districts of each site, two areas stand out with the highest growth rates.

The Cerro Colorado district in the north experienced a housing growth rate of over 8.4% during this period. This indicates a significant increase in the number of housing units in the northern direction of the city, reflecting the ongoing urban expansion in that region.

On the other hand, the district of Mollebaya in the south exhibited a remarkable housing growth rate of more than 21.7%. This signifies a strong trend of urban expansion in the

southern direction within the city, with a substantial increase in the housing stock in this particular region.

These findings highlight the current dynamics of urban expansion in Arequipa, with notable growth in housing development in both the northern and southern directions. The increased share of housing in these regions reflects the city's expanding residential areas and the corresponding need for infrastructure and services to support this growth.

Overall, the high housing densities and the increasing densities in the northern and southern districts highlight the ongoing urban expansion and the creation of various residential areas within Arequipa.

5.2. Virgen del Rosario settlement study

5.2.1. Services and state of development

The study of site number 6, which involved detailed analysis and numerous field visits, has revealed significant deficiencies in terms of services, infrastructure, and neighborhood facilities. The residents of the Virgen del Rosario district are currently facing a lack of essential amenities needed for the development of a sustainable neighborhood.

One of the primary concerns is the absence of educational facilities, parks, and treatment centers in the area. The limited availability or non-existence of these crucial amenities hampers the quality of life for the residents. Additionally, there is a lack of recreational spaces that are either underdeveloped or non-existent.

The spaces initially designated for the construction of such infrastructure currently remain vacant, exacerbating the scarcity of services accessible to the neighborhood's residents. As a result, they are compelled to seek necessary services outside the neighborhood, often traveling to Uchumayo or the center of Arequipa, where most of the residents are working.



Figure 77 : Empty areas in lack of public equipment and services in Virgen del Rosario settlement (Photos: H. LE VASLOT)

Furthermore, due to the mountainous terrain, the neighborhood lacks vegetated areas. While a few plots may have trees, they remain a minority, and overall, the absence of green spaces is notable.

Additionally, access to basic water and electricity services in the informal district remains relatively limited for its inhabitants. In particular, water availability is intermittent, and the service is plagued by numerous contamination issues. This poses a significant challenge for the development and well-being of the neighborhood.

The unreliable and contaminated water supply is a pressing problem that needs to be addressed as a priority. Adequate access to clean and reliable water is essential for the residents' daily needs, sanitation, and overall quality of life. Efforts should be made to ensure a consistent and safe water supply, implementing measures to address contamination issues and improve the infrastructure supporting water distribution in the area.

Similarly, attention should be given to improving access to electricity services. Reliable and consistent electricity supply is crucial for various aspects of daily life, including lighting, cooking, and powering essential appliances and devices.

Addressing these issues of limited access to water and electricity services is vital for the development and sustainability of the neighborhood. It requires collaborative efforts from relevant authorities, community organizations, and stakeholders to implement solutions that ensure reliable, clean, and accessible services for the residents of the informal district.

These findings underscore the urgent need to address the deficiencies in services, infrastructure, and settlement facilities within site number 6. It is crucial to prioritize the development of educational institutions, parks, treatment centers, recreational areas and more importantly basic services to enhance the quality of life for residents and promote the establishment of a sustainable and well-equipped neighborhood.

5.2.2. Housing typology results

In the study of the Virgen del Rosario district, a typological analysis of the dwellings was conducted, resulting in a breakdown of the dwellings by type. This breakdown provides insights into the level of development within the settlement. The identified dwelling types are as follows:

- Type 1.1: Prefabricated housing
- Type 1.2: Prefabricated hut without housing function
- Type 2.1: Intermediate housing with better construction materials
- Type 2.2: Intermediate housing of 2 or more floors
- Type 3.1: Modern concrete housing
- Type 3.2: Concrete housing with 2 or more floors

By analyzing the distribution of these dwelling types across the site, it becomes possible to understand the varying levels of development within different areas of the district. This information sheds light on the quality and construction standards of the housing units present in the settlement. The breakdown of dwelling types allows for a comprehensive assessment of the neighborhood's housing stock and highlights the diversity of housing conditions within the Virgen del Rosario district.

Type of housing		Number	Proportion (%)
Prefabricated housing	1.1	596	29,1%
	1.2	582	28,4%
Intermediate housing	2.1	208	10,1%
	2.2	41	2,0%
Modern housing	3.1	16	0,8%
	3.2	17	0,8%
Empty parcel		590	28,8%
Total of parcels		2050	100%

Table 13: Housing typology in Virgen del Rosario settlement – May 2023

Upon analyzing the results of the typological study, several observations can be made regarding the housing situation in the Virgen del Rosario district.

Out of a total of 2050 residential plots within the site, a significant proportion is occupied by prefabricated dwellings and prefabricated huts without housing functions. More specifically, there are 596 occupied plots with prefabricated dwellings and 582 occupied plots with prefabricated huts. This means that a total of 1180 plots, or 57.5% of the total, are occupied by precarious prefabricated constructions, predominantly made of wood. This highlights the

prevalence of insecure housing within the informal neighborhood, indicating the overall weak development in this area.

Intermediate dwellings, constructed using bricks, cinder blocks, or volcanic rock, occupy a total of 249 plots, accounting for 12.1% of the site's plots. Among these, 41 dwellings are densified with a minimum of 2 floors. This typology represents a moderate proportion of the housing stock, indicating some level of development and densification within the neighborhood.

Additionally, dwellings constructed with concrete and reinforced concrete represent a minority of the housing types observed. A total of 33 plots, or 1.6% of the total, are occupied by this type of construction. Among these 33 units, 17 have 2 or more floors. This suggests a limited but present trend towards more developed housing options, albeit still in the minority.

Additionally, the typological study reveals that a significant number of plots within the site remain unoccupied by any dwellings or buildings. These unoccupied plots account for more than 590 plots, constituting 28.8% of the entire site. This further underscores the lack of urbanization and development in the settlement.

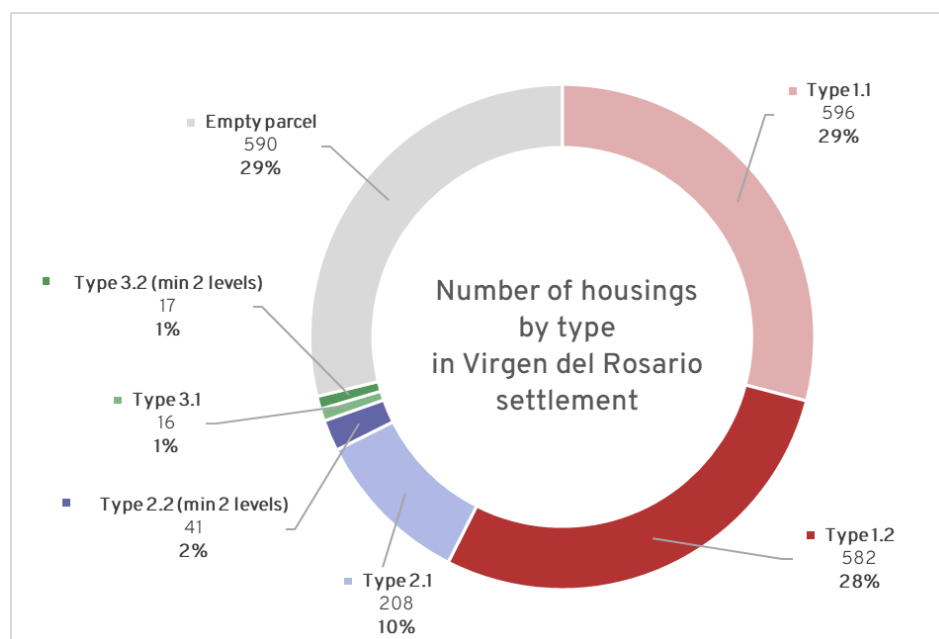


Figure 78: Housing typology repartition in Virgen del Rosario settlement – May 2023

Overall, the findings of the typological study highlight the predominance of precarious housing, particularly prefabricated constructions, within the Virgen del Rosario district. While there are indications of some development and densification in intermediate and concrete housing types, they remain in the minority compared to the overall housing stock. The significant number of unoccupied plots points to the challenges and opportunities for further urbanization and development efforts within the neighborhood.

5.2.3. Overall assessment of the settlement study

After conducting a comprehensive analysis of the Virgen del Rosario informal district, it is possible to assess its strengths, weaknesses, opportunities, and threats through a SWOT analysis.

First, the main **strengths** of the site are a strong social organization, and a structured urban framework. The neighborhood benefits from a relatively strong and well-organized social structure. The Virgen del Rosario association actively engages with residents and encourages their participation in the development of the neighborhood. Also, the district has a structured urban layout, characterized by orthogonal cutting and residential islets with plots of similar sizes.

Secondly, regarding the **weaknesses** of the site, the Virgen del Rosario settlement presents some drawbacks regarding its current state of development. Indeed, the neighborhood is currently at a low level of development, with limited progress in terms of urbanization. Only 10% of the area has been urbanized as of 2022.

Likewise, a significant proportion of the housing in the neighborhood consists of precarious constructions, such as prefabricated dwellings and huts. This poses challenges in terms of safety, infrastructure, and overall living conditions.

Furthermore, the neighborhood lacks essential public services and facilities. Currently, there are only a few amenities available, including a children's playground, a multi-sport field, and a small number of shops. Insufficient provision of water and electricity services further hinders the neighborhood's development.

Currently, the absence of proper road infrastructure and sidewalks significantly hampers mobility within the area, presenting another significant disadvantage.

Regarding **opportunities** for improvements, the proximity of the site to a national road presents an opportunity to improve connectivity between the neighborhood and the center of Arequipa. This can facilitate transportation and enhance accessibility for residents, promoting economic activities and social integration. Secondly, the ongoing formalization process with COFOPRI (Peruvian Commission for Formalization of Informal Property) is a significant opportunity for the neighborhood. Formalization can result in improved services, infrastructure, and legal recognition of property rights. This process has the potential to enhance the overall development and quality of life in the area in the near future.

Development of the site is confronted with several **threats**. Firstly, the area's significant topographical relief poses a constraint on its urbanization, with various regions prone to landslides, as previously studied, on the outskirts and within the site itself. Moreover, the steep slopes increase the vulnerability of dwellings located at the bottom of the site to flooding and water flow events. Additionally, the limited financial and natural resources available to the neighborhood hinder its development and infrastructure. Furthermore, the site's geographical location and distance from the center of Arequipa create numerous mobility complications for the residents, requiring a public transport journey of approximately 1 hour and 30 minutes.

By considering these factors within the SWOT analysis, stakeholders and decision-makers can better understand the current state of the Virgen del Rosario settlement and identify strategies to address its weaknesses, leverage its strengths, seize opportunities, and mitigate threats to promote sustainable development and improve the quality of life for its residents.

Upon analyzing all these criteria, it becomes evident that the district of Virgen del Rosario is faced with numerous constraints that pose challenges to its future development, even with ongoing formalization efforts. The district's geographical position and the characteristics of the land it occupies will severely impede its urbanization and significantly limit the potential for neighborhood densification.

It is worth noting that the formalization process of neighborhoods, such as Virgen del Rosario, can be lengthy and expensive according to the city of Arequipa. This raises questions about the value of developing such areas, especially considering the current lack of infrastructure and limited access to mobility services due to its geographical remoteness. The challenges associated with formalization and the existing deficiencies in the neighborhood's amenities may lead to discussions regarding the feasibility and benefits of further development in Virgen del Rosario.

5.3. Methodology limitation and discussion

The methodology employed in this project, which involves comparing sites of informal urban expansion, offers valuable insights. However, it also possesses certain limitations. One limitation is that using satellite imagery to study urban expansion may lead to difficulties in accurately identifying historical built structures. Additionally, this approach does not provide information about the availability of various services to the residents of each site. This missing element could be addressed by conducting field visits to each site to gather additional data.

Indeed, informal urbanization is a highly complex process, and solely relying on satellite analysis may not adequately capture the intricacies of certain sites. To accurately describe and comprehend informal urbanization, interviews and field visits play a crucial role. These methods allow researchers to gather first-hand information, understand the development challenges, and delve into the historical context of each site, including the constraints it faces. By incorporating interviews and field visits, a more comprehensive understanding of the sites can be attained, leading to a more nuanced analysis of their development dynamics.

Furthermore, the study did not delve into the complex processes of territorial management and urban expansion by the city of Arequipa. It would be beneficial to compare the level of urbanization observed in the city with the municipality's development plans. This analysis would shed light on the alignment between the actual urban growth and the envisioned development strategies set forth by the local authorities.

Conclusion

In conclusion, the study of urban expansion involves multiple criteria that shed light on the dynamics of the studied area of the city of Arequipa. Factors such as the extent of urbanized areas and their evolution over time, demographic trends, and housing patterns in specific neighborhoods and districts of Arequipa, provide valuable insights into the processes of urban expansion. Analyzing population growth rates, population density, and housing density across all districts of Arequipa has enhanced the understanding of the distinct patterns of urban expansion observed in different parts of the city.

The study has identified significant periods of urban development, such as the 1980s and the early 21st century, characterized by rapid urban expansion towards the north, south, and east of the city. These periods coincided with factors such as increased migration to Arequipa, rural-to-urban migration, and natural disasters like seismic events that profoundly impacted the city's urban expansion. Consequently, the city administration, in response to these dynamics, had to create new residential areas or contend with illegal settlements on the city outskirts.

By analyzing these various criteria and understanding the historical context, it was possible to gain valuable insights into the processes driving urban expansion and the challenges faced by cities like Arequipa. This knowledge can inform urban planning efforts, disaster management strategies, and policies aimed at addressing the needs of growing populations and fostering sustainable urban development.

The findings of the study revealed notable urban expansion trends in the city of Arequipa, primarily driven by significant population growth. The expansion predominantly occurred in the northern and southern areas of the city. It was observed that this urbanization process led to the creation of new residential areas characterized by various disadvantages and negative impacts on the city's environment.

These newly formed neighborhoods exhibited characteristics of informal land use, with a partial or complete absence of essential services and infrastructure for the residents. Additionally, the presence of significant mobility constraints and pronounced geographical remoteness posed considerable challenges for the future development of these areas.

One specific neighborhood that was studied, the district of Virgen del Rosario, was found to be in a relatively underdeveloped state. However, efforts were underway to formalize this area, aiming to address its developmental shortcomings. The study highlighted the complexities associated with the future development of these informal neighborhoods,

emphasizing the need for comprehensive planning and interventions to improve living conditions and overall development.

Indeed, categorizing a site as an informal settlement can be really challenging due to the lack of well-established criteria in the current scientific literature. However, given the prominence of informal urbanization as a widespread phenomenon, especially in Latin America and other countries of the Global South, it is necessary to develop a deeper understanding of this type of urbanization, and this type of study is contributing to it. This understanding can help in formulating new tools, strategies, and policies aimed at mitigating the negative impacts associated with informal urbanization.

Some of the negative impacts that need to be addressed include the artificialization of soils, which can have detrimental effects on the environment, increased risk of flooding, reduced accessibility due to limited mobility options and excessive reliance on private transportation networks, as well as social risks such as heightened insecurity and chaotic traffic conditions.

Finally, considering the current relatively high growth rates, it is anticipated that the trend of urban expansion and significant population growth will persist in the city of Arequipa. However, it is crucial to acknowledge that addressing this phenomenon effectively requires profound changes in land management policies and the availability of new studies and expertise focused on the subject of informal urbanization.

By implementing comprehensive land management policies and strategies, the city and the country as a whole can better manage and respond to the challenges posed by informal urbanization. This includes developing and implementing effective urban planning measures, improving access to services and infrastructure in informal settlements, and promoting sustainable and inclusive urban development practices.

Furthermore, conducting further research and fostering expertise in the field of informal urbanization can provide valuable insights and guidance for addressing this phenomenon. This knowledge can contribute to the development of informed policies and interventions, ultimately helping to mitigate the negative impacts associated with informal urbanization and foster more sustainable and inclusive urban growth in Arequipa and beyond.

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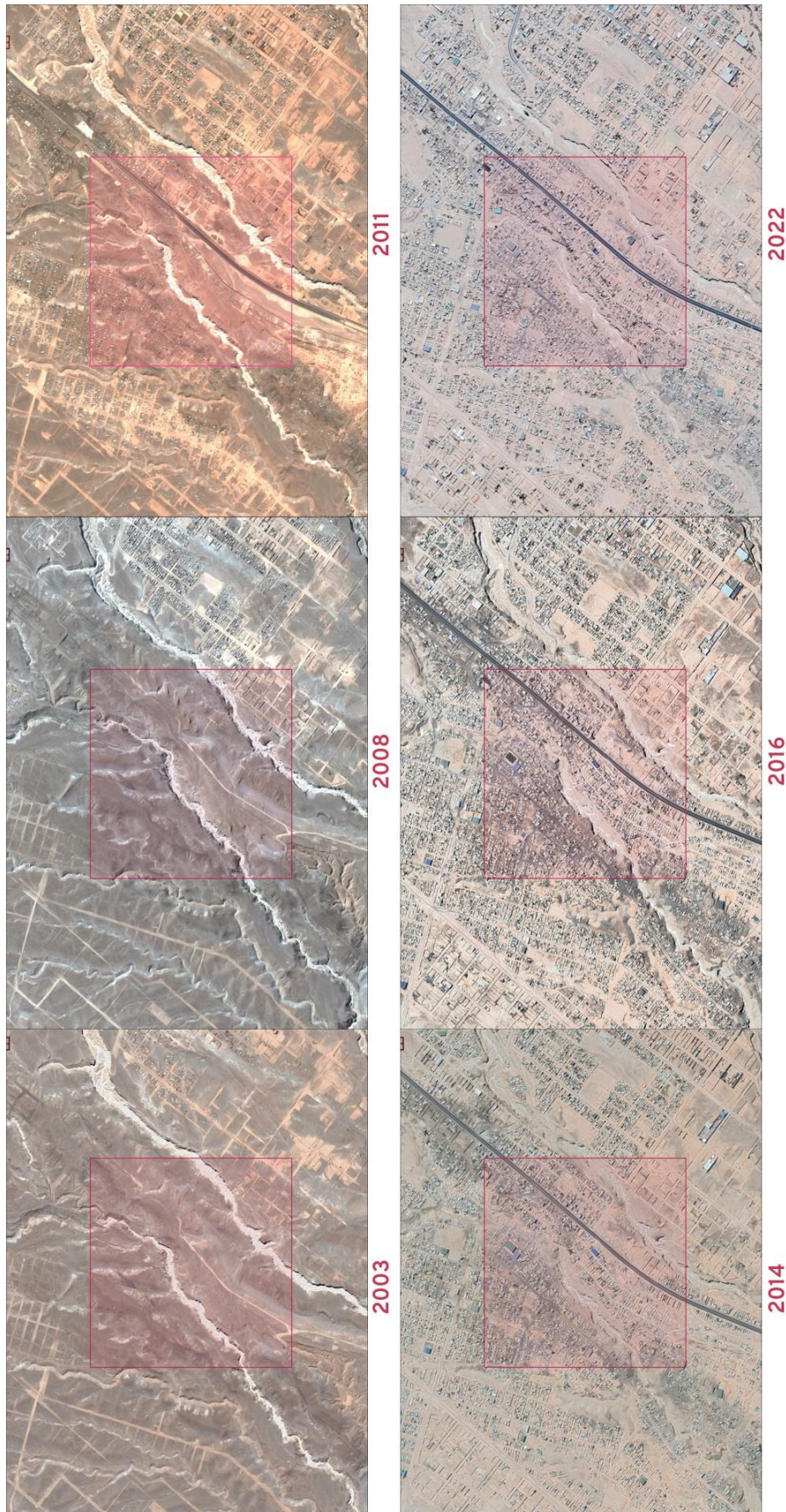
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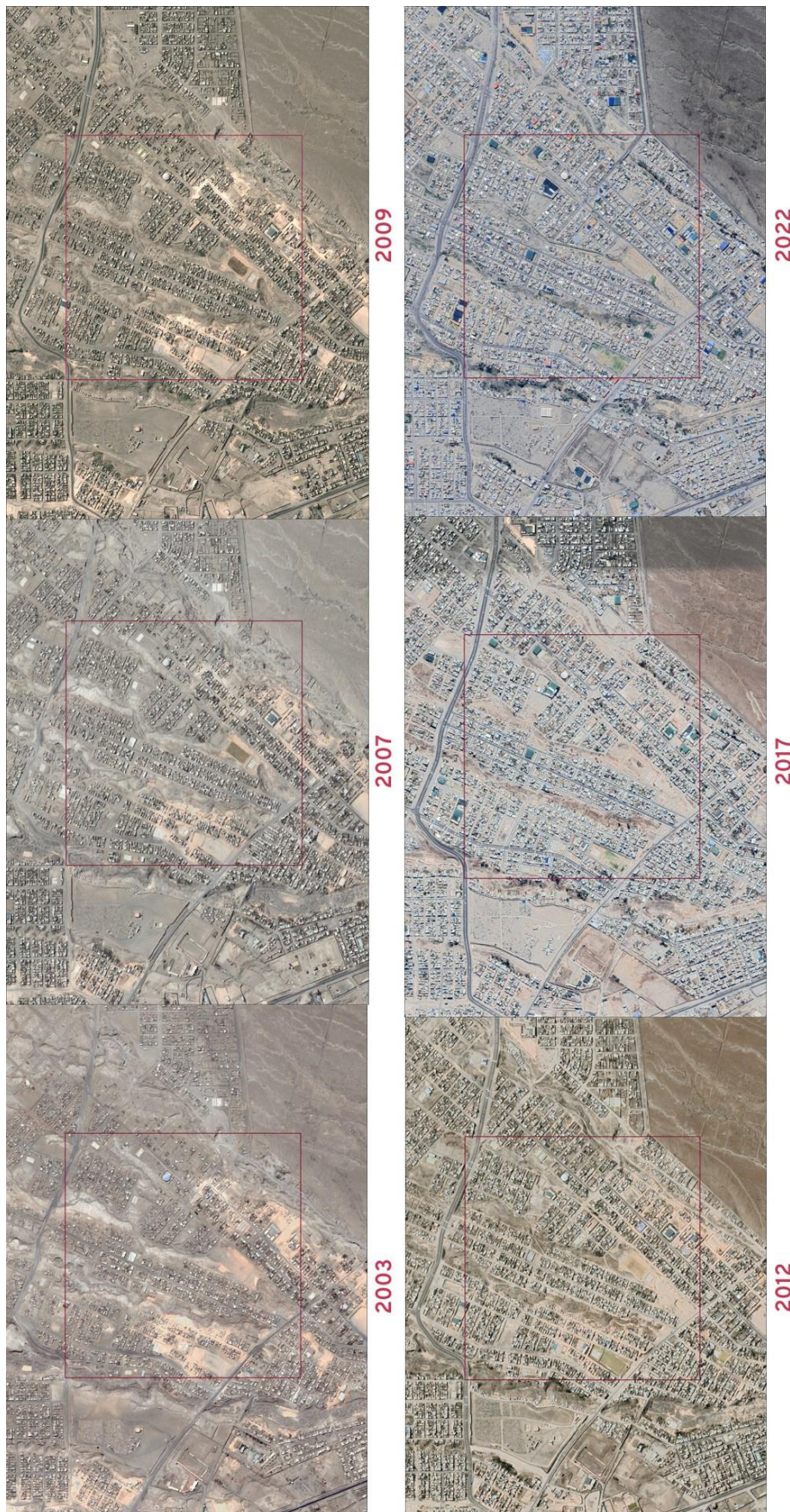
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Annexes

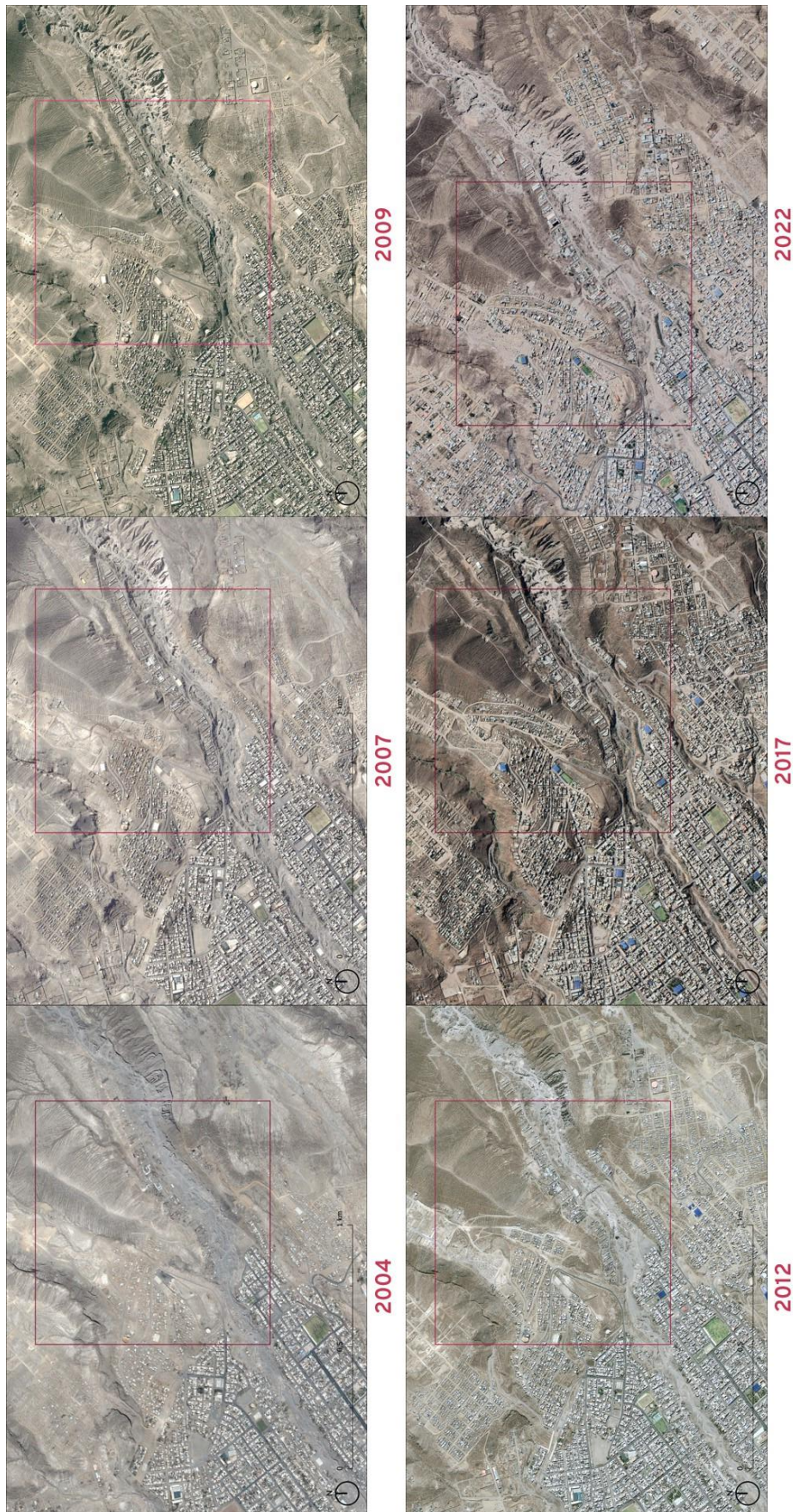
Historical satellite maps of Site 1 – informal settlements analysis:



Historical satellite maps of Site 2 – informal settlements analysis:



Historical satellite maps of Site 3 – informal settlements analysis:



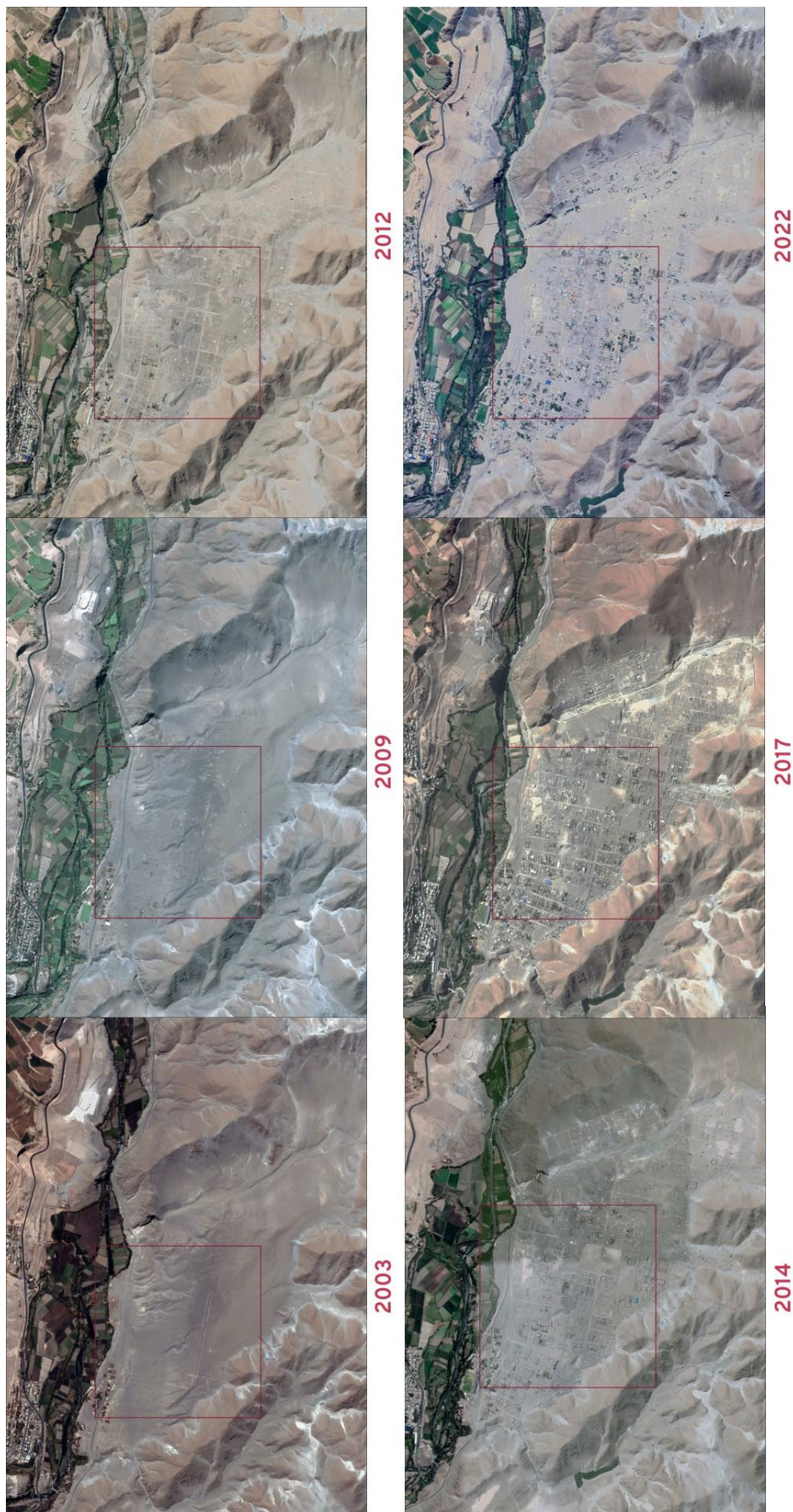
Historical satellite maps of Site 4 – informal settlements analysis:



Historical satellite maps of Site 5 – informal settlements analysis:



Historical satellite maps of Site 6 – informal settlements analysis:



Interview with Julio Ronald MELGAREJO ZEBALLOS (president of the housing association of Virgen del Rosario) in English and Spanish:

- Since when did the residents settle in the territory and what is the history of the settlement?
- ¿Desde cuando la gente se instala en el territorio y cuál es la Historia del barrio?

J. R. M. ZEBALLOS: I would like to give you a reminiscence. The Virgen del Rosario Housing Association dates to 2001, as a result of the earthquake in September 2001 in the south of the country and the city of Arequipa was affected. Thus, the district authorities see this part of Uchumayo as an urban expansion zone. So, it dates back to 2001. In relation to the earthquake and considering that the geography of the main town has no more expansion areas. That is why they looked at this place as part of demographic expansion for the population of the place and the surrounding population.

J. R. M. ZEBALLOS: Yo te hago una remembranza. La Asociación de Vivienda Virgen del Rosario data del 2001 del año 2001, a consecuencia de que en el En el 2001, en septiembre de 2001 hubo un terremoto en el sur del país y la ciudad de Arequipa se vio afectada. Es así que las autoridades del distrito ven a esta parte de Uchumayo como zona de expansión urbana. Entonces data del 2001. En relación con el terremoto y teniendo en cuenta que la geografía del pueblo principal no tiene más áreas de expansión. Es por ello que miraron a este lugar como parte de expansión demográfica para la población del lugar y también la población aledaña.

- How was the settlement created? How is the urban fabric defined? Have you received design assistance (architects, urban planners)?
- ¿Cómo fue creado el barrio? ¿Como se define la trama urbana? ¿Ha recibido ayuda para el diseño (arquitectos, urbanistas)?

J. R. M. ZEBALLOS: As I mentioned in the creation of the association, it has basically been due to the housing needs of many residents. Not all the people who live in the area are local people, 60% of them are from rural areas in the highlands. There have been a lot of social problems. Suddenly part of the terrorism, part of the economic shortages, part due to temperatures because of the triage time. So the people from the highlands of the department of Arequipa have migrated to the city and have taken this place as part of their home. And this is how the development has been taking place. Initially the services of a topographer and an architect are taken to make the survey of plans of more the peripheral plans, and based on it is given to the first and beginnings of formalization of the association with its real plans. Trained personnel have been taken to make these surveys and now we have the projection

of a city, a populated and modern center, with all its contribution areas or areas of education, health. What a new, populated center requires.

J. R. M. ZEBALLOS: Como te comento en la creación de la asociación, básicamente ha sido por necesidad de vivienda de muchos pobladores. No toda la gente que vive en el lugar es población del lugar, es el 60%, es población de zonas rurales de la parte alta. Ha habido un montón de problemas sociales. De repente parte del terrorismo parte de repente carencias económicas, parte por temperaturas por el tiempo de triaje. Es así que la gente de las partes altas del departamento de Arequipa ha migrado a hacia la ciudad y han tomado este lugar como parte de su vivienda. Y así se ha ido dando el desarrollo. Inicialmente se toma los servicios de un topógrafo y un arquitecto para que hagan el levantamiento de planos de más aneo los planos periféricos, y en base a ello se da a los primeros y inicios de formalización de la asociación con sus planos reales. Se ha tomado personal capacitado para que haga dichos levantamientos y se tenga ahora la proyección de una ciudad, un centro poblado y moderno, con todas sus áreas de aporte o áreas de educación, salud. Lo que requiere un nuevo, un centro poblado.

- What is your social organization in the neighborhood with the association (number of leaders and their functions)? and their interactions with residents?
- ¿Cuál es su organización social en el barrio con la asociación (número de líderes y sus funciones)? y sus interacciones con los residentes?

J. R. M. ZEBALLOS: About the social organization. Basically, the association is a non-profit organization. There is no profit motive. The idea is the purpose of housing. To look for the common good and that the people who are part of this association have a formalized housing. So, we as directors, as advisors and as a work team, seek that the people have formalized housing and at the same time we seek that they have all their basic services, such as water and electricity. So far, these services are not 100% efficient, but at least they have a service that allows them to have a certain quality of life.

The way of interacting with the inhabitants of the place is through meetings, generally at the end of the month, where we explain to them what progress has been made or what achievements have been made so far. No? Then, this type of meetings are carried out by the Board of Directors, which is presided by myself, and where we explain all the objectives or achievements so far, so that the villagers can participate in the development and also in the problems.

J. R. M. ZEBALLOS: Ya la organización social. Básicamente la asociación es una organización sin fines de lucro. No existe fines de lucro. La idea es el fin de vivienda. Buscar el bien común y que las personas que sean parte de esta asociación tengan una vivienda ya formalizada. Entonces nosotros como directivos, como asesor y equipo de trabajo, buscamos que las personas tengan una vivienda formalizada y a la par buscamos que cuenten con todos sus servicios básicos, que es el agua, la luz. Hasta el momento son servicios que no son del todo 100% eficientes, pero al menos cuentan con un servicio que les permite tener cierta calidad de vida.

La forma de interactuar con los pobladores del lugar es a través de reuniones, generalmente a fin de mes, donde se les explica cuáles son los avances o cuáles son los logros que se ha tenido hasta el momento. No? Entonces, ese tipo de reuniones se las lleva el Consejo Directivo que lo preside en mi persona y donde exponemos todos los objetivos o los logros hasta el momento, para que se los hace partícipes a los pobladores del desarrollo y también de la problemática.

- And can residents help and propose solutions to improve the condition of the neighborhood?
- ¿Y los residentes pueden ayudar y proponer soluciones para mejorar la condición del barrio?

J. R. M. ZEBALLOS: This is definitely the case in the assemblies. The residents, as you say we tell the settlers, they participate in the meetings and at the same time they suddenly contribute possible solutions to the problems we are facing. That is the real situation of how the meetings are conducted. There is a meeting on the last working Sunday of each month, that is, there is one meeting per month.

J. R. M. ZEBALLOS: Así es definitivamente dentro de las asambleas. Los residentes como tú les dices que nosotros le decimos a los pobladores, ellos son partícipes de las reuniones y a la vez aportan de repente posibles soluciones a los problemas que nos vemos inmersos. Esa es la situación real de la forma como se lleva las reuniones. Hay una reunión el último domingo hábil de cada mes, o sea, al mes hay una reunión al mes.

- Among the leaders of your association, are there other meetings as well?
- ¿Entre los líderes de su asociación, hay otras reuniones también?

J. R. M. ZEBALLOS: La asociación quién está a cargo del manejo de la asociación en la Junta Directiva, la cual yo presido. Nosotros somos los que llevamos la reunión y proponemos acciones a seguir y les hacemos conocedores a todos los asociados de los logros alcanzados y

cuáles son los siguientes el dentro del plan de trabajo, cuáles son las cosas a solucionar y los hacemos partícipes a todos los pobladores de dicha asociación.

J. R. M. ZEBALLOS: The association who oversees the management of the association is the Board of Directors, which I chair. We are the ones who lead the meeting and propose actions to follow and we make all the associates aware of the achievements and what are the next ones in the work plan, what are the things to be solved and we make them participate to all the inhabitants of the association.

- About mobility, is there a bus line? How much per day?
- ¿Sobre la movilidad, hay una línea de bus? ¿Cuánto pasan por día?

J. R. M. ZEBALLOS: Ya se tiene una empresa que brinda el servicio de transporte con un intervalo de cada 20 minutos de salida entre bus y bus. No, ese es un prácticamente un tráfico, algo fluido. No hay un intervalo de 20 minutos para que puedan salir a la ciudad, y llegar al centro de Arequipa.

J. R. M. ZEBALLOS: There is already a company that provides transportation service with an interval of every 20 minutes from bus to bus. No, that is practically a traffic, somewhat fluid. There is not an interval of 20 minutes so that they can leave to the city and arrive to the center of Arequipa.

- What parks, green areas and education services (schools) do you have?
- ¿Qué servicios de Parques, áreas verdes y servicios de educación (escuelas) tienen?

J. R. M. ZEBALLOS: Le comento, no como usted ya debe saber, nosotros nos acabamos de formalizar y en ese proceso de ya formalizamos todo el desarrollo de dichas áreas, están en pleno proceso, tanto los parques como las áreas verdes recién se las está adjudicando a la municipalidad, que va a ser el ente de tomar esas áreas y de darles la respectiva habitabilidad y mostrarlos en el futuro como un parque o un área verde, pero eso demora un proceso ya como ya está formalizado, será de acá un año, me imagino yo.

En el futuro plan que se realizara, Hay también áreas de educación, hay áreas de salud, hay áreas de entidades del Estado. Bajo ese contexto se tiene todas las áreas de aporte que necesita un nuevo centro poblado para el bienestar de su población.

En este momento la asociación cuenta con un local social implementado. A la vez tiene una plaza principal donde se ha realizado eventos cívicos y cuenta también con un parque de recreación que está a disposición de los niños del lugar. Hay un vivero, entonces hay áreas que están a disposición de los asociados de la sociedad. Eso, eso ha sido construido con

recursos propios. Entonces, estamos a la espera de que la Municipalidad, en este caso el Estado, ya sea seamos nosotros parte de este desarrollo y que estemos incluidos en el presupuesto. Entonces, para que el mismo Estado ejecute obras en el lugar.

J. R. M. ZEBALLOS: As you must know, we have just formalized and in the process of formalizing all the development of these areas, they are in full process, both the parks and the green areas have just been awarded to the municipality, which will be the entity that will take these areas and give them the respective habitability and show them in the future as a park or a green area, but this will take a year, I imagine, as it has already been formalized.

In the plan to be carried out, there are also areas of education, there are areas of health, and areas of state entities. In this context, there are all the areas of contribution that a new population center needs for the welfare of its population.

At this time the association has a social premises implemented. At the same time it has a main square where civic events have been held and also has a recreation park that is available to the children of the place. There is a nursery, so there are areas that are available to the associates of society. That, that has been built with own resources. So we are waiting for the Municipality, in this case the State, either we are part of this development and we are included in the budget. Then, for the same State to execute works in the place.

- What basic services are in the neighborhood now (water, drainage system, electricity)?
- ¿Qué Servicios básicos hay en el barrio ahora (agua, sistema de desagüe, electricidad)?

J. R. M. ZEBALLOS: En cuanto al agua, se tiene una app que es una junta administradora de agua potable. Ellos nos brindan el servicio de agua, es por horas, entonces ya el poblador las horas que le toca el agua las reciben sus pequeños pozos o depósitos y ha lo lo distribuye ya para sus sus usos domésticos o sus usos eh higiénicos. Y todo ello en cuanto al desagüe. Acá no hay desagüe, la gran mayoría de no que la gran mayoría todos los pobladores tienen un silo. Un silo es un lugar donde van los desechos de producto de las necesidades propias del ser humano. Para la luz, en este caso en nuestra asociación tenemos dos medidores trifásicos que es la luz colectiva. Estamos con luz colectiva que de alguna manera cubre la necesidad de los pobladores, de los que realmente viven no con luz colectiva. Esa es la situación real en este momento.

J. R. M. ZEBALLOS: As for water, you have an app that is a drinking water management board. They provide us with water service, it is for hours, then the villager the hours that the water is received by their small wells or tanks and has distributed it already for their domestic uses or their hygienic uses eh. And all this in terms of the drain. Here there is no drain, the vast majority of which most of the inhabitants have a silo. A silo is a place where waste products from the needs of the human being go. For light, in this case in our association we have two three-phase meters which is the collective light. We are with collective light that somehow covers the need of the inhabitants, of those who really live not with collective light. That is the real situation at the moment.

- What is the next stage of settlement improvement?
- ¿Cuál es la Próxima etapa de mejoramiento del barrio?

J. R. M. ZEBALLOS: Once formalized, we will be part of the district's participatory budget. Then the municipality through, that is with state funds, will have to intervene in all that is avenues, roads, will take areas, green areas, recreation areas and already be part of development, not with all that, that is the situation, those are the benefits of formalization for such a place and okay.

J. R. M. ZEBALLOS: Ya formalizados, nosotros vamos a ser parte del presupuesto participativo del distrito. Entonces la municipalidad a través de, o sea con fondos del Estado, van a tener que intervenir en todo lo que es avenidas, las vías, va a tomar las áreas, las áreas verdes, las áreas de recreación y ser parte ya del del desarrollo, no con todo ello, esa es la situación, esos son los beneficios de la formalización para dicho lugar y okay.

- How will they formalize the neighborhood with cofopri?
- ¿Cómo van a formalizar el barrio con cofopri?

J. R. M. ZEBALLOS: 50% of the partnership is now formalised. The other is in an evaluation process. But there are already half of residents who already have a title, that is, it is 50% already formalized with Cofopri, but we continue in a process because the other 50% is in a process of evaluation. The State's criterion for starting to evaluate the first stage includes all sites that have zero risk or low risk, those are those that have already been formalized. We go to another stage. Those who have medium or high risk are those who are waiting to be formalized.

J. R. M. ZEBALLOS: Ya está formalizado el 50% de la asociación. El otro restante está en un proceso de evaluación. Pero ya existen la mitad de los pobladores que cuentan ya con un título de propiedad, o sea, está al 50% ya formalizado con Cofopri, pero seguimos en un proceso porque el otro 50% está en un proceso de evaluación. Son etapas el criterio del Estado para entrar a evaluar la primera etapa entran todos los predios que tienen cero riesgo o riesgo bajo, esos son los que ya se han formalizado. Pasamos a otra etapa. Los que tienen riesgo medio o riesgo alto son los que están pendientes por formalizarse.

- How did the COVID crisis affect the development of the neighborhood and its organization?
- ¿Cómo afectó la crisis del COVID al desarrollo del barrio y a su organización?

J. R. M. ZEBALLOS: Eh, esta pandemia definitivamente que ha sido algo dura. Hemos visto vecinos o conocidos, En algunos casos para algunas personas un familiar, Partir. Entonces ha sido algo dura, Nosotros como directivos hemos tratado de apoyar con los pocos recursos que teníamos en víveres, oxígeno, a los que hemos podido, no? Pero a la vez, eh, eso ha sido un impedimento para que no se podía tener ningún tipo de reuniones. Pero en cuanto a la formalización, nos ha favorecido en cierta medida porque el trámite que veníamos realizando en esa época ha avanzado. Tal es el caso que terminada la pandemia, nosotros entramos al proceso de formalización, como se ha venido dando.

J. R. M. ZEBALLOS: Eh, this pandemic has definitely been something hard. We have seen neighbors or acquaintances, In some cases for some people a relative, Depart. So it's been hard, We as managers have tried to support with the few resources we had in food, oxygen, to which we could, right? But at the same time, uh, that's been an impediment so you couldn't have any meetings. But as for the formalization, it has favored us to some extent because the process that we had been doing at that time has advanced. Such is the case that after the pandemic, we entered the process of formalization, as has been happening.