


Article

Chincheró as Tourism Hub and Green Corridor as a Social Integrator in Cusco Peru 2023

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Abstract: This research focuses on the proposal of a corridor design that allows social and ecological integration in the context of a city with emerging potential as a tourist destination in Chincheró, Cusco. Key challenges addressed include lack of infrastructure to manage growing tourism demand, fragmentation of social identity, displacement of the local population due to gentrification processes, uncontrolled urban sprawl, and inappropriate exploitation of natural, cultural, and agricultural lands. To address these issues, a comprehensive diagnosis was carried out covering various urban-environmental dimensions, such as topography, road infrastructure, archeology, climate, and biodiversity. In this process, digital tools such as Blender, AutoCAD, Photoshop, and Affinity Designer were used. As a result of the analysis, an urban green corridor is proposed consisting of seven sectors covering the shores of the Piuray lagoon, the city center, and its archeological area, through the creation of socially active public spaces equipped with cultural, sports, and recreational facilities. The city of Chincheró, with its growing importance as a tourist destination, presents the opportunity and the need to develop a controlled urban development axis that promotes the connection between environmental, cultural, archeological, social, and tourism aspects. This objective is materialized in the form of a green corridor that seeks to promote social integration and a sense of territorial belonging.

Keywords: green corridor; social integration; tourism hub; sense of belonging; sustainable urban development



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1. Introduction

The construction of a new international airport presents a duality of effects on the urban development of a city. On the one hand, it acts as a node of growth and concentration of activities, generating significant opportunities. However, on the other hand, it brings with it new demands for services and urban growth, which in turn implies risks in social, economic, environmental, and cultural terms [1]. This phenomenon has manifested itself in various parts of the world. For example, in the case of Canberra International Airport, Australia, its development triggered social conflict related to noise pollution and challenges in land use decision making [2]. Likewise, in the development and rehabilitation of the Athens International Airport, it was observed that the creation of green areas and public spaces increased property values [3]. The new Chincheró Cusco International Airport (AICC) is a case of interest in this context. This airport, which will replace the Alejandro Velasco Astete Airport, has the potential to turn the city of Chincheró into a major national and international tourism center, even surpassing the number of tourists that traditionally travel from Lima [4]. However, it is important to note that Chincheró, with its current population of 10,477 inhabitants, mostly engaged in rural activities [5], is not prepared to receive the projected influx of tourists after 2025 [4]. This situation poses a dilemma, as

the immediate response could lead to urban sprawl without adequate planning. While it could address immediate needs, it runs the risk of failing to address long-term sustainability and resulting in inappropriate land use that would be difficult to reverse or remedy [6]. However, the growing tourism demand also represents a challenge and, at the same time, an opportunity for the city that will host the airport, with the potential to become a major tourist center [1].

A “tourism hub” is defined as a city that experiences a massive influx of visitors, which opens new opportunities for the provision of tourism services. This phenomenon not only enriches the economy, but also has a positive impact on the social and cultural aspects of the city, in addition to generating synergies with the surrounding tourist attractions [7]. An example of this is on the west coast of the Korean peninsula, where the development of a tourism belt is being considered with the aim of catering to potential Asian tourists and becoming a recreational epicenter in the East Asian region [8]. According to a European study, for a tourism hub located in rural areas to be effective, it is important that it is connected by road no more than 30 min away [7]. In the case of Cusco, a substantial increase in tourism activity has been observed between 2001 and 2010, surpassing even the tourism activity of Lima and the average for Peru as a whole [9]. All this leads to the consideration that the city of Chinchero is on its way to becoming an outstanding tourist hub in the future, receiving a massive flow of tourists directly.

It is relevant to note that the district of Chinchero is one of the few district municipalities in Peru that has an Urban Development Plan (PDU), with only 30% of municipalities nationwide having a similar plan [10]. However, despite the existence of this plan, a construction “boom” has already begun in Chinchero, motivated mainly by opportunism in the valorization of land for profit, rather than by the search for sustainable urban development [11]. In this sense, urban growth, despite having an Urban Development Plan (PDU) with a vision towards 2028, has been uncontrolled and has resulted in the degradation of natural, cultural, and agricultural soils, in addition to the loss of local identity due to the growing internationalization of the city [12]. Thus, the challenges identified in Chinchero are multiple and pressing. First, there is a clear lack of infrastructure capable of accommodating the projected tourism demand, which poses a threat to the sustainability of urban growth in the area. This lack of infrastructure is also reflected in minimal social integration and the displacement of the local population due to gentrification, itself promoted by real estate speculation.

Effective intervention and coordination between local and central government are essential to ensure the successful implementation of the plan approved by the Ministry of Housing, Construction and Sanitation (MVCS) [12]. In this context, it becomes imperative to carry out a project of innovative public spaces that promotes urban, social, and green integration, and that is worthy of a city with aspirations of becoming a tourist hub. This project should not only function as a reference point, but also as a roadmap for public management, with the objective of ensuring sustainable urban growth and promoting social integration in an appropriate manner.

Also, the preservation of local identity becomes a fundamental element to promote social integration in the area. Establishing a solid connection between local inhabitants and the city is essential to avoid their displacement due to urban sprawl. Local citizens’ sense of belonging to their public spaces is based on the ease of participation and shared use of these places [13]. Therefore, the promotion of local identity and the connection between the community and its urban environment should be considered as an integral part of the innovative public spaces project to ensure effective social integration in Chinchero.

However, in the urban area of the Chinchero district, the presence of contamination has been observed around the meanders and canals, as well as a significant accumulation of solid waste in these places (Figure 1). Nine critical points of contamination and three critical points where solid waste is dumped have been identified [14]. This situation of pollution and improper waste management not only affects the natural environment, but also undermines the community’s sense of belonging to their public spaces. To effectively

address these challenges, comprehensive measures are required to promote environmental conservation, active community participation and the revitalization of local identity as a fundamental part of social integration in the Chinchero district. (Figure 1)



Figure 1. Environmental contamination points in the urban area of Chinchero.

In addition, some of the impacts that arise in situations where roads present problems and there is a lack of public green areas are addressed. Poorly maintained roads can lead to increased emissions of greenhouse gases and other air pollutants. This is due to slower vehicle traffic and congestion on the roads [15]. The cities with the highest concentration of carbon dioxide in Peru are Arequipa, Cerro de Pasco, Chiclayo, Chimbote, Cusco, Huanayo, Ilo, Iquitos, La Oroya, Lima–Callao, Pisco, Piura, and Trujillo, with Cusco being the fifth city with the highest concentration of CO₂ in its atmosphere [16].

On 9 December 1983, in Paris, UNESCO declared the city of Cusco as the Cultural Heritage of Humanity, which is why it is one of the largest tourist destinations in Peru. This makes its inhabitants play a significant role in the care of their environment and the authorities regulate the circulation of certain motorized vehicles that emit excessive GHG (greenhouse gases), as they would be the major pollutants (Table 1).

The lack of public green areas can also contribute to increased air pollution, as plants play a crucial role in reducing pollutants in the environment [17]. As a result, air pollution caused by poorly maintained roads and lack of public green spaces can increase the risk of respiratory and cardiovascular diseases. In addition, insufficient public green space can increase the likelihood of stress-related diseases and lack of physical activity, such as obesity and diabetes. These deficiencies negatively affect the quality of life of urban residents, since green areas provide spaces for recreation, exercise and contact with nature [18]. On the other hand, roads in poor condition not only increase travel times and traffic congestion, but also lead to higher maintenance and repair costs. This, in turn, can have a negative impact on a city's budget [19]. These factors highlight the close relationship between road quality, the presence of green spaces, and the quality of life in urban areas, as well as the challenges faced by planners and local authorities to effectively address these issues.

Table 1. Emissions levels, according to activity category for the Cusco Air Basin (Ton/year).

Activity	PM ₁₀	SO _x	NO _x	CO	VOC	Pb
Solvents and paint	0.0	0.00	0.00	0.00	282.83	0.00
Food manufacturing	664.2	0.00	0.00	0.00	0.00	0.00
Sawmills and carpentry	3.8	0.00	0.00	0.00	4.57	0.00
Printers	0.0	0.00	0.00	0.00	1.71	0.00
Brick making	1067.3	7.96	55.75	5574.44	1831.93	0.00
Use of boilers and heaters	0.7	26.63	6.45	3.77	1.41	0.00
Rotisseries	38.3	0.78	2.08	132.27	41.62	0.00
Bakeries	134.3	5.41	13.37	1252.94	526.68	0.00
Fuel sales	0.0	0.00	0.00	0.00	135.67	0.00
Vehicular transport	148,989.4	605.33	2437.47	6848.87	1264.94	30.26
Air transport	5.0	7.60	72.00	0.00	103.40	0.00
Laundries	0.0	0.00	0.00	0.00	112.80	0.00
Houses	650.2	45.89	97.41	3944.96	1994.69	0.00

An effective strategy to address a city's accelerated growth and at the same time mitigate its ecological problems is the implementation of green corridors. These corridors consist of sets of ecological public spaces that intertwine in a systemic way, crossing significant sectors of the city. Based on the experience of the "Milan South Agricultural Park", the fundamental objectives of a green corridor include the following: (i) the protection and restoration of landscape and environmental aspects in the transition zone between the urban and rural environment, as well as in the peripheral areas that are linked to the urban green space system; (ii) the promotion of ecological balance in the metropolitan area; (iii) the preservation, qualification, and strengthening of agricultural and livestock activities, in accordance with the particularities of the region; (iv) the promotion of cultural and recreational enjoyment of the territory by citizens [20].

Considering these fundamentals, the creation of a green corridor in the heart of Chinchero will not only contribute to protect the archaeological center of the city but will also act as an essential link between areas of high tourist interest, such as the city of Cusco, Urubamba, Ollantaytambo, and Aguas Calientes [12]. This strategy not only provides ecological and cultural benefits, but also has the potential to improve the quality of life of Chinchero's residents and strengthen its role as an attractive tourist destination in the region.

The objective of this research is to propose a green corridor design as an integrating element of ecological character, in response to the potential of the city of Chinchero as an emerging tourist hub [21]. Regarding the social dimension, integration is materialized through the creation of socially active public spaces, preferably dedicated to leisure and recreation activities, which will have cultural, sports, and recreational facilities [22].

2. Literature Review

Urban ecology emerged in the 1970s as a subdiscipline of ecology to study human impact on urbanized landscapes, and much of the research is conducted at the regional level, primarily by ecologists [23]. Currently, there is growing collaboration between urban ecologists and urban planners, which is leading to the integration of ecological concepts in urban planning to address issues related to climate change and the management of the urban environment. In that sense, urban planners are interested in applying ecosystem-based knowledge, such as ecosystem services and urban resilience, in their practices [24].

Over the past 20 years, there has been significant growth in the development and application of green infrastructure (GI) or nature-based solutions (NBS) planning in decision making and urban planning globally [25]. Green infrastructure (GI) planning addresses the environment as an integrated system that includes built, natural, and social aspects, with a holistic and systemic approach [26]. Thus, it is concluded that interdisciplinary and integrative approaches are required to establish functional feedback between ecological

and social systems, taking advantage of various sources of information and knowledge from multiple fields of study.

Specifically, green infrastructure (GI) is used at the regional level primarily as a conservation planning strategy to improve the interconnectivity of green hubs [27], while at the urban level, it focuses on multifunctionality and the distribution of ecosystem services. However, there is a lack of a clear definition of green infrastructure (GI) planning and how it can be integrated into urban planning. Consequently, greater effort is required to prioritize the integration of green infrastructure (GI) in urban planning and give ecological resources the same importance as other urban infrastructures. Therefore, it is important to highlight that this urban green infrastructure (UGI) planning strategy has the potential to improve urban landscape planning by providing a comprehensive understanding of how socio-ecological systems function. Urban green infrastructure (UGI) planning, by generating diverse ecosystem services and taking a proactive and multidisciplinary approach, strengthens our capacity to address climate change at the urban level [28].

GI can be defined in various ways to include a wide variety of types of green spaces and natural areas, such as protected green corridors, parks, urban forests, and woodlands [29], which provide a series of ecosystem services for urban environments [30]. Most varieties of green infrastructure offer some level of regulation of ecosystem services, such as reducing stormwater effects, reducing urban heat, and mitigating pollution [31]. Furthermore, GI types such as urban forests and wetlands perform supporting functions, such as creating habitats for wildlife [32]. Most of these GI variants also provide cultural services that are interconnected. For example, bio-retention facilities and rain gardens not only contribute to stormwater management, but also add aesthetic value and educational opportunities for visitors [33].

In this sense, green corridors, as a key tool in urban planning, play a fundamental role in managing the growth of cities. These corridors are designed by establishing protected green zones that surround the urban core with the purpose of limiting urban expansion, safeguarding the natural environment, and maintaining a clear distinction between urban and rural areas [20].

On the other hand, tourism hubs play a fundamental role by acting as main centers for tourism activities and services. Their objective is to attract many tourists, both domestic and international, and to stimulate economic development through the tourism industry. The creation and development of a nationwide tourism hub requires effective coordination between various levels of government, private sector stakeholders, and community groups [7]. A focus on social integration is essential to foster inclusive and cohesive communities in urban environments. This implies guaranteeing equal access to resources, opportunities, and social networks, regardless of social origin. This goal is achieved through community participation, affordable housing policies, an efficient public transportation system, and the development of mixed-use areas that promote interaction among diverse groups [13]. In addition, the importance of strengthening urban residents' sense of belonging, which is defined as the emotional connection that people feel with their urban environment and their identification with the local community, is highlighted. This feeling is influenced by factors such as architecture, urban landscape, and public spaces. Improving this link with the community can have a positive impact on quality of life, social cohesion, and community engagement in urban planning and development [13].

Finally, the importance of sustainable urban development as an alternative to disorganized and destructive urban growth is emphasized. It focuses on achieving balanced and planned growth that meets current needs without compromising future generations. This is achieved through policies and practices that promote sound land management, sustainability in the use of natural resources, sustainable mobility, green building, proper waste management, protection and conservation of cultural and natural heritage, and citizen participation in planning and decision making [1].

3. Materials and Methods

3.1. Methodology

The design of urban green corridors requires an approach that encompasses environmental, urban, and landscape aspects, and this must be addressed by multidisciplinary technical teams in charge of unifying the different perspectives of the territory (Figure 2).

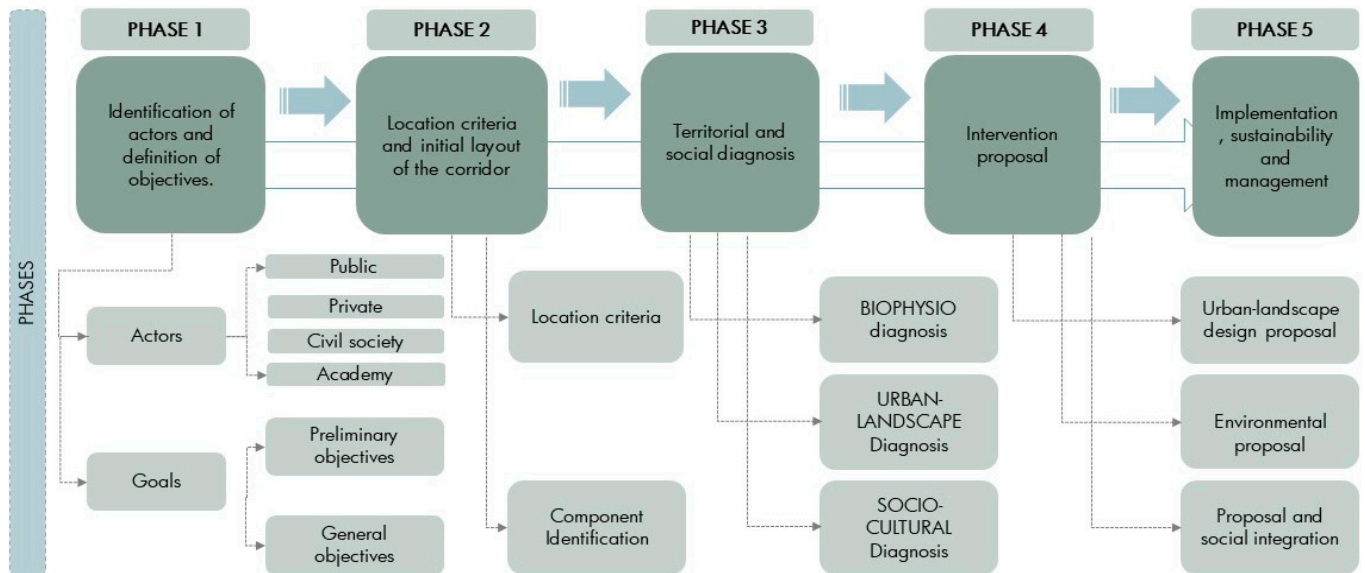


Figure 2. Methodological research process [34].

These perspectives, together with the needs of the residents and main users, must be amalgamated to give rise to a project that generates benefits from both an environmental and socio-cultural perspective. It is essential to recognize the new planning paradigms that seek to orient efforts towards the study of the various ecosystem processes of a city, the ecosystem services linked to these processes, and the variation in the quality and quantity of ecosystem supplies derived from land use in the territory. In this context, natural or semi-natural ecosystems can play a vital role in resolving issues related to climate change and its effects on the territory through the following stages:

1. Identification of key stakeholders and definition of objectives.
2. Establishment of criteria for the location and initial layout.
3. Territorial and social diagnosis.
4. Intervention proposal.
5. Implementation, sustainability, and management.

3.1.1. Identification of Key Stakeholders and Definition of Objectives

To begin the project, it is essential to conduct a preliminary identification of the possible objectives, general guidelines, and the problems to be addressed by the introduction of green corridors in the urban environment. These objectives will serve as the basis for the first sketches of the location of the urban green corridors and, at the same time, will facilitate the identification of key actors that can participate in the initiative. This in turn will allow the formation of strategic alliances to support the various stages of the planning and execution process. Regarding the identification of relevant stakeholders, it is essential to conduct a stakeholder mapping process that includes both public and private entities, and civil society organizations and academic institutions. This is intended to involve these stakeholders in the distinct phases of the project, from planning to execution and maintenance.

3.1.2. Establishment of Criteria for the Location and Initial Layout

In this step, the purpose is to recognize the areas that will integrate the green corridor and, consequently, to define its route. To carry out this task, it is essential to consider the vision and objectives previously established in the previous stage, as these will guide the strategies that will be implemented to achieve various goals, such as improving connectivity between public spaces, containing urban sprawl, optimizing relations between neighborhoods, and creating corridors for biodiversity, among other aspects.

- Spaces that are part of public green areas

We proceed to locate and recognize green spaces and public areas within the city. To conduct this process, it is advisable to resort to planning documents containing maps and data related to preservation and conservation areas, urban green spaces, parks, and public areas of different dimensions, such as neighborhood, zonal, and urban.

- Spaces that allow for the integration and enhancement of natural resources

We proceed to recognize the connecting elements, both natural and those altered by human intervention, which are present in the city. To conduct this process, it is necessary to have maps related to road infrastructure, pedestrian routes, and watercourses, as well as knowledge of native flora and fauna.

- Spaces that allow the articulation of existing urban projects and/or those planned by the government.

Connectivity and the ability to perform multiple functions are essential aspects that characterize green corridors. Therefore, urban projects considered strategic because of their importance in terms of tourism, entertainment, or other reasons are examined on the maps. It is important to note that, both to define the corridor route and to establish the location criteria, in addition to using cartographic information, additional tools are used, such as satellite images, aerial photographs obtained by drones, and geographic information systems (GIS). These software programs facilitate the analysis and creation of thematic maps in an efficient manner.

3.1.3. Territorial and Social Diagnosis

Once the areas that will make up the urban green corridor have been identified, the first step is to diagnose the area in which to be intervened. This process will be developed based on three fundamental axes: biophysical, urban landscape and social, which will make it possible to identify not only the components that make up these areas, but also the dynamics that develop in them.

- Diagnosis of the biophysical environment

In the analysis of the biophysical component, it is essential to recognize the significant characteristics of the physical and biological elements in the territory. This should start with a general assessment, considering the city environment, and then focus on the sections selected for corridor creation.

- Diagnosis of the urban and landscape environment

Urban green corridors are developed within the context of cities; therefore, it is vital to understand the urban characteristics of the area in which to be intervened. This includes the evaluation of public green areas, roads, trails, signage, and existing facilities, as well as the identification of future projects planned by the local government. This information is essential to determine the corridor route and the elements that will be part of the comprehensive proposal.

- Socio-cultural diagnosis

Given that the population is the main beneficiary of the implementation of green corridors, it is essential to identify the main characteristics, economic activities, and cultural identity of nearby communities.

3.1.4. Intervention Proposal

Once the diagnostic phase has been completed, the framework of the general strategies that will guide the development of the urban green corridor proposal will be established. This is carried out to ensure that the interventions are supported by the previous studies and respond to a comprehensive vision. In addition to the general strategies, it is suggested that the proposal be based on three fundamental axes: the urban landscape aspect, the environmental approach, and integration with society.

3.1.5. Implementation, Sustainability, and Management

Urban green corridors are green infrastructure projects that have a significant impact on urban planning. This is because they contribute to the creation of axes that prioritize non-motorized mobility, the promotion of biodiversity in urban environments, the protection of watercourses (such as river and stream margins), the creation of protected natural areas, and the creation of urban spaces with recreational areas for the enjoyment of the population.

3.2. Actors Involved in the Design of a Green Corridor

The Chinchero tourist hub and green corridor proposal was developed as a commitment on the part of different actors within the city, as well as a tool for local development.

Actors Involved in the Proposal

The stakeholders involved in the proposal aim to acquire a deeper understanding of the actions they are conducting and the objectives they pursue by being present in the territory, as well as their short-term vision. The use of the social map is essential to represent and understand the complexity of the social reality in which the intervention will take place, providing a more solid basis than simply relying on common sense or the opinion of a qualified informant. This tool is considered crucial in the process of project design and execution, as well as in the negotiation and joint construction of urban development proposals. In this sense, the stakeholder map will play a key role in identifying alliances, conflicts, and authoritative voices in the community, which facilitates the appropriate selection of stakeholders to be targeted at specific times.

The classification of actors is as follows:

- Public institutions: District Municipality of Chinchero, Peruvian National Police, health center, Regional Culture Directorate, and educational institutions.
- Functional grass-roots social organizations: soup kitchens, milk banks, sports, cultural and/or folkloric associations, etc.
- Territorial social organizations: peasant communities and citizen participation.

3.3. Place of Study

The study site is in Peru, specifically in the department of Cusco, within the urban area of the district of Chinchero (Figure 3a–e). Near the intervention area is the new Chinchero Airport, in which construction is scheduled to be completed in 2025 [35], as well as the Chinchero archaeological zone (Figure 3e).

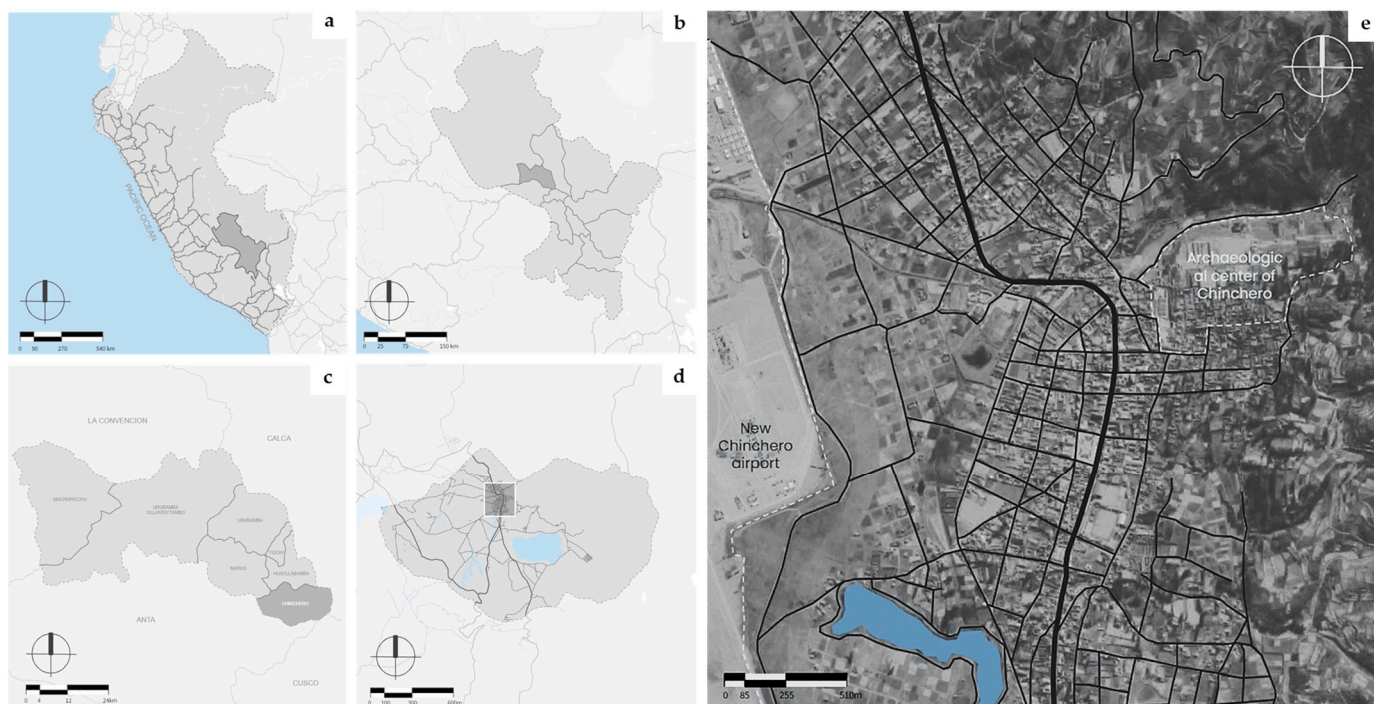


Figure 3. (a) Map of Peru, (b) map of the department of Cusco, (c) map of the province of Urubamba, (d) Chinchero district map, (e) map of the urban area of the Chinchero district.

3.4. Diagnosis of the Territory

3.4.1. Urban Analysis

- Road analysis

In Peru, the road network is divided into several categories, including trunk roads, secondary roads, tertiary roads, and residential roads [36]. The trunk road is the highway that connects the city of Cusco with the city of Urubamba, and Chinchero is in the center of this main route. Secondary roads connect with relatively distant communities, while tertiary roads connect with nearby population centers. On the other hand, residential roads delimit the most urbanized areas of the city, and most of these roads are in poor condition. This situation, coupled with the lack of public green areas in the city, can have multiple negative effects on the quality of life of its inhabitants, as well as on their health and the environment [37].

The main road that crosses the urban area of Chinchero has a length of 6.245 km and is categorized as an unpaved road: Gravel [38] (Table 2, Figures 4 and 5).

Table 2. Characterization of the Chinchero highway.

Code	Typology	Length	Surface
PE-28J Emp. PE-28F (Chinchero)	National road	6.245 km	Affirmed

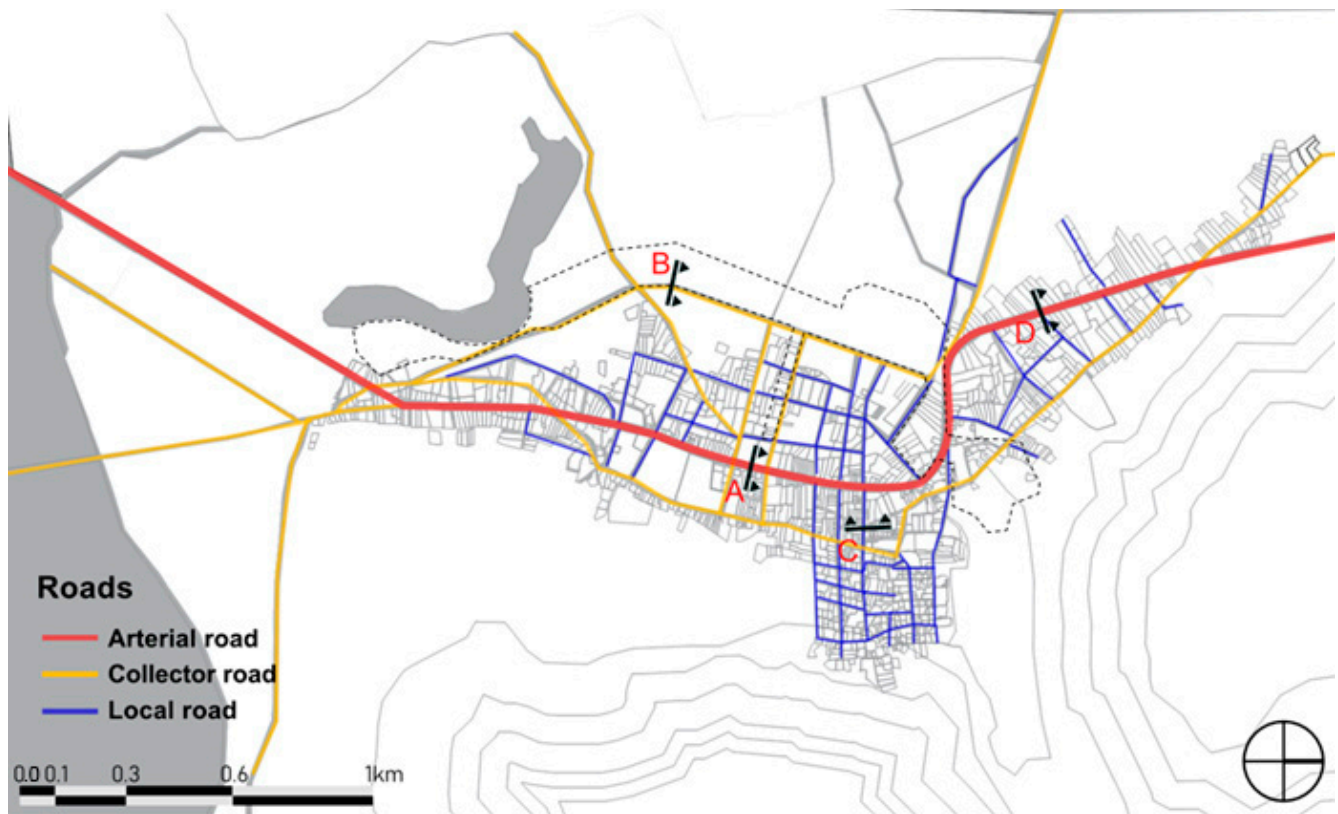


Figure 4. Road system of the urban area of Chinchero.

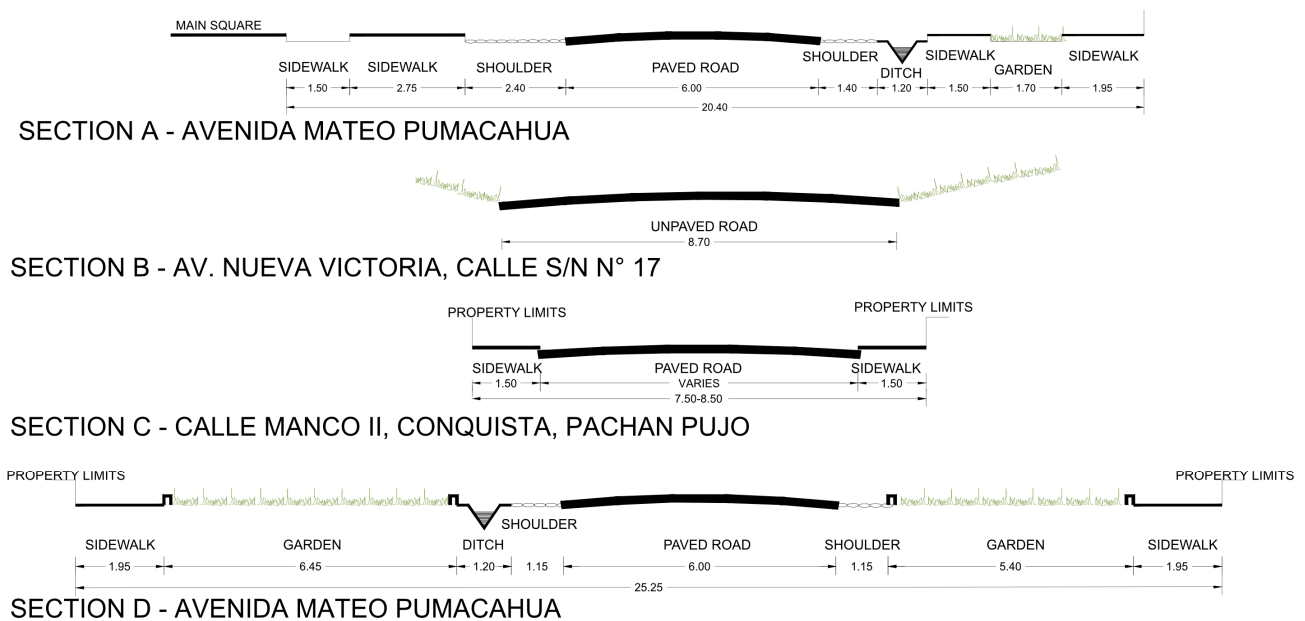


Figure 5. Road closures on the Chinchero highway.

With the construction project of the new Chinchero airport, improved road interconnection conditions are expected, enhancing access to roads that connect different regions with the new Chinchero airport to promote tourist destinations [39].

To achieve this, the COPESCO Plan (translates to Special Commission for Coordinating and Supervising the Cultural Tourism Plan Peru – UNESCO) has undertaken road improvements, among other discussed aspects, to coordinate the development of technical project documents for the initiative aiming to enhance the transitivity of interurban roads

and the service on the stretch of the national road Pe-28 J, CPP Sencca Quispihuara—Huila Huila in the districts of Poroy, Cachimayo, and Chinchero in the provinces of Cusco, Anta, and Urubamba. This project will improve the transitability connecting Cusco with the Chinchero airport, passing through the Poroy and Cachimayo sectors, and the district itself by the Piuray lagoon. It was noted that this project covers a 15 km stretch with asphalt. Additionally, it has been proposed for the regional road hierarchy due to its significant connectivity [40].

- Land use

Nearly half of the city is housing, while the other majority comprises empty lots. There seems to be a few sparsely distributed commercial businesses. Also, the Historic Center and the Archeological Park are the biggest anchor of attention, while the Education facilities comprise the biggest one-piece lot in the city.

The provision of educational services in the district is affected by the significant movement of students from rural areas to urban centers and the presence of schools at all levels. Thus, the district's 2015 educational system comprises 62 educational institutions as part of its infrastructure [41].

Within the health services, CLASS Chinchero (translates to Local Health Administration Communities), the Ocutuán health post, and the Huaypo health contingency are the identified facilities. Co-management with the community is the strategy used by these establishments to improve the quality and coverage of first-level care services. However, the state of infrastructure and equipment is still insufficient in meeting the needs. Parameters established by technical standards are also disregarded, contributing to the deficiency in human resources.

Regarding security services, Chinchero has a police station that addresses the frequency of crimes, with the perception of insecurity in the district reaching 50% of the population.

On the other hand, leisure and sports activities are scattered between urban and rural areas. Sports courts and soccer stadiums are used for the organization of cultural and sports events, but they lack sanitary facilities, and the stadium is in poor condition. The indoor coliseum is another space used for the development of sports and cultural activities [42] (Figure 6).

In terms of basic service provision, access to sanitation, and quality, in 2014, 27.1% of water supply systems met the required minimum quality standards, while in 2007, 54.8% of water supply systems met the required minimum quality standards. Households have access to drinking water, 11.1% have sewerage connections, and 85% have electricity connections.

However, in urban areas, there was 100% connectivity 24 h a day. Currently, there is a shortage of nursing care in rural areas, and individuals can only receive care for 4 to 6 h a day, 4 to 7 days a week [43].

- Historic evolution and demography

This populated center has been around before the era of the Incas. And it was continuously lived in by the Incas, then by the Spanish colonizers, and after that by the Republic of Peru to this day. The city grows from east to west, starting from the archeological park valley to the historic center, to the east side of the road and then along the road from north to south [44] (Figure 7).

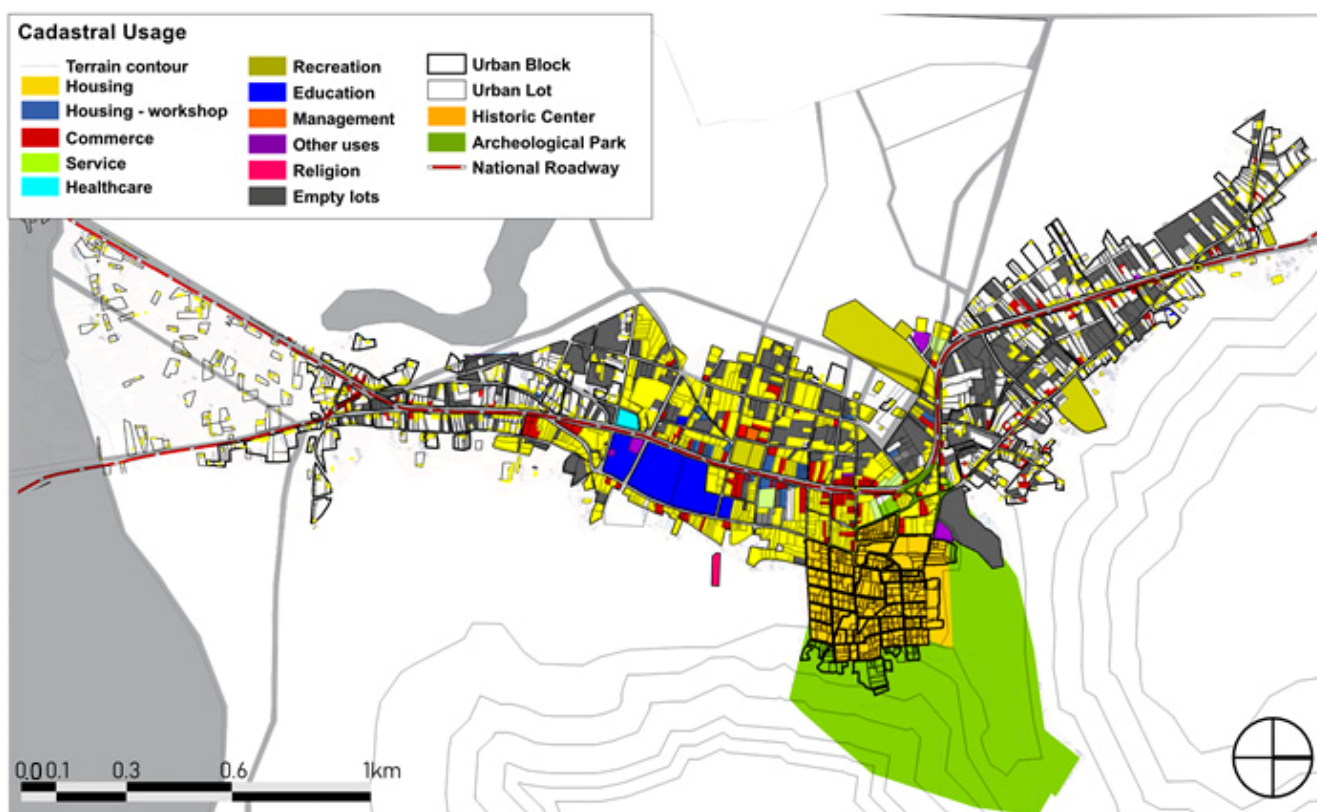


Figure 6. The usage of land in the urban area of the city of Chinchero. Map based on the Urban Development Plan of 2018 of the same city.

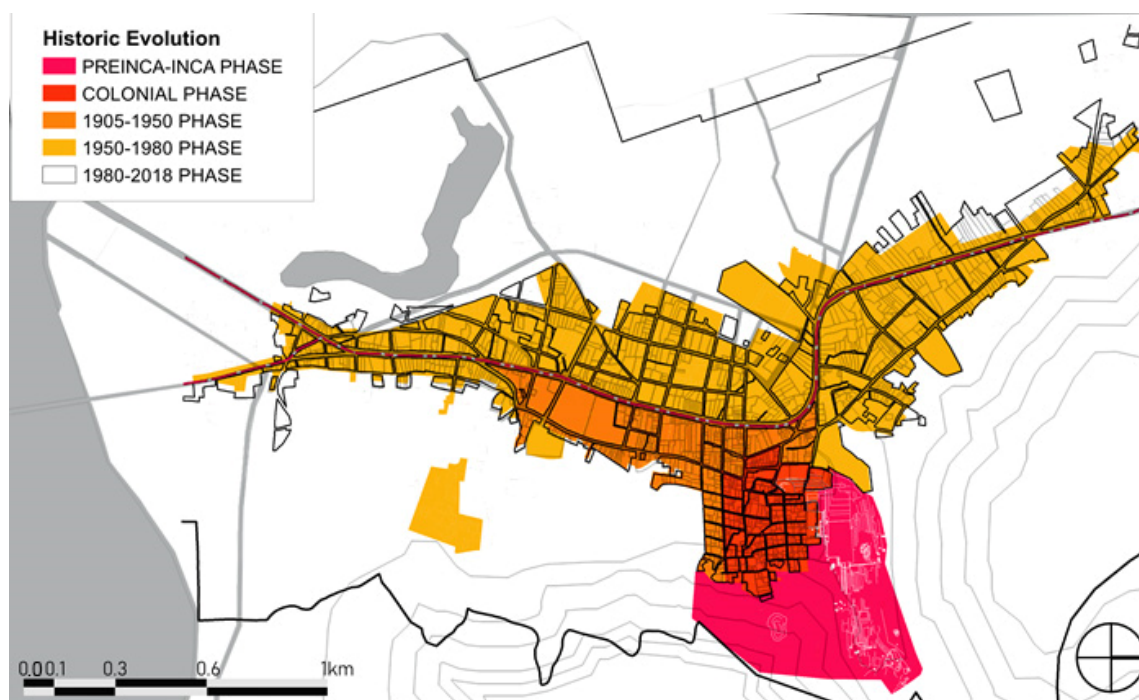


Figure 7. Evolution history of the Chinchero district.

Figure 8 The historic evolution of the city of Chinchero. Map based on the Urban Development Plan of 2018 of the same city.

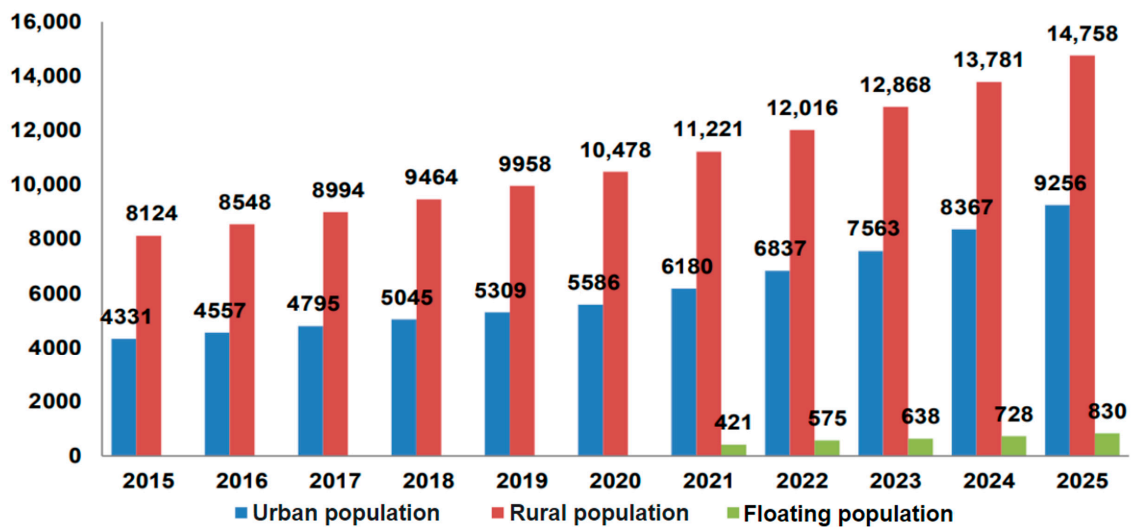


Figure 8. Population growth and projection of the Chinchero district.

The census results of 1981, 1993, and 2007, along with projections show significant population growth. By the year 2015, a total of 12,455 inhabitants were recorded, representing approximately 18.5% of the provincial total and 0.95% of the departmental total. Chinchero, between 1981 and 2015, has increased by 1.6 times, with an average annual population growth rate of 1.4% [42].

The population growth recorded in recent years and projections based on the new Chinchero airport project will bring migrations and tourism development, leading to population growth in the coming years. It is estimated that by 2025, the population of the Chinchero district will reach a total of 24,844 inhabitants, of which 37% will be urban, 59% rural, and 3% floating population. The growth is primarily driven by the construction and operation of the new airport, the consolidation of Chinchero as a tourist district, and the development of commercial, logistical, tourist, cultural, recreational, and agricultural activities as elements driving both urban and rural economies [42].

- Economic activities

Regarding the economic activities developed in the Chincheros district, one of the pillars supporting the socio-economic well-being is the productive, commercial, and service sectors, whose gross production value level, both agricultural and livestock, represents 29.2% and 36.6% of the provincial level, respectively.

According to the information provided in the Chinchero PDU 2016–2025, for the year 2008, the economic structure of the Chinchero district generated an approximate total of 56 million soles. This was mainly supported by the development of the agricultural (27.0%), construction (32.0%), services (32.0%), manufacturing (5.0%), and commerce services (4.0%). Similarly, the tourist activity in the Archaeological Park of Chinchero has allowed the creation of ventures such as handicrafts, involving a total of 654 artisans (mostly women), showcasing the cultural heritage through textiles that are currently marketed within and outside the district [42] (Figure 9).

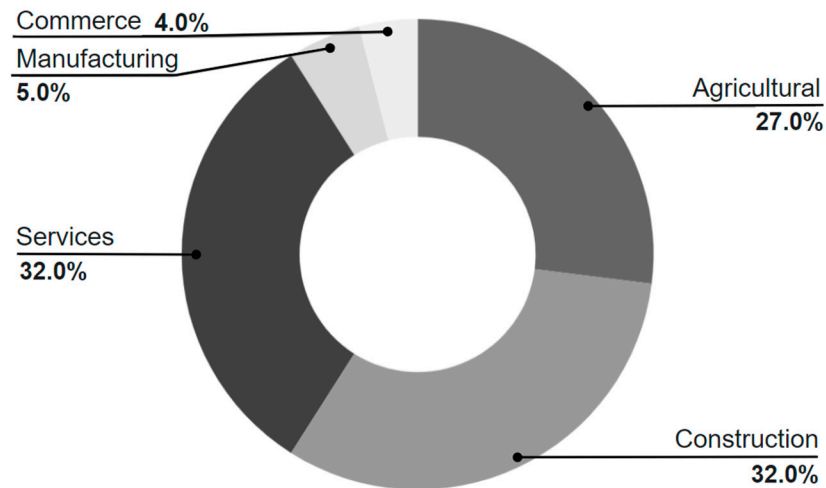


Figure 9. Economic activities district of Chinchero.

3.4.2. Climate Analysis

Temperature, humidity, and precipitation: A constant average is observed throughout the year, but during the winter season it shows extreme changes in cold and heat. This indicates that summer is characterized by cold but less fluctuating temperatures, and a very fluctuating winter with minimum temperatures reaching 0 °C. The relationship between relative humidity and precipitation versus normal direct solar radiation is inversely proportional. The periods of highest radiation, which is the winter (June to August), are the driest and least rainy periods, while the summer from December to March is rainy and humid. The greatest amount of rain comes in the summer, between December and March, with amounts of 3 mm on average (Figure 10).



Figure 10. Cont.

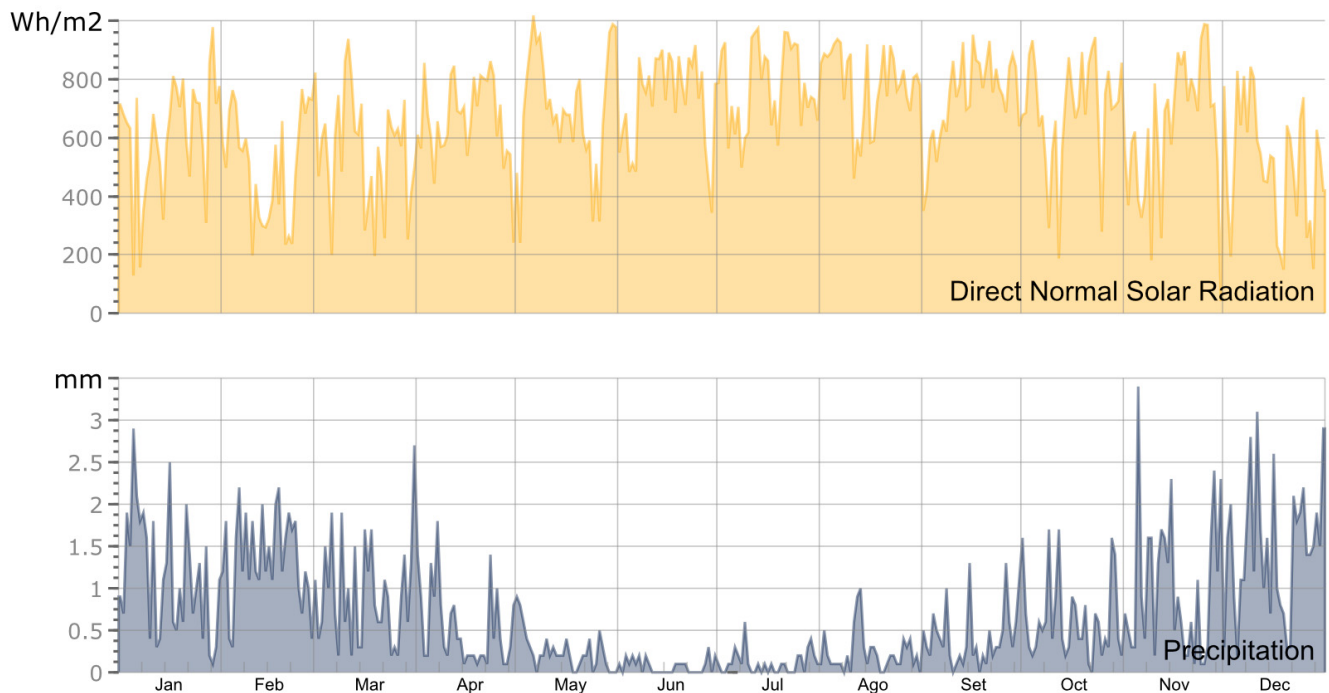


Figure 10. EPW-based meteorological data in dry bulb temperature, relative humidity, normal direct solar radiation and precipitation.

Solar radiation: The location of latitude 13.5° S indicates that the site is in the southern hemisphere, within the tropical belt. Therefore, a building will have greater solar gain on the roof than on its walls, and the sun will have a zenithal inclination from the north during the winter from March to September, and from the south during the summer from December to February.

Winds: Winds mostly come from the north, east, and west, both in greater frequency and in speed. Speeds are mostly light breezes. Twenty-four percent of the year is calm [45] (Figure 11).

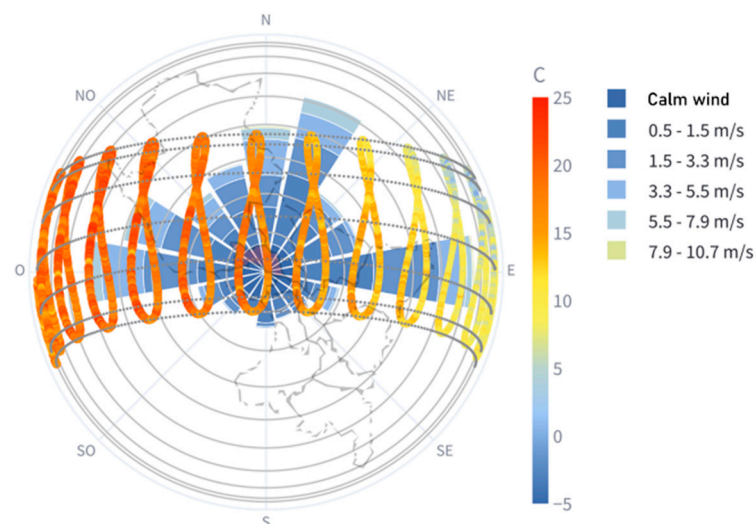


Figure 11. EPW-based meteorological data.

3.4.3. Flora

The flora of the area is characteristically highland centered, with small shrubs and shoots, but little tree density. Domesticated animals and agricultural flora have been excluded (Figure 12).

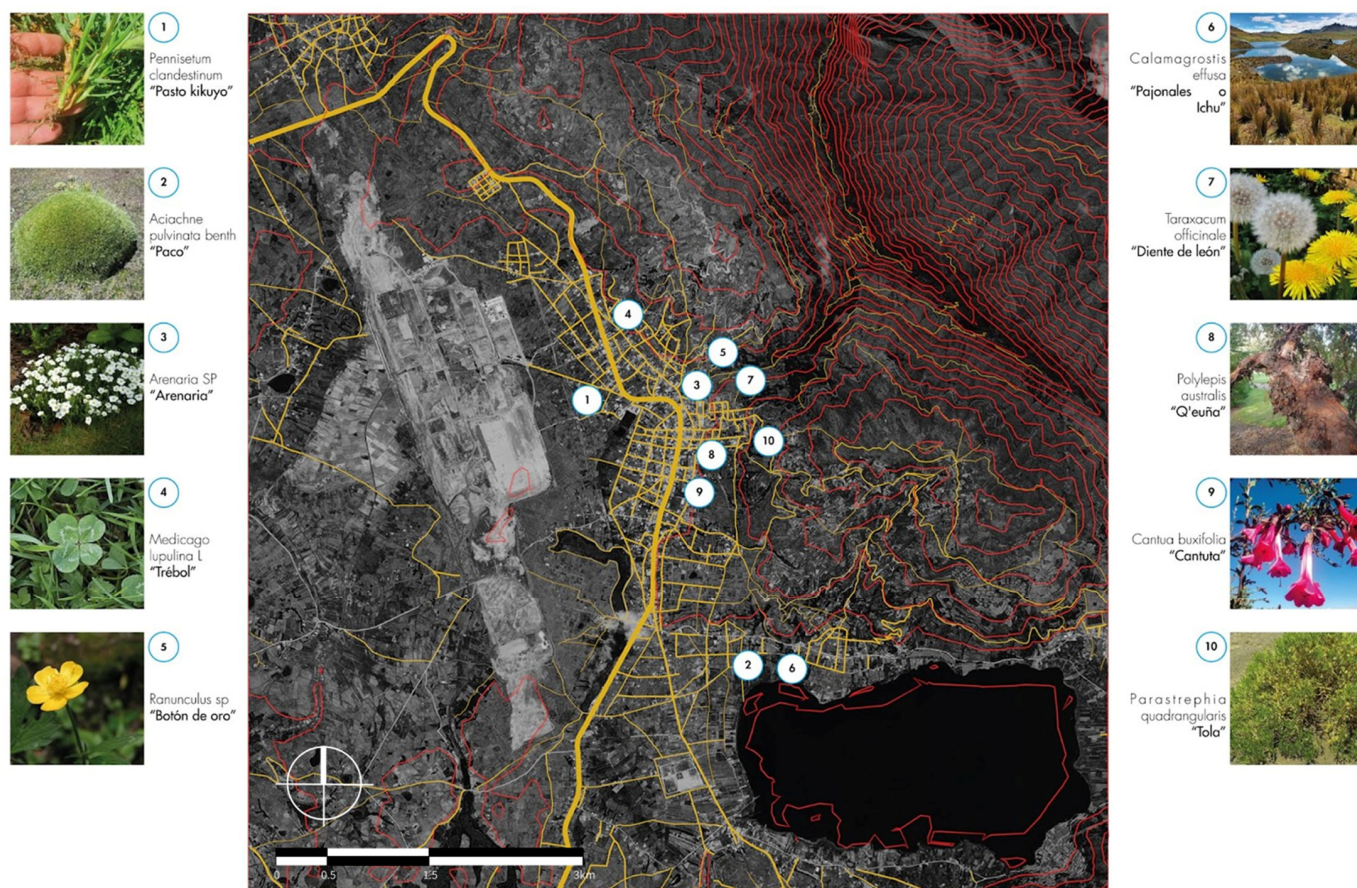


Figure 12. Distribution of flora in the intervention area, city of Chinchero. Latin nomenclature accompanied by local name.

3.4.4. Fauna

Chinchero is remarkably diverse in terms of its biological life due to its location in an ecologically high-altitude zone. A wide variety of grass species are found in this area, as well as at least sixty distinct species of Puna grasses. In addition, the area is home to a variety of birds found in the "bofedales" and hydromorphic environments. Water bodies in the area are also an important source of water for human consumption and livestock [12] (Figure 13).

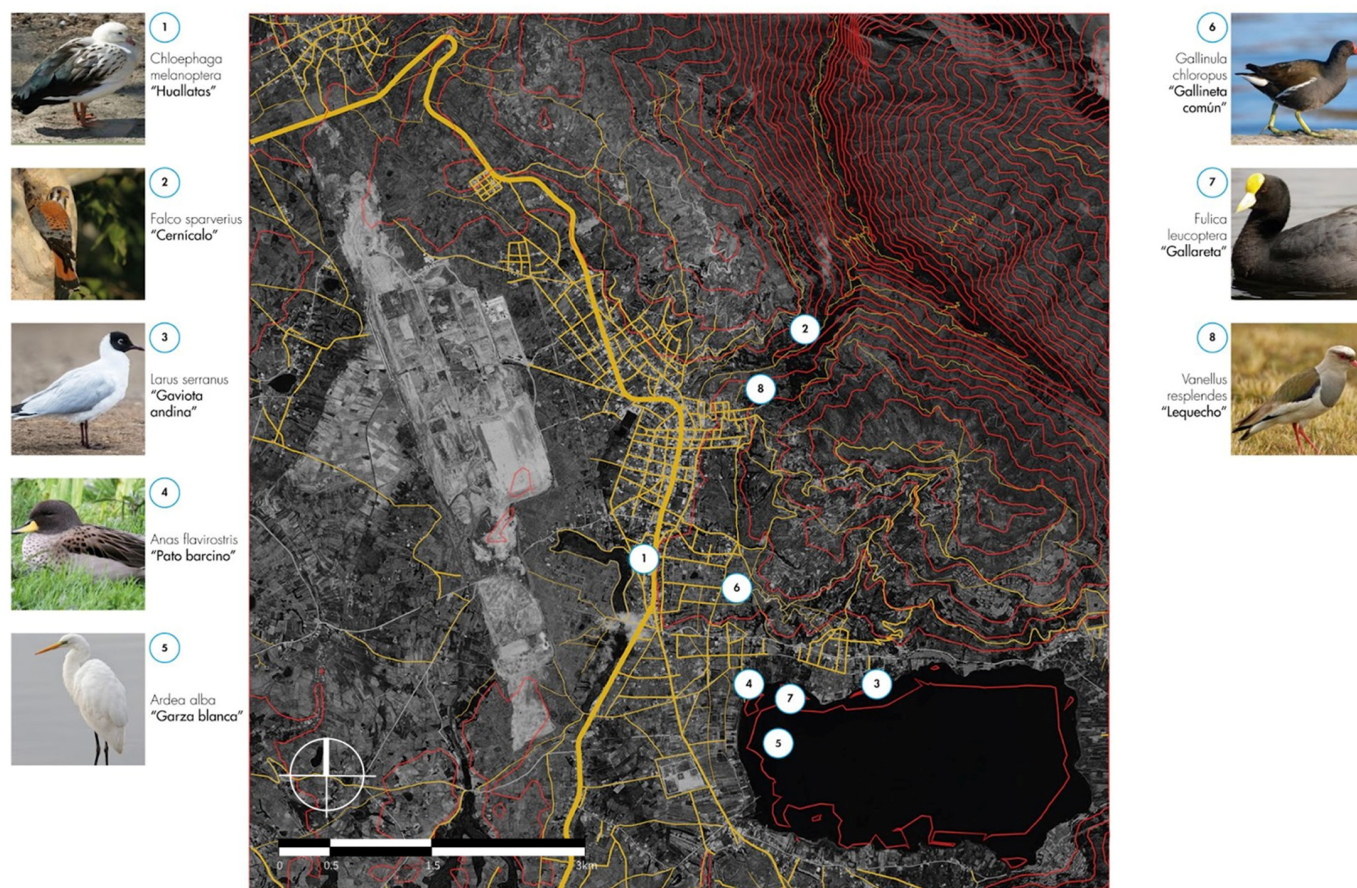


Figure 13. Distribution of fauna in the intervention area, city of Chinchero. Latin nomenclature accompanied by local name.

4. Results

4.1. Location

The proposal is in the urban area of the Chinchero district, which includes the Chinchero Archaeological Center with an area of 43.10 hectares and a perimeter of 2638.30 linear meters. This district is located 31 km from the city of Cusco [46]. In addition, this area includes the land where the new Chinchero International Airport is being built, which is scheduled to replace the Cusco International Airport in 2025 and covers an area of 875,518 m² [42]. An important water resource in the study area is Lake Piuray, which gives rise to springs and lagoons in the surrounding area [47]. These facilities, land, and resources have been considered in the proposal (Figure 14).



Figure 14. Location of intervention.

The proposal for the tourism hub and corridor covers an area of 2397.7 km². The design of the green corridor is based on the achievement of four fundamental objectives, which are closely related to the resources available in the city of Chinchero. The intervention is conducted in the urban area with the purpose of establishing a link that does not damage the existing heritage. These four objectives are as follows: 1) revalue and preserve, 2) revitalize, integrate, and activate. These objectives are aligned with the Sustainable Development Goals (SDGs) (Figure 15).



Figure 15. Goals of the project.

The proposal contemplates a landscaped route that runs parallel to the departmental highway that crosses Chinchero. This green corridor has two highlights at its ends: to the north is the Chinchero Archaeological Center and market, which has given rise to a heritage area, and to the south is an unnamed lagoon and wetland. The design of the route is organic and easy to interpret for local inhabitants, with curved paths inspired by the conceptualization of the Inca routes, using colors, symbols, and elements typical of this culture (Figure 16).



Figure 16. Conceptualization.

In this context, the proposal hugs the city from the west, serving as a green belt that acts as a barrier to prevent the expansion of the city to the west, where the land of the future Chinchero International Airport under construction is located (Figure 17). Within the proposal, four zones have been established according to their proximity to the facilities in the immediate surroundings, assigning compatible functions and uses. Urban and architectural proposals include the Alpaca Sanctuary, Textile Plaza, Municipal Stadium, the sport circuit, Biofair, Renewable Energy Capture Place, artificial wetland, the Interpretation Center, protective communities, and ecotourism piers.



Figure 17. Master plan.

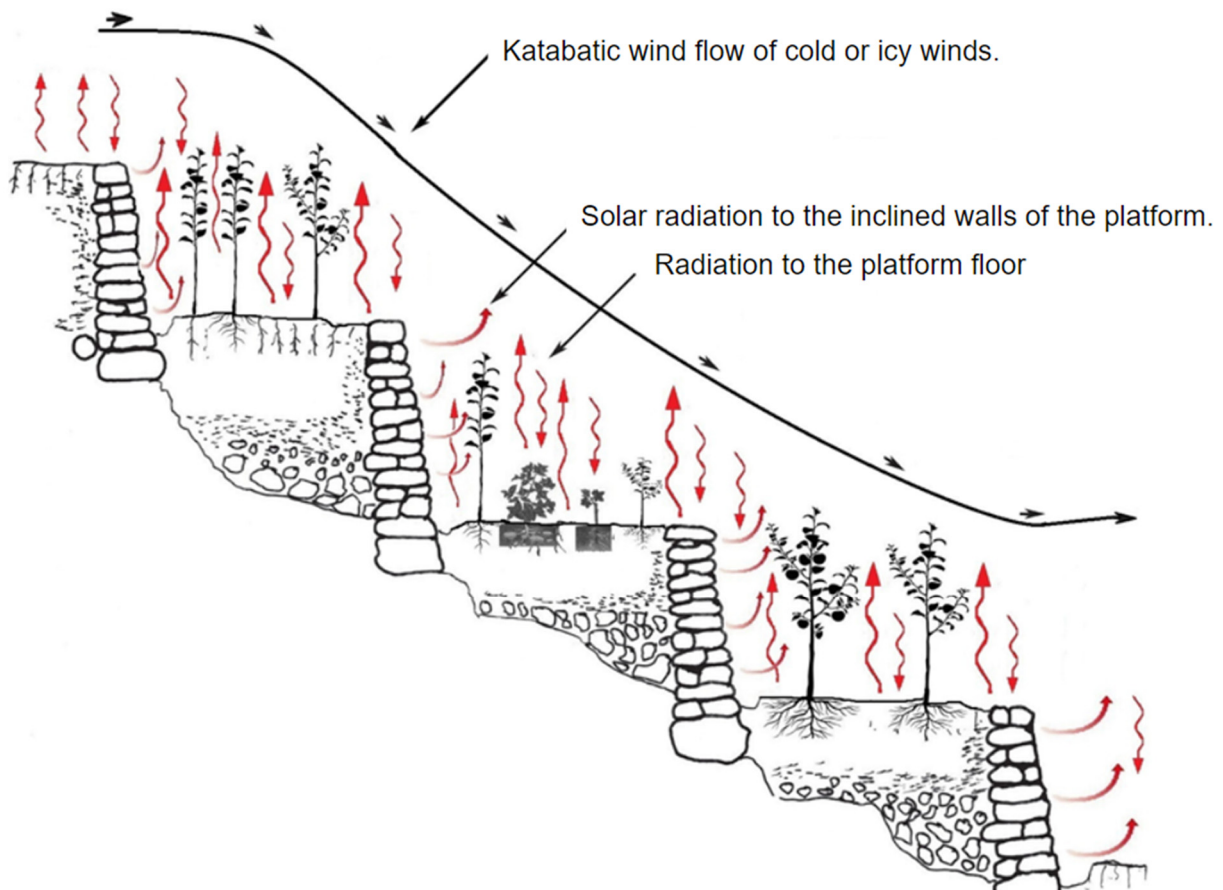
Mountain areas are extremely vulnerable to climate change, which poses significant risks in terms of water resources and has a direct impact on the development indicators of local communities and urban populations [48]. In the Andean region, precipitation patterns vary significantly with altitude, and one of the most notable effects of this change is the rapid decline in tropical glaciers [49].

To address the challenges of water scarcity, governments have sought to implement large-scale “gray infrastructure” interventions such as reservoirs, floodwalls, and river defenses. However, nature-based solutions, such as traditional engineering practices like terraces or terraces, have also proven to be effective options [50]. In Peru, community initiatives to improve water security range from wetland and forest conservation to the restoration of pre-Incan infiltration canals. The use of “andenes” and terraces has been highlighted as effective practices for water and soil conservation [51].

Chinchero is located at an altitude of 3762 m above sea level and is a highly productive city, as evidenced by the amount of farmland. Within the intervention area, the implementation of type 1 walkways (Table 3) [52] is proposed in three zones of the green corridor: the Heritage Zone, the Environmental Awareness Zone, and the Community Zone, all of which are adapted to the topographic characteristics of the surroundings (Figure 18).

Table 3. Platform typology.

Platform	Platform Profile	Retaining Wall	Irrigation System
(Type 1)	Horizontal	Inclined	Yes
(Type 2)	Horizontal	Vertical	Yes and no
(Type 3)	Inclined	Rustic	Generally not
(Type 4)	Without platform profile	Without retaining wall	Not

**Figure 18.** Platforming operation.

The Implementation of these “andenes” will serve several purposes. In the Heritage Zone, they will contribute to providing food for the Alpaca Sanctuary and may be used for studies and research and conservation projects, including soil conservation. In the Environmental Awareness Zone, they will help in the prevention of risks around the terraces. Finally, in the Community Zone, they will be aimed at guaranteeing agricultural production for local communities (Figure 18).

4.2. Master Plan

4.2.1. Patrimonial Zone

The main objective of the Heritage Zone, which covers an area of 56,691.8 m² at the northern end of the proposal, is to enhance the value of the Chinchero Archaeological Center. This will be achieved through organic elements that will be directly related to nearby facilities, such as the market and the site museum.

Within this area is the “Alpaca Sanctuary”, a natural esplanade with three levels of terraces where the alpacas will coexist in their natural environment. This space will serve as a refuge for these animals and will be near the “Textile Plaza”, where the tradition, process, and history of alpaca fiber, one of the most emblematic camelids of Chinchero, will

be highlighted. The strategic location of this textile plaza near Chinchero’s current best-known textile stores will allow visitors to obtain a close-up look at this tradition (Figure 19).



Figure 19. (a) Intervention radius of the patrimonial zone; (b) Alpaca Sanctuary, (c) Textile Plaza.

A bypass has been proposed to maintain the visual continuity of the land without affecting the vehicular flow of the departmental road. This structure is designed to create an open direction for pedestrian and transportation flow, interacting synergistically with the existing roadway without competing for space (Figure 20).



Figure 20. Bypass proposal.

4.2.2. Sport Zone

The creation of a “Sport Zone” has been proposed based on the need to refurbish the current municipal stadium, which lacks adequate facilities (Figure 21). The new infrastructure will be designed to accommodate 1200 people and will be oriented towards obtaining 70% of its light energy from the Environmental Awareness Zone. This sports area covers an area of 46,102.5 m².



Figure 21. (a) Current land condition, (b) current stadium condition.

In addition to the stadium, the creation of a sports circuit preceding the municipal stadium has been planned. The purpose of this circuit is to encourage the active participation of the community in various sports activities. It will include bike paths, yoga areas, picnic areas, and running tracks. The space is intended for public use and will promote a variety of sports, socio-cultural, and outdoor leisure activities. This approach seeks to encourage the practice of popular sports such as soccer, volleyball, and athletics, taking advantage of Chinchero’s altitude above sea level, a factor that Peruvian athletes also use in their training (Figure 22).



Figure 22. (a) Intervention radius of the Sport zone, (b) Municipal Stadium, and (c) sport circuit.

4.2.3. Environmental Awareness Zone

The Environmental Awareness Zone covers an area of 66,726.8 m² and consists of four main elements: Biofair, Renewable Energy Capture Place, artificial wetland, and an Interpretation Center (Figure 23a).



Figure 23. (a) Intervention radius of the Environmental Awareness Zone; (b) Biofair, (c) Renewable Energy Capture Place, (d) artificial wetland, (e) Interpretation Center.

Biofair

This proposal is located on a perpendicular axis to the green corridor and serves as a connector between the green corridor and the main square. It will function as a space for local use where villagers will be able to sell products from their gardens (Figure 23b).

Renewable Energy Capture Place

This space is located between the airport and the city and consists of a landscaped promenade surrounded by wide open areas. Its main function is to provide electrical energy through energy collectors. The energy collected can be used immediately or stored for future use through elements such as solar panels, wind energy generators, and artificial wetlands distributed throughout the landscaped walkway (Figure 23c).

Artificial Wetland

The proposal includes the implementation of artificial wetlands and microbial fuel cells (MFCs) for wastewater treatment and power generation (Figure 23d). These systems can operate independently or together.

Artificial wetlands are used to treat wastewater and improve process efficiency. They also make it possible to harness the electrical energy generated by microorganisms during the oxidation of organic matter [53] (Figure 24).

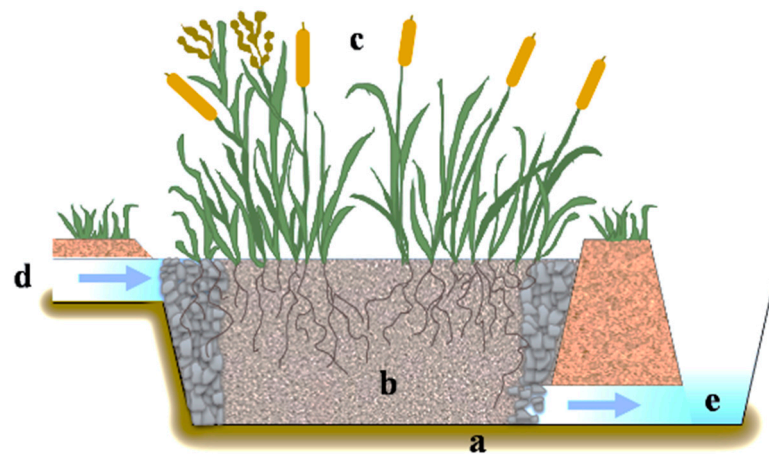


Figure 24. Components of an artificial wetland: (a) impermeable layer, (b) substrate or bed, (c) vegetation (macrophytes), (d) influent (wastewater), (e) effluent (treated water).

The generation of electrical energy in this process is based on the bacteria's ability to metabolize organic matter and produce electrons. In a natural system, these electrons are transferred to a natural electron acceptor, such as nitrates or oxygen [54]. However, in an electrochemical system of a microbial fuel cell (MFC), electrons are transferred to an external solid anode, which is connected to a cathode through an external circuit and a resistor. The movement of these electrons generates an electric potential difference, and upon reaching the cathode in the presence of an electron acceptor, such as oxygen, water is produced as the final product [55] (Figure 25).

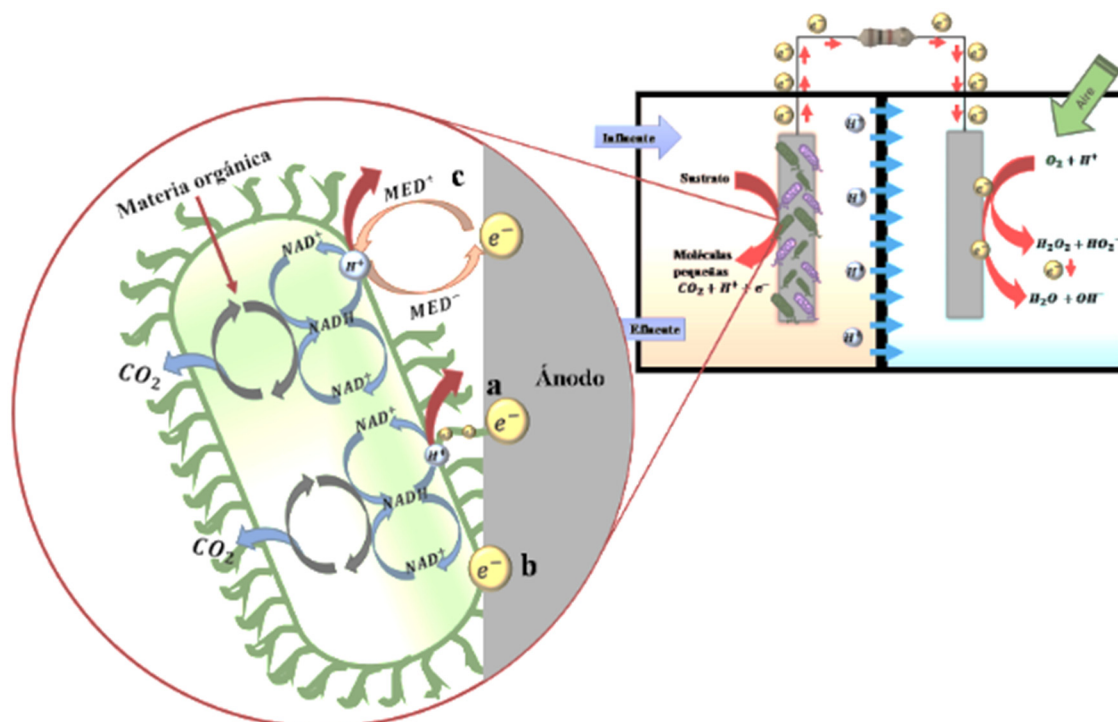


Figure 25. Structure of a microbial fuel cell: (a) anode chamber, (b) cathode chamber, (c) cation exchange membrane.

Interpretation Center

The proposed Interpretation Center aims to promote knowledge about Chinchero's native flora and fauna species and will serve as a place to conduct research related to energy harvesting in the area. In terms of materiality, the use of polished stone, wood, treated stainless steel structures, aluminum frames, native vegetation, gravel, and boulders as ground and paving material is recommended.

In terms of climatic design, greater protection against solar radiation is proposed through the creation of tree density and water bodies that allow evaporative cooling. The furniture and elements of the interpretive center shall be designed in an open manner to allow humid air to circulate and prevent the accumulation of moisture in enclosed areas. In addition, sloped or tensioned roofs will be installed to prevent moisture from accumulating at critical points and to allow controlled water flow to the drainage system in walkable areas.

4.2.4. Community Zone

In this area, which is characterized by its proximity to Lake Piuray, the revaluation of its immediate surroundings is proposed. The idea is that the communities currently residing in this area become "protector communities" of the nearby wetland as part of a strategy to preserve and activate the region's heritage resources (Figure 26b,c). In addition, the construction of two docks that go into the wetland is proposed to promote selective, low-environmental impact tourism aimed at small- or medium-sized groups of visitors. These docks will provide quiet and respectful access to the natural environment and will provide an interconnected walkway through the wetland. The "totora" wetlands, which remain present in this area throughout the year, will be used as a resource to promote recreational and social activities in this part of the city (Figure 26d,e).



Figure 26. (a) Intervention radius of the Community Zone, (b,c) protective communities, and (d,e) an ecotourism pier.

Figure 27 shows the implementation of the landscaped green area within the green corridor yields consistent results in the absorption of CO₂ and the production of clean air. These results were determined using conversion factors provided by the World Health Organization (WHO [56]).

$$a = 2.3 \text{ kg (b) for 1 year.}$$

where

a = Annually absorbed CO₂ (kg for a year);

b = Green area under study (landscaping), expressed in hectares;

$$c = 1.7 \text{ kg (b) for 1 year.}$$

where

c = Annually produced fresh air (kg. year);

b = Green area under study (landscaped green area), expressed in hectares.

Hence, when calculating the results using these factors, the following data were obtained.



Figure 27. Location of the landscaped green area within the green corridor.

Table 4 displays the amount of captured CO₂ by the landscaped green area within the green corridor, amounting to 21.16 kg, and resulting in a total of 15.64 kg of fresh air generated.

Table 4. Annual CO₂ absorption and fresh air production.

	Landscaped Green Area in Green Corridor (ha ²)	Absorbed CO ₂ (kg)	Produced Fresh Air (kg)
1	9.20	21.16	15.64
Total	9.20	21.16	15.64

In Table 5, the absorption quantity through the implementation of a bamboo forest in the southern area of the green corridor, covers a total of 2.2 hectares, and yields a cumulative total of 47.11 tons. Just one hectare of bamboo has the capacity to absorb 21.41 tons of CO₂ annually, storing approximately 150 tons in the first 7 years of life when planted [57].

Table 5. CO₂ absorption due to the implementation of bamboo forests.

	Green Bamboo Forest Area (ha ²)	Absorbed CO ₂ (ton)
1	2.2	47.11
Total	2.2	47.11

5. Discussion

In increasingly urban societies, many cities are turning to nature-based solutions (NBS) to help develop more sustainable, resilient, healthy, and ultimately livable urban spaces. The Chinchero green corridor, which spans from the preservation of cultural and natural heritage to the promotion of ecological and renewable energy practices, exemplifies how nature-based solutions (NBS) can play a crucial role in urban planning and development, particularly in areas vulnerable to the challenges of climate change. This comprehensive vision of urban development in Chinchero aims to pave the way for more sustainable and equitable cities, providing inspiration to other communities seeking to enhance the quality of life in urban environments.

An example is the Metropolitan Forest of Madrid, in Spain, based on the concept of green infrastructure and nature-based solutions, it will extend along 75 km within the city of Madrid [58]. This project's main objective is to restore the balance of the city, reduce CO₂ emissions, combat climate change, restore degraded areas both from an ecological and landscape point of view, and expand the network of pedestrian and cycling routes, in addition to promoting the health of the population. The project will function as a forest belt that will circumvent Madrid and to achieve this, the green areas previously qualified by urban planning will be used, which will allow the formation of a green corridor, seeking maximum continuity from both an ecological and spatial perspective. It contemplates ecoducts (green bridges) that allow crossing the main transportation infrastructures at strategic points, thus contributing to maintaining the ecological and functional continuity of the corridor and its components, as well as creating trails for walking and practicing sports, rest areas, and other equipment that encourage its use and enjoyment by the community, and also, at the tree level, mainly by native species. An innovative contribution is that the master plan incorporated, through an international competition in 2020 [59], winning proposals for different lots of the project, which have been executed since 2021.

The Madrid Metropolitan Forest represents an ambitious and innovative project that demonstrates how green infrastructure can play a fundamental role in urban revitalization. This approach seeks not only to address environmental issues, such as reducing CO₂ emissions and ecological restoration, but also to promote community health and well-being through the creation of accessible public spaces. The incorporation of winning proposals

through an international competition adds a touch of originality to this project, highlighting the importance of collaboration and innovation in urban planning [60]. The Chinchero green corridor and the Madrid Metropolitan Forest project in Spain share similarities in their approach to developing sustainable urban areas and restoring degraded environments. Both projects aim to reduce CO₂ emissions and address climate change, as well as promote community health and well-being. In Chinchero, the green corridor proposal encompasses a wide range of initiatives, including ecological restoration, renewable energy generation, and water treatment. On the other hand, the Madrid Metropolitan Forest focuses on creating a forest belt that will encircle the city and leverage green areas previously designated by urban planning.

Likewise, the Sud Milano Agricultural Park, located around Milan, Italy, represents a relevant case study for the discussion of effective urban planning strategies. This semi-ring-shaped park was established with the purpose of regulating urban growth, protecting agricultural activity, preserving historical and natural heritage, and promoting the respectful use of environmental resources. This case highlights the importance of sustainable water resource management, with historic rivers, navigable canals, and numerous sources that contribute to biodiversity. Containing protected areas, such as nature reserves and natural oases, further enriches this environment. The park's landscape is characterized by its complex agricultural labyrinth, crossed by natural waterways and artificial canals, providing refuge for fauna [61].

Sud Milano exemplifies, in practice, how an urban planning strategy can harmonize urban development with the protection of the natural and cultural environment, serving as a valuable model to address the challenges of urban expansion in other regions. The Chinchero green corridor shares notable similarities with Sud Milano. Both projects have the balance between urban development and the preservation of the natural and cultural environment as their main objective. Sud Milano, on its part, was established to regulate urban growth, protect agricultural activity, preserve historical and natural heritage, and promote the respectful use of environmental resources. Both projects recognize the importance of sustainable water resource management and biodiversity. Chinchero benefits from water resources like Lake Piuray, while the Sud Milano Agricultural Park stands out for its management of historic rivers, navigable canals, and sources that contribute to biodiversity. The integration of protected areas and natural reserves in the landscape is a common feature in both projects, enriching their natural environment and improving the quality of life of their communities.

In the Latin American context, the Metropolitan Green Belt project, known as the Circunvalar Garden of Medellín in Colombia, promoted by the municipal administration, stands out as a plan that seeks the integration of disadvantaged neighborhoods located on the edges of the slopes of the Aburrá Valley, addressing significant social challenges, through the generation of public space works and equipment that allow the sustainable development of the slopes in the long term, in this way, developing the first stage located in the eastern communes of Medellín. Despite facing significant challenges, such as high marginality and economic, social, political, and ecological vulnerability, as well as informal occupation in areas prone to landslides or flooding near streams, along with vulnerability to climate change due to its location in a tropical zone and the influences of El Niño and La Niña, Medellín has managed to stand out as a model of inclusive, peaceful, and sustainable urban development. Since 2008, the city has implemented green strategies including the creation of a green belt and improvements in waste management. The project contemplates the ecological restoration of 42 hectares, 12 ecoparks, an educational classroom and two environmental classrooms, two forms of security equipment, the involvement of 590 families in the planting of agroecological gardens, etc., all of this in three areas of action: Consolidation Strip, Transition Strip, and Protection Strip [62]. In short, large-scale projects like this pose fundamental challenges related to unemployment, informality, and the relocation of families in the city. Although they seek formalization and improved qual-

ity of life, these projects also carry the possibility of a higher cost of living, higher taxes, and the need to adapt.

The Chinchero green corridor and the Circunvalar Garden project in Medellín, Colombia, share similarities in their approach to integrating marginalized communities in ecologically vulnerable areas and promoting long-term sustainable development. Both projects address significant challenges related to economic, social, political, and ecological vulnerability, as well as informal occupation in landslide-prone or flood-prone areas. In Chinchero, a green corridor is projected, encompassing a wide range of initiatives, from the preservation of cultural and natural heritage to the promotion of renewable energy and water treatment systems. On the other hand, the Circunvalar Garden focuses on creating public spaces and equipment that enable the sustainable development of hillsides in the long term, with ecological restoration of 42 hectares, ecoparks, and the participation of local communities. Both projects recognize the importance of effective urban planning and social-ecological integration. In both Chinchero and Medellín, the aim is to improve the quality of life of residents and create a shared social and community identity. However, they also face fundamental challenges related to unemployment and informality.

The cited projects prominently exemplify how effective urban planning strategies can harmonize urban development with the preservation of the natural and cultural environment. These projects represent valuable models that address the challenges of urban growth in different regions, promoting the creation of more sustainable, resilient, and enriching urban spaces for local communities. The combination of green infrastructure and nature-based solutions emerges as a promising approach to tackle environmental and social issues in an increasingly urbanized world.

Green corridors offer a comprehensive and sustainable solution to address the challenges associated with urban growth, which is of relevance in the contemporary urban planning of growing cities that seek to meet the growing demand of new markets, as is the case of Chinchero, Cusco, an emerging tourist destination. Evidence from executed projects supports the need to consider a sequence of solutions for the integration of an urban project of this magnitude. To implement this proposal, it is crucial to align with current demands and develop a coherent set of multifunctional project interventions as proposed in this article, and channel it through local governments that articulate “Plans for Territorial Conditioning and Urban Development” [63], including thematic plans or other adequate master plans for smaller urban cities such as Chinchero, together with effective citizen participation processes in terms of territorial conditioning and urban development.

6. Conclusions

Chinchero, in its strategic role as a future tourist center, offers a pressing opportunity to develop a planned urban development axis. The Chinchero green corridor addresses not only the planned expansion of the city but also the creation of green spaces, urban revitalization, the promotion of sustainable practices, and the preservation of the natural and cultural wealth of the region. The proposal encompasses a wide range of zones, from heritage areas to community spaces and environmental awareness areas. This reflects the comprehensive approach of the project. Its core vision is to play a crucial role in building community identity and strengthening the sense of belonging. Additionally, its location serves as a natural barrier that separates the infrastructure of the new Chinchero International Airport from future urban growth. This project represents an exemplary case of urban planning that strives to achieve a crucial balance between urban development and the preservation of the natural and cultural environment. Amid an increasingly urbanized society, the challenges of city growth are evident, and projects like this stand out as viable and effective solutions.

The Chinchero proposal extends from the Piuray Lagoon to the archaeological valley and focuses on improving the quality of life for residents and visitors, while contributing to effective urban planning. It also plays a vital role in preserving community identity and preventing gentrification, enabling sustainable growth, and harnessing Chinchero’s

considerable potential for expansion and progress. The integration of a landscaped green area within the green corridor effectively plans to capture CO₂, generating fresh air. Additionally, a bamboo forest in the southern section can absorb CO₂. This highlights the substantial carbon sequestration potential of strategic landscaping and afforestation in urban corridors.

The research highlights that other examples of green infrastructure and nature-based solutions are not uniform in all cases, challenging previous conceptions and underscoring the importance of considering contextual and normative variations that go beyond other environmental, cultural, archaeological, and social aspects. In that sense, this article presents an opportunity for urban landscape projects of this kind to be established as a comprehensive urban planning strategy. The central focus of the green corridor is to promote social–ecological integration, social urbanism, and to strengthen the sense of territorial roots. By systematically establishing a network of public spaces, a backbone is created in the city that acts as a catalyst for the construction of a shared social and community identity.

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