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The Importance of the Strategic Urban Rehabilitation Plan in the Sustainable Development of the Municipality of Machico

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Abstract: Through the requalification of buildings, the improvement of public spaces and the reorganization of motorized and pedestrian circulation, success is achieved, and thus the trend of decay of the urban fabric is reversed, transforming and returning urban centers to the people. The Strategic Plan for Urban Rehabilitation of Machico is an important document for the sustainable development of the city, which will contribute to social harmony and the improvement of the people's quality of life, reducing the environmental impact of human mobility, boosting the economy, and creating conditions for the usufruct of the city of Machico in terms of mobility. The current article arises with the main objective of analyzing the Strategic Plan for Urban Rehabilitation of the Municipality (PERU) of Machico, which is an essential tool for the sustainable development of Machico. It is also important to emphasize the dimension of PERU in local economic development, from the perspective of the real estate market and in public investment. The results obtained showed that the Municipality of Machico faces some challenges in the implementation of sustainable urban development programs, due to the recent financial and economic crisis, which could limit the existing funding to fund sustainable urban development programs. It is from this plan, from the solutions determined for the rehabilitation of the public space in terms of security and mobility, based on the urban operations that are being developed, that it will be possible to offer the population a sustainable future.

Keywords: Machico; Porto da Cruz; strategic plan for urban rehabilitation (PERU); sustainability; sustainable urban development; urban rehabilitation



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1. Introduction

The subject of the study is developed around urban rehabilitation and its importance in the sustainable development of the Municipality of Machico.

Since cities represent the result of the development model of societies and their level of performance in the economic, environmental, and social sectors over time, urban rehabilitation interventions on public space and built heritage are assumed to be a key instrument for Sustainable Urban Development [1].

Given the importance of rehabilitation in the country, the Municipality of Machico decided to carry out PERU in 2018. In the Strategic Plan for Urban Rehabilitation (PERU), a proposal for a systematic Urban Rehabilitation Operation (ORU) was established for the delimited Urban Rehabilitation Area (ARU) of Machico and Porto da Cruz. This

strategy was adopted by other municipalities in Portuguese territory, including Monção [2], Lagos [3], Maia [4], and Funchal [5].

PERU aims at the sustainable and strategic development of the city through the rehabilitation of public and private buildings, the rehabilitation of the city's socio-economic, cultural, and sporting structure, and the promotion of sustainable mobility and qualification of public spaces. It focused on urban land use and seeks to respond to current challenges, through the enhancement of buildings and public spaces of architectural value, bringing together the dispersed parts into an interconnected and harmonious whole [2].

It can be said that the PERU are documents of paramount importance for the strategic and functional development of the Municipality, which uses its structuring projects to achieve various objectives, namely:

- Protection of the cultural and historical built heritage;
- The definition of interventions at the level of buildings and infrastructures/equipment concurring with sustainable development;
- The definition of initiatives that financially boost local commerce and recreational activities;
- Additionally, the resolution of the degradation of specific nuclei through initiatives, incentives, and social support, thus allowing the defense of the territory as a harmonious whole.

Regarding the Strategy of the Municipality of Machico, this focused on the elaboration of Structuring Projects (which are part of the proposed ORU, which should be completed in 2028). In this work, the Structuring Projects (PE) associated with the Rehabilitation of the Public and Private Building Park will be addressed. The strategy defined in Machico is very similar to the strategy defined in Lagos, since they share similar problems, among them human desertification, mainly as a result of the exodus of the young [3].

The Urban Rehabilitation Strategy of the ARU of Machico and Porto da Cruz approved by the Municipality is part of the diploma that defines the Legal Regime for Urban Rehabilitation (DL 307/2009 of 23 October, amended and republished by Law 32/2012 of 14 de Agosto) which states that *“urban rehabilitation is assumed today as an indispensable component of city policy and housing policy, insofar as the objectives of requalification and revitalization of cities converge in it, in particular its most degraded areas, and the qualification of the housing stock, seeking a globally more harmonious and sustainable functioning of cities and the guarantee, for all, of decent housing”*, and also in this context defines ARU as *“a territorially delimited area that, by virtue of the insufficiency, degradation or obsolescence of buildings, infrastructures, equipment for collective use and urban and green spaces for collective use, in particular and with regard to its conditions of use, solidity, safety, aesthetics or health, justifies an integrated intervention, through an urban rehabilitation operation approved in its own instrument or in a detailed urban rehabilitation plan”*. Similar to what happened with PERU in the Municipality of Maia [4] and Funchal [5], its preparation also observed the assumptions established regarding the approval of Transactions of Urban Rehabilitation through its own instrument, namely the one considered in the numbers 3 and 4 of article 17 for issuing a non-binding opinion by the Housing Institute and Urban Rehabilitation (IHRU).

Thus, this article aims to analyze the urban rehabilitation strategies for the Urban Rehabilitation Areas of the Municipality of Machico, defined in PERU, which are the most used urban operations in the parishes of Machico and Porto da Cruz, and also to determine the increase in rehabilitation processes after the approval of PERU, allowing an analysis of the influence of the Strategic Plan for Urban Rehabilitation in the parishes of Machico and Porto da Cruz. Figure 1 shows the Urban Rehabilitation Area of the parish of Machico and the ARU of the Parish of Porto da Cruz.



Figure 1. Urban Rehabilitation Areas in the parish of Machico (**top**) and Porto da Cruz (**bottom**) (Source: Authors).

In order for residents to enjoy the advantages associated with rehabilitation, within the areas identified in Figure 1, the following steps must be taken:

1. Make sure that the property you want to rehabilitate is within one of the ARU;
2. Submit the Application for Initial Assessment of the state of conservation at the City Council, which determines that a technician from the municipality travel to the site to assess the state of conservation before starting work;
3. After the technician's evaluation, you can start the rehabilitation work on the property;

4. Once the rehabilitation is completed, you must submit the Application for Final Assessment of the state of conservation at the City Council, so that a technician can travel to the site again to assess the state of conservation after the works are completed;
5. If the result of the Final Assessment is two levels above the one assigned before the intervention, you must submit the request for a Tax Benefits Certificate to be delivered to the local tax service.

2. Methodology

2.1. Legal Framework

Buildings, namely in the historic centers, constitute a repository of the memories, history, and art of the people, materialized in the architectural heritage that it is important to value and safeguard. This is the reason for the existence of legal barriers to the demolition of buildings (classified or mere monitoring) for replacement by new construction in Old or Historic Urban Spaces, framed by the various instruments for regulating the occupation of these spaces (Municipal Master Plans (PDM), Urbanization Plans, Detailed Plans, among others) [6].

The need to protect and safeguard heritage is considered and framed in the Constitution. According to the Constitution of the Portuguese Republic [7]:

- Article 66, no. 2, subparagraph (c), it is incumbent upon the State to “... *classify and protect landscapes and sites, in order to guarantee the conservation of nature and the preservation of cultural values of historical or artistic interest*”;
- Article 78, no. 2, subparagraph (c), it is incumbent upon the State, in collaboration with all cultural agents, to “*promote the safeguarding and enhancement of the cultural heritage, making it a vitalizing element of the common cultural identity*”;

The Cultural Heritage Basic Law [8] also conveys the need to protect and enhance heritage, which is a fundamental task of the State:

- “*Through the safeguarding and enhancement of cultural heritage, the State must ensure the transmission of a national heritage whose continuity and enrichment will unite the generations in a unique civilizational path*”;
- “*The knowledge, study, protection, enhancement and dissemination of cultural heritage are a duty of the State, the Autonomous Regions and local authorities*”.

The Legal Regime for Urban Rehabilitation [9], hereinafter referred to as RJRU, framed by Decree-Law 307/2009, of 23 October, republished by Law 32/2012 of 14 August, provides for the possibility of constituting “*areas urban rehabilitation*” (ARU) which are defined as “*territorially delimited areas that, due to the insufficiency, degradation or obsolescence of buildings, infrastructures, equipment for collective use and urban and green spaces for collective use, namely with regard to their conditions of use, solidity, safety, aesthetics, or salubrity, justify an integrated intervention, through an urban rehabilitation operation approved in a specific instrument or in a detailed urban rehabilitation plan*”.

The area of Intervention of this program is fully covered by the Regional Program for Spatial Planning (PROTRAM) of the Autonomous Region of Madeira [10] and by the Municipal Master Plan (PDM) of Machico [11].

The PROTs establish the strategic options for organizing the regional territory and the major options for public investment with a significant territorial impact, constituting the strategic reference framework for plans at the intermunicipal and municipal levels [12].

The Machico PDM presents guidelines for urban intervention and management, especially for the two urban rehabilitation areas in the Municipality of Machico, classified predominantly as “Ancient or Historic Urban Spaces” (EUAH). The New Municipal Regulation for Urbanization, Building and Fees (NRMUET) [13] provides for a bond in its article 30 for the maintenance of load-bearing walls in stone masonry in order to protect and safeguard the heritage within the EUAH, extending it to the entire perimeter of the ARU in the parish of Machico.

2.2. Study Area

The Madeira Archipelago is located in the North Atlantic, more precisely in the region called Macaronesia, between the parallels $30^{\circ}01' \text{ N}$ and $33^{\circ}08' \text{ N}$ and the meridians $15^{\circ}51' \text{ W}$ and $17^{\circ}30' \text{ W}$ of Greenwich. With a total of 796.77 km^2 , the archipelago is made up of Madeira Island, the largest and most important island in the group, with an area of 736.75 km^2 ; by Porto Santo, with 42.17 km^2 ; by the Desertas, with 14.23 km^2 ; and by the Selvagens, with 3.62 km^2 [14].

Specifically, the municipality of Machico is located on the easternmost tip of the island, extending from the sea to the northern mountains and ending at Ponta de São Lourenço, with a total area of 68 km^2 . It is delimited to the southwest by the municipality of Santa Cruz, to the west by the municipality of Funchal, through a small band located to the north of the municipality of Santa Cruz, and to the northwest by the municipality of Santana. The municipality of Machico is composed of five parishes, visible in Figure 2: Santo António da Serra, Porto da Cruz, Caniçal, Machico, and Água de Pena. Of the five parishes, only Machico [15] and Porto da Cruz [16] have approved a strategic plan for urban rehabilitation (PERU).



Figure 2. Location of the study area—Machico municipality (Source: wikipedia.org accessed on 8 October 2022).

2.3. Machico Urban Rehabilitation Area

The Machico Urban Rehabilitation Area (ARU) encompasses the old core of the city and its more recent surroundings and comprises an area of about 0.316 km^2 (31.6 ha).

The Historic Center retains the oldest buildings of greater heritage value, and presents a more “closed” urban fabric, with narrow streets and a higher building density.

The city of Machico, as it is also the county seat, has a significant offer of equipment and infrastructure. In addition to the City Hall, it also houses the Municipal Market, the Health Centre, the Machico Forum, the Fire Station, the Municipal Warehouse, the House of Music, the Bus Center, the Police Station (PSP), and the connection to the Pier/Port of Machico. In the area of education there are three Kindergartens, a Secondary School, and three Primary Schools, as well as the Conservatory—School of Arts.

Figure 3 shows the delimitation of the ARU for the center of Machico (green spot), which concentrates a large part of commercial and service establishments, as well as some collective and administrative facilities [17]. It is still possible to observe the delimitation of the historic center of Machico in red and the public and private buildings, target of future rehabilitations, in red and yellow circles correspondingly.



Figure 3. Delimitation of the Machico Urban Rehabilitation Area (Source: Peru Machico).

This historic center is characterized by a morphology of traditional occupation of the Renaissance city where the reticle and orthogonality of the embryonic nucleus can already be foreseen, very limited to the conditions of the relief and hydrography of the place [17]. The morphology is characterized by continuous street fronts forming blocks with a functional typology of mixed-use housing with other functions at the ground floor level. In this nucleus, the most relevant historical and cultural heritage and the most structured road and pedestrian network are located [17].

Regarding the specifics related to the rehabilitation operations for the buildings within the Machico ARU, Machico city hall have defined the specific repair and regeneration process as a result of the decision-making process:

- Rehabilitate degraded historic buildings;
- Allow the expansion of buildings respecting the volume parameters according to the buildings in the surroundings, in accordance with the Municipal Master Plan of Machico (PDM) [11], respecting the General Regulation of Urban Buildings (RGEU) [18];
- Maintain or reinforce the historic structure in stone masonry, maintaining its original construction technique whenever possible;
- Allow the execution of extensions without jeopardizing the integrity of the stone structure, mitigating the visual impact of the new solution on the historical part of the building;
- The vernacular architectural language must be maintained in the historical fractions of the building, guaranteeing its identity and proportions;

- In the new areas, the language of the exterior envelopes should be limited only by the respective volumetric framework, freeing the proportions of spans and construction materials to the creativity of the project;
- Finally, the adoption of energy efficiency solutions should be promoted in the outer envelope of public or private buildings, always respecting the identity of the historic plots.

With regard to the built heritage, the following properties are distinguished in the ARU de Machico:

- Church of Nossa Senhora da Conceição: Property of Public Interest [19]
- Nossa Senhora do Amparo Fort: Property of Public Interest [19]
- Chapel of Nosso Senhor dos Milagres: Property of Public Interest [19]
- Chapel of São Roque: Property of Public Interest [19]
- Machico Aqueduct: Property of Municipal Interest [20]
- Solar do Ribeirinho: Property of Municipal Interest [21]
- Old Market: Property of Municipal Interest [22]
- Municipal Market/Praça de Peixe de São Pedro: Property of Municipal Interest [23]
- City Hall Building: Property of Municipal Interest [24]
- Former Slaughterhouse/Municipal Butchery: Property of Municipal Interest [25]

Regarding private buildings, the built structure of residential and non-residential buildings in the Urban Rehabilitation Area is, for the most part, characterized by traditional constructions, dating from the late 18th, 19th, and 20th centuries.

In terms of quantity, the Machico ARU has a total of around 492 buildings. In terms of the construction process, the oldest buildings, prior to 1950, are of traditional construction, more specifically in stone masonry, and have 1 or 2 floors, while the more recent ones have a reinforced concrete structure and mostly have 2 or more floors.

Since the objective of PERU is rehabilitation, special attention was given to the oldest buildings. In the ARU there were about 133 stone masonry properties, of which 56 are located on Rua da Banda d'Além and the remaining 77 in the Central Nucleus.

Regarding the typology of uses of the ARU buildings, it appears that most of them are exclusively used for housing. In the more central and commercial areas, this exclusivity is less relevant, since, despite the existence of housing in the building, the ground floor is usually allocated to commerce or services.

The conservation assessment of the building was carried out with an in loco observation of the state of the facades and roofs at the exterior level. To determine the state of conservation of the building, levels of anomalies were assigned that reflect its current state. The model of the evaluation form of the level of conservation prepared for application in the New Regime of Urban Lease—NRAU [26] was followed, where the state of conservation can be classified as:

- Excellent (predominance of level 5 anomalies): Absence of anomalies or meaningless anomalies;
- Good (predominance of level 4 anomalies): Anomalies that impair the appearance and require work that is easy to perform;
- Medium (predominance of level 3 anomalies): Anomalies that impair the appearance and require work that is easy to perform; Anomalies that impair use and comfort and that require cleaning, replacement or repair work that is easy to perform;
- Bad (predominance of level 2 anomalies): Anomalies that impair use and comfort and that require cleaning, replacement or repair work that is difficult to perform; Anomalies that put health and safety at risk, which may lead to minor accidents that require easy-to-perform work;
- Very bad (predominance of level 1 anomalies): Anomalies that put health and safety at risk, which can lead to serious accidents that require work that is difficult to perform; Absence or inoperability of basic infrastructure.
- Ruin (building that cannot be used for reasons of safety and/or health).

In Figure 4, it is possible to observe examples of buildings from the ARU in all of the six different stages.



Figure 4. Examples of buildings in 6 different stages (Source PERU Machico).

In Table 1, it is possible to observe that the total number of degraded buildings, that is, with a classification lower than 3 (NRAU classification), is 67. In percentage terms this is 13.62% of the total ARU buildings.

Table 1. Buildings in the Machico ARU with a rating below 3 (NRAU) (Source: Authors).

State of Conservation	Number of Buildings	Percentage of Buildings
Bad (Figure 5)	37	7.52%
Terrible (Figure 5)	23	4.67%
Ruins (Figure 5)	7	1.42%



Figure 5. Examples of buildings, in ruins (**left**), in terrible state of conservation (**cent.**), and in bad state of conservation (**right**) (Source: PERU Machico).

Figure 6 shows the properties to be rehabilitated in the Machico ARU, with their respective state of conservation. Buildings in ruins are identified in red, buildings in poor condition in orange, poor condition in yellow, reasonable condition in blue and, finally, buildings in good or excellent condition in green. In grey, buildings from the last quarter of the 20th and 21st centuries are identified, and are not included in the global inventoried values of stone masonry buildings.

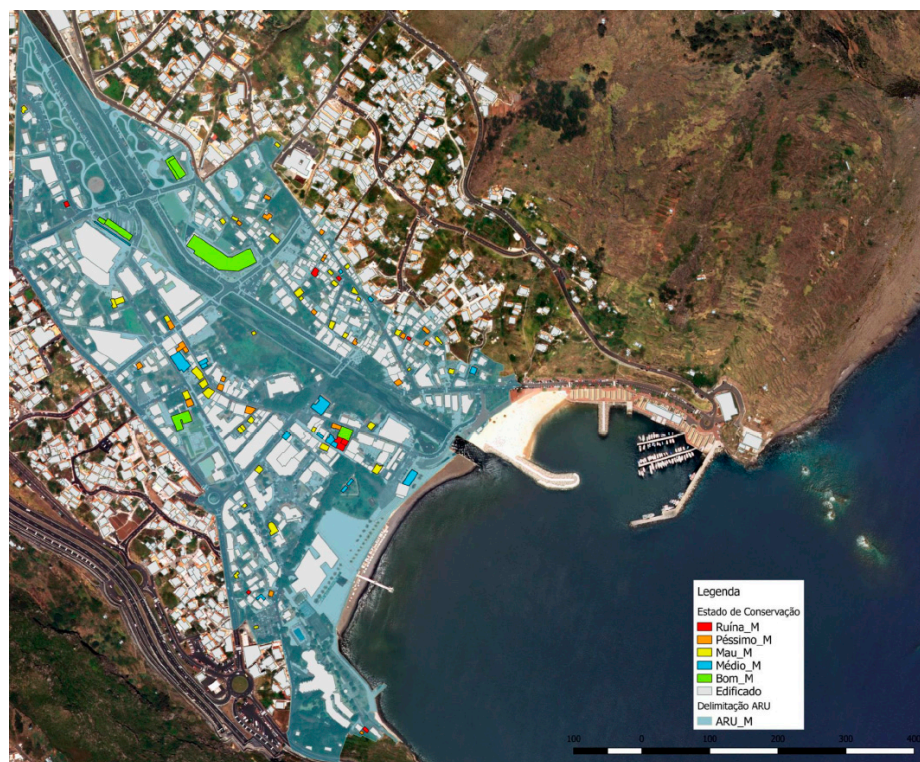


Figure 6. State of Conservation of the Building—ARU Machico. (Source: PERU Machico).

2.4. Porto da Cruz Urban Rehabilitation Area

The Porto da Cruz Urban Rehabilitation Area covers the old core of the city and comprises an area of approximately 0.094 km² (9.4 ha).

The village of Porto da Cruz is a parish by charter dated 26 September 1577, signed by D. Sebastião. Its predominant activity is agriculture, of which the “American” wine stands out, produced in vineyards close to the land and sugar cane, the reason for the existence of three sugar mills, of which only the historic Engenho do Porto da Cruz remains today. There is the only steam engine still in operation in Europe, owned by Companhia Engenhos do Norte. Located in the center of the village, it is a poster of the typical Madeira sugarcane brandy.

The parish had a brief period under the administration of Santana by the decree of 1835 that created that municipality. Until 1852 it was also by decree that it returned to the heart of the municipality of Machico.

From the consultation of the censuses [27] that describe the evolution of the population since 1864 (when it had almost 3000 inhabitants), it can be seen that the parish reached its maximum population in 1920 (with about 5800 inhabitants) and in 1950 (with about 5600), which could result from the exodus from cities and towns in times of the so-called world wars. Since then, the parish has been losing population consistently, reduced in the first decade of the 21st century to a deficit of only 200 inhabitants, having had almost 2600 inhabitants in the 2011 census.

Porto da Cruz is today an internationally recognized area for sports, including surfing, mountain biking, trail running, and paragliding.

Through Figure 7, the delimitation of the ARU to the center of Porto da Cruz can be seen (purple spot), which presents contiguous buildings with formation of a road front associated with some dispersed building [19]. This nucleus, more rural in its genesis and less structured, was consolidated with the (agro)industrial presence of the sugar cycle, with a strong connection to the riverside of supply, fish market/butchery, church, and the very strong orographic conditioning, with the center being divided by two deep streams of large hydrographic basins that, as in Machico, are periodically devastated by alluvial regimes. Regarding uses, this area is mostly affected by housing with some mixed buildings that include services and commerce [19]. Despite being an area with little extension, in some streets with reduced profiles the circulation continues to be carried out in a mixed way, without favoring pedestrian circulation to the detriment of the road, which should be reassessed [19]. It is still possible to observe the delimitation of the historic center of Porto da Cruz in red and the public and private buildings, target of future rehabilitations, in red and yellow circles correspondingly.

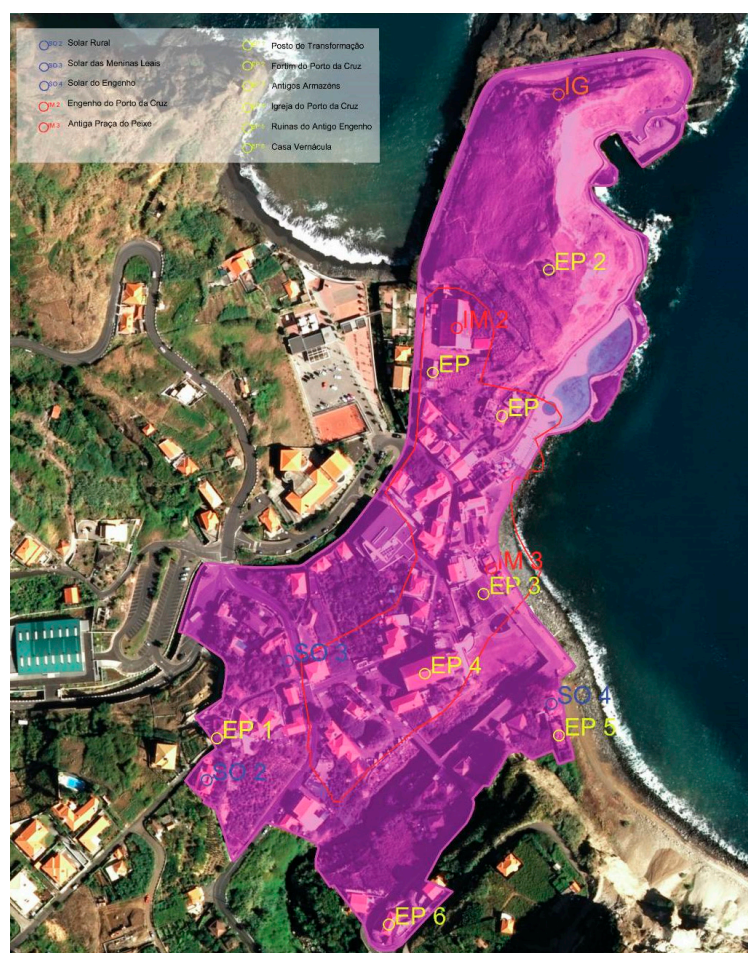


Figure 7. Delimitation of the Porto da Cruz Urban Rehabilitation Area (Source: PERU Porto da Cruz).

Similar to what we had already observed for the Machico ARU, the specifics related to the rehabilitation operations for the buildings within the Machico ARU, Machico city hall have defines the specific repair and regeneration process as a result of the decision-making process:

- Rehabilitate degraded historic buildings;
- Allow the expansion of buildings respecting the volume parameters according to the buildings in the surroundings, in accordance with the Municipal Master Plan of Machico (PDM) [11], respecting the General Regulation of Urban Buildings (RGEU) [18];

- Maintain or reinforce the historic structure in stone masonry, maintaining its original construction technique whenever possible;
- Allow the execution of extensions without jeopardizing the integrity of the stone structure, mitigating the visual impact of the new solution on the historical part of the building;
- The vernacular architectural language must be maintained in the historical fractions of the building, guaranteeing its identity and proportions;
- In the new areas, the language of the exterior envelopes should be limited only by the respective volumetric framework, freeing the proportions of spans and construction materials to the creativity of the project;
- Finally, the adoption of energy efficiency solutions should be promoted in the outer envelope of public or private buildings, always respecting the identity of the historic plots.

With regard to the built heritage, the following properties are distinguished in the ARU of Porto da Cruz:

- Engenho do Porto da Cruz: Property of Municipal Interest [28]
- Praça Velha/Praça de Peixe: Property of Municipal Interest [29]

Regarding private buildings, the built structure (residential and non-residential buildings) of the ARU is, for the most part, characterized by traditional constructions, dating from the late 18th, 19th, and 20th centuries.

In terms of quantity, the Porto da Cruz ARU accounted for a total of 85 buildings. In terms of the construction process, the oldest buildings, before 1950, are of traditional construction, more specifically in stone masonry, and have 1 or 2 floors, while the more recent constructions have a reinforced concrete structure and mostly have 2 or more floors.

Since the objective is the rehabilitation of the area, special attention was given to the older buildings. Therefore, 56 stone masonry buildings were counted. Regarding the typology of uses of the ARU buildings, it can be seen that most of them are exclusively used for housing.

- Likewise, the assessment of the conservation of the building was carried out with an in loco observation of the condition of the facades and roofs at the exterior level. To determine the state of conservation of the building, levels of anomalies were assigned that reflect its current state. The model of the assessment form of the level of conservation prepared for application in the New Urban Lease Scheme [26]—NRAU was followed:
- Excellent (predominance of level 5 anomalies): Absence of anomalies or meaningless anomalies;
- Good (predominance of level 4 anomalies): Anomalies that impair the appearance and require work that is easy to perform;
- Medium (predominance of level 3 anomalies): Anomalies that impair the appearance and require work that is easy to perform; Anomalies that impair use and comfort and that require cleaning, replacement or repair work that is easy to perform;
- Bad (predominance of level 2 anomalies): Anomalies that impair use and comfort and that require cleaning, replacement or repair work that is difficult to perform; Anomalies that put health and safety at risk, which may lead to minor accidents that require easy-to-perform work;
- Very bad (predominance of level 1 anomalies): Anomalies that put health and safety at risk, which can lead to serious accidents that require work that is difficult to perform; Absence or inoperability of basic infrastructure.
- Ruin (building that cannot be used for reasons of safety and/or health).

In Figure 8, it is possible to observe examples of buildings from the ARU in all of the six different stages.



Figure 8. Examples of buildings in six different stages (Source PERU Porto da Cruz).

In Table 2 it is possible to observe that the total number of degraded buildings, that is, with a classification lower than 3 (NRAU classification), is 21 and in percentage terms 24.71% of the total ARU buildings.

Table 2. Buildings in the Porto da Cruz ARU with a rating below 3 (NRAU) (Source: Authors).

State of Conservation	Number of Buildings	Percentage of Buildings
Bad (Figure 9)	7	8.24%
Terrible (Figure 9)	7	8.24%
Ruins (Figure 9)	7	8.24%



Figure 9. Examples of buildings, in ruins (left), in terrible state of conservation (cent.), and in bad state of conservation (right) (Source: PERU Porto da Cruz).

Figure 10 shows the properties to be rehabilitated in the ARU, with their respective state of conservation. Buildings in ruins are identified in red, buildings in poor condition in orange, poor condition in yellow, reasonable condition in blue and, finally, buildings in good or excellent condition in green. In grey, buildings from the last quarter of the 20th and 21st centuries are identified, and are not included in the global inventoried values of stone masonry buildings.

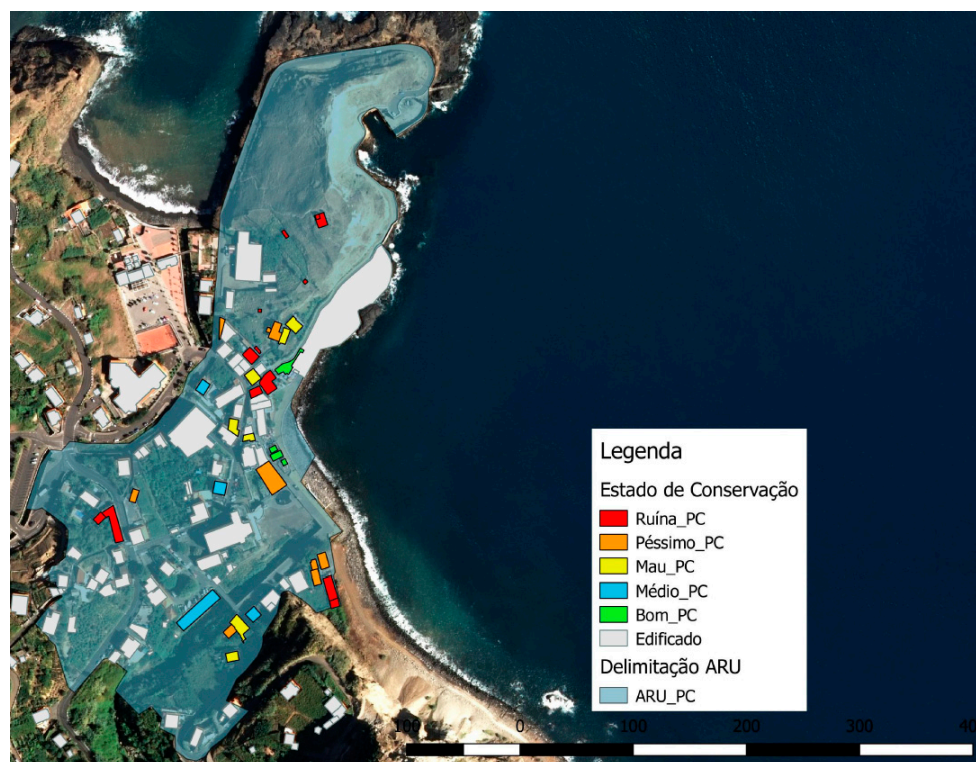


Figure 10. State of Conservation of the Building—ARU Porto da Cruz (Source: PERU Porto da Cruz).

2.5. Applied Methodology—Structuring Projects

Figure 11 shows that the summary of the methodology adopted for the work, in a first phase, was the study of the legal framework for rehabilitation (Legal Framework), followed by the analysis of the main characteristics and problems identified for each of the ARUs (Characterization and Diagnosis of the ARU), moving on to the definition of rehabilitation strategies (Strategic Framework), right after the definition of structuring projects (Definition of the ORU), and finally an analysis of the sustainable development of the territory leveraged by PERU.

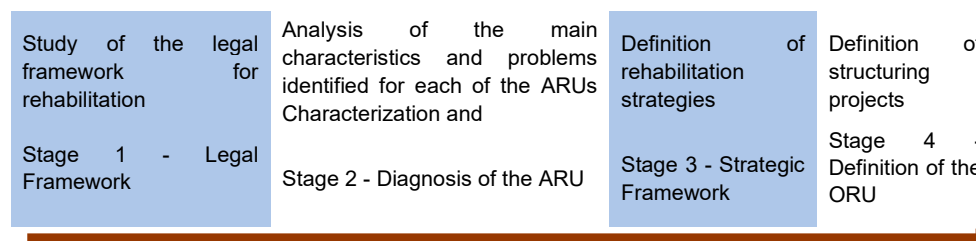


Figure 11. Summary of the methodology's selection criteria and case study selection process (Source: Authors).

The Municipality of Machico is the managing entity of the two ORUs to be developed in each of the ARUs. Despite the tasks of the managing entity being borne by the Municipality, the success of the ORU's strategic program implies a strong articulation with the owners and other holders of private buildings. Therefore, the implementation model of the systematic ORU to be adopted consists, with regard to the rehabilitation of private buildings, of the monitoring of the private initiative of individuals on the one hand, and of the initiative of the Municipality with regard to selected municipal buildings to intervene [30]. With regard to the rest of the public urban space, including infrastructure and green spaces for collective use, an exclusive initiative of the Municipality was foreseen, using in these two cases the share of own funds to be captured in the municipal budgets and the part of the financing through the Financial Instrument for Urban Rehabilitation and Revitalization (IFRRU) [31].

This model presupposes the existence of an effort of coordination and commitment between the different actors, so that there is synergy in the compatibility of the actions of private and public initiative. The Execution Term of the ORU will be 10 years, with the possibility of extension, and cannot be in force for a period exceeding 15 years, counting from the date of approval of the ORU, under the terms of the RJRU [9].

The Strategic Axes (EE) of the Municipality come mainly from the need to renew and revitalize Machico [15] and Porto da Cruz [16], through the treatment of the built fabric and public space. Therefore, the following axes are defined, with their respective objectives (OE):

1. Rehabilitation of the Building Park;
2. Rehabilitation of the Socioeconomic, Cultural and Sporting Structure;
3. Promoting Sustainable Mobility and Strengthening Integration and Connectivity;
4. Qualification of Public Spaces;

In this way, several Structuring Projects (SP) were defined that correspond to concrete intervention proposals that, as a whole, aim to achieve the strategic objectives underlying the ARU rehabilitation strategy [32]. Tables 3 and 4 present the summaries of the projects and actions that embody the Urban Rehabilitation Operation of Machico and Porto da Cruz, associated only with Strategic Axis 1—Rehabilitation of the Building Park.

Table 3. Structuring projects and the respective actions—ORU Machico (Source: Authors).

Strategic Axes	Structuring Projects	Actions
EE1—Rehabilitation of the Building Park	PE1—Solving the problems of degradation and abandonment of buildings	1.1. Encouraging the rehabilitation of private buildings
		1.2. Promote the recovery of vacant dwellings, through the Re-Habita Machico program
	PE2—Rehabilitation of Municipal Buildings	2.1. Rehabilitation of Municipal buildings
		2.2. Expansion of the Paços do Concelho Building, with partial occupation of the adjacent municipal garden.

Table 4. Structuring Projects and Actions—ORU Porto da Cruz. (Source: Authors).

Strategic Axes	Structuring Projects	Actions
EE1—Rehabilitation of the Building Park	PE1—Solving the problems of degradation and abandonment of buildings	1.1. Encouraging the rehabilitation of private buildings
		1.2. Promote the recovery of vacant dwellings, through the Re-Habita Machico program
	PE2—Rehabilitation of Municipal Buildings	2.1. Rehabilitation of Municipal buildings

The structuring project, related to the resolution of problems of degradation/abandonment of private buildings, is entirely part of the private initiative, and the Municipality only interferes to the extent of moral and financial incentives in order to combat the degradation/abandonment of buildings.

Figure 12 shows the private building to be rehabilitated. In the case of Machico, the figure on the top, there are 75 cases in the ARU that can be intervened, and for Porto da Cruz, figure on the bottom, there are 23 cases in the ARU that can be intervened.



Figure 12. Location of private buildings to be rehabilitated in the parish of Machico (**top**) and Porto da Cruz (**bottom**) (Source: PERU Machico and PERU Porto da Cruz).

Regarding the structural project related to the rehabilitation of municipal buildings, in the case of Machico in Figure 13 on the top, in the ARU, there are 11 cases of municipal buildings that are expected to be intervened, and in the case of Porto da Cruz on the bottom, they are highlighted. In the ARU, four cases of municipal buildings are expected to be intervened.

The implementation of public initiatives present in PERU depends on the available budget, for the urban operations of urban rehabilitation, on the Municipality of Machico, and on the financing lines of the European Funds [31], both for Machico [15] and for Porto da Cruz [16].

In Table 5, it is possible to observe the comparison between the two parishes in terms of private buildings inside the ARU. In percentage terms, the parish of Porto da Cruz presents a higher percentage of buildings classified as Ruin, Very Bad, Bad, and Medium compared to Machico. Machico, in terms of percentage, has a higher percentage of buildings classified as Good and Excellent.

Table 5. Buildings to rehabilitate in ARU in Machico and Porto da Cruz (Source: Authors).

Private Buildings				
	Machico		Porto da Cruz	
Ruin	37	8%	7	8%
Very Bad	27	5%	7	8%
Bad	7	1%	7	8%
Medium	10	2%	4	5%
Good	170	35%	23	27%
Excellent	241	49%	37	44%



Figure 13. Cont.



Figure 13. Location of municipal buildings to be rehabilitated in the parish of Machico (**top**) and Porto da Cruz (**bottom**) (Source: PERU Machico and PERU Porto da Cruz).

3. Definition of Materials, Practices, and Techniques

Despite the positive aspects, to achieve the success of urban rehabilitation, new challenges are imposed on society as a whole, namely: to political decision-makers; to companies and technicians related to the construction industry; to associations and non-governmental organizations and citizens.

In addition to the difficulties of a political nature, there are others of a more technical nature, one of which is to achieve the conditions of intended habitability.

One of the most difficult aspects to get around is the adequacy and correct application of current materials and techniques in old buildings, which were built with techniques and materials with properties different from those in force. Current materials have characteristics and behaviors that are different from the old ones, so their conjugation must be thought and studied.

In this way, at ARU, materials and techniques to be used were defined according to the technical knowledge of the materials and traditional techniques.

Table 6 presents the Synthesis of Practices and Techniques most used in Urban Rehabilitation defined for ARU.

Table 6. Synthesis of Practices and Techniques in Urban Rehabilitation (Source: Authors).

Practices and Techniques	Description	Benefits
Sandblasted lime coatings on old walls	The coating technique with aerial lime mortar on old walls aims to provide robustness, resistance, a greater compatibility with old masonry, increase the hydraulic characteristics, and consequently allow drying and hardening of renders, even in humid environments [33].	Aerial lime mortars are presented as the most compatible solution with old masonry, both in terms of resistance and deformability, and manage to generate a good interaction between materials and construction solutions. Aerial lime mortars are also free of soluble salts, do not exhibit restricted shrinkage cracking, and have high water vapor permeability values [33].
Ventilated Plaster	This system consists of two layers (plaster and plaster) and is based on the fact that humid air is heavier than dry air. The first layer consists of plaster where continuous vertical slots are made to favor the accumulation of salts in these grooves and thus helps to release the existing moisture in the masonry and facilitate the drying process of the wall. The last layer is plaster, which, through this technique, achieves less crystallization and accumulation of salts [34].	The “ventilated plaster” system, thanks to the existence of vertical slots, prevents the accumulation of salts in the masonry and in the plaster (when water repellent lime mortar is used in the plaster), increasing the durability of the coating system [34].
Ventilated Floors	The ventilated floor technique aims to reduce and prevent rising damp in building elements in contact with the ground. It consists of a ventilation system at the base of the existing walls, in order to increase its capacity of drying, prevent capillary rise of water and reduce the accumulation of moisture. Air circulation through a perforated tube placed inside the pavement is ensured by the action of the wind or by placing fans when necessary [35].	Installing ventilation around the interior and exterior of the walls reduces the risk of moisture on the floors (condensation and infiltrations) and prevents rising damp, thus increasing thermal comfort conditions [35].
Water and Sewage System	In the rehabilitation of old buildings, replacement or intervention in water networks, stormwater, and domestic sewage is quite common. Precarious networks are generally found, leading to intervention solutions in these special installations that almost always culminate in the total renewal of the networks [36].	In a rehabilitation, the networks become identical to those obtained in new construction, therefore with better conditions in terms of comfort and even greater savings in water, energy, and maintenance actions. In the case of lead water supply networks, which require entirely new construction, the materials are replaced by more durable and high-quality ones. There is now thermal protection for the hot water piping, which leads to a reduction in heating losses and inadequate heating of building elements. Ensuring the continuous supply of water, in sufficient quantity, with the desired pressure and speed of drainage compatible with the perfect functioning of the equipment; Implementation of effective maintenance systems and easy future expansion (note that the pipes can be installed visible, in galleries, gutters, false ceilings, sheathed or recessed into the wall) [37].

Table 6. Cont.

Practices and Techniques	Description	Benefits
Rehabilitation of masonry—Repointing of joints	<p>The need to rehabilitate facades arises after analyzing the different anomalies and their causes. The most common cause is humidity and consequently one of the major concerns in old buildings, being associated with the appearance of many anomalies and their evolution into situations that are quite serious for the structure. In this way, protective measures against humidity become indispensable when trying to prevent the manifestation of anomalies. That said, it is necessary to carry out the most appropriate intervention, resorting to consolidation techniques in order to restore the initial resistant capacity, or carry out reinforcement techniques whose function is to increase the load capacity or to limitation of structure deformation [38].</p>	<p>Protection and reinforcement of external wall faces. Restore the integrity conditions of the facades. Improve mechanical characteristics. Apply the principles of quality management, through their inclusion in the quality plan of the work [38].</p>
Facade insulation—ETIC systems	<p>This system consists of thermal insulation plates fixed to the wall by gluing or mechanically fixing, which receive a continuous reinforced outer coating on site. With the appropriate finishing and decoration coatings, it provides a high degree of thermal protection efficiency [39].</p>	<p>Increased thermal inertia inside buildings, given that most of the mass of the walls is located inside the thermal insulation. This fact translates into improved thermal comfort in winter, by increasing useful solar gains, and in the summer due to the ability to regulate the indoor temperature and improve energy savings, due to the reduction in heating and cooling needs of the interior environment and greater comfort and protection given to the roughness of the walls against the demands of atmospheric agents (thermal shock, liquid water, solar radiation, etc.) [39].</p>
“Old” window replacement	<p>When carrying out the complete replacement of the frames using frames that look similar to the original, with the same base material (be it wood or another material). It is through glazing that the greatest heat losses per unit area take place, but also the greatest heat gains when properly exposed. The thermal characteristics of the frame (window) play an important role in the energy performance of buildings and in the interior comfort conditions [40].</p>	<p>High thermal/acoustic behavior; high durability; water tightness; better air permeability; increased noise protection [40].</p>
Thermal Solar Collectors	<p>Solar thermal energy is energy that, through the use of sunlight, allows heating domestic water and reducing dependence on traditional burning equipment, which uses natural fossil fuels as an energy source. Namely the conventional equipment used for heating water: water heaters, gas boilers, and gas and/or electric water heaters [41].</p>	<p>Installation is simple both to design and to build [41].</p>
Rehabilitation of facades—Paintings	<p>The application of a paint coating, mono or multilayer, on the outer faces of the facades of a building has the following objectives: Wall protection, by preventing water penetration and disintegration of the application base; Intervention of an aesthetic nature, to adapt or improve the architectural aspect [42].</p>	<p>Maintenance of architectural features; return of the building’s identity; more careful public space; rehabilitation of the façade; wall protection [42].</p>

Table 6. Cont.

Practices and Techniques	Description	Benefits
Foundation rehabilitation— Micropiles	This reinforcement of foundations with micropiles in rehabilitation is used when the feasibility of surface reinforcement is reduced due to the poor resistance capacity of the foundation soil at the surface, there being a need to find the superstructure in deeper layers, with better resistance characteristics and less deformability previously proven by geotechnical study [43].	Reduced disturbance to building, terrain, and surrounding buildings, both in terms of vibrations and noise, mobilizing the resistance of deep soil strata, and being implemented with low power drilling equipment and rotary; Efficiency in crushing foundations, since the small size of the machine, together with the absence of vibrations, cause disturbances minimum in foundations or structures to be underpinned; Little intrusive solution suitable for complex old buildings in densely populated urban environments, due to the smaller need for a yard area and lighter means of transport and reduced dimensions of the drilling equipment. Possibility of carrying out structural reinforcement work with minimal impact on existing structures and compatible with the normal functioning of buildings; Possibility of implantation in tight spaces, both with ceiling height limitations of up to 2.20 m, as well as limitations in terms of available space in the plan, given the reduced dimensions of some of the drilling equipment. Low cost when it is economically unfeasible to improve existing foundations. Equipment versatility. Allow to be implemented with different inclinations [43].
Anchoring with injected sleeves	The “CINTEC” system is an anchoring system, consisting of a resistant element surrounded by a woven sleeve which is filled using a special inorganic grout. The shape and dimensions of individual components can be varied to meet different design requirements. This work is intended to ensure the improvement of the connection between orthogonal walls, namely when these connections are affected by cracking; exceptionally, it can be carried out as a way to solidify walls affected by cracking of great importance [43].	Moderately intrusive technique; confinement of sealing mortar; improvement of global stability with reinforcement of the connection between structural components; improved visual appearance; recovery/increase of resistance capacity [43].
Roof waterproofing	Interventions on the roofs aim not only to correct existing anomalies, which sometimes occur occasionally, but also, and whenever possible, to adapt the respective structures to new requirements arising from the regulations in force. These anomalies are consequences of excessive deformation, degradation of support elements, degradation of ceramic tiles, accumulation of debris, existence of cracks/fractures, development of vegetation, color change, damp spots, etc. [44,45].	The moderately intrusive technique; Use of original materials and readability of the intervention (reinforcement of elements with steel parts); Increased strength, rigidity and bracing capacity of masonry walls; Execution of thermal insulation and correct application will significantly reduce the risk of condensation; Facilitate the normal drainage of rainwater and prevent its accumulation, in the correction of slopes; Ensuring functionality and safety characteristics of the roof, in the punctual replacement of elements; Thermal comfort; Reduce the likelihood of condensation occurring [44,45].

Table 6. *Cont.*

Practices and Techniques	Description	Benefits
Rehabilitation of wooden beams	In general, as there has been no relevant change in the conditions of use or support of the pavements, it will be in repair situations, so interventions will largely be dealt with by removing the damaged material with the replacement of material rotted by the action of humidity and/or attacked by fungi and insects [38,46].	Easiest solution to run; Fill existing voids in the wood; Reinforce the mechanical behavior by placing metal rods or polyester bars; Maintenance of original materials; Reduced intrusiveness; Very versatile and efficient system; Cost-effective solution [38,46].
Consolidation of masonry by injection	The masonry consolidation technique by injection consists of introducing grout through previously drilled holes in the exterior walls of masonry, for filling interior voids and/or sealing cracks, changing the characteristics physical and mechanical characteristics of the masonry material [38,46].	Improvement of mechanical resistance, reinforcement of its internal cohesion; They can also be made in soils, increasing their load capacity; Promote the improvement of the conditions of connection between its elements; “Multiple-ply” walls, this technique also allows for consolidating the generally weak inner core; Preserves the original appearance of the walls [38,46].
Roof insulation	In the traditional roof, insulation serves as a support for waterproofing, with the need to place a barrier to the vapor under the insulator, due to the permeability of this solution to water vapor. The protection layer (light or heavy) depends on the accessibility of the roof [39].	Waterproofing stability; Secure installation; Resistant to the force of winds; Excellent thermal delay; Excellent sound insulation; Durability [39].

4. Results

4.1. Rehabilitation Private Buildings

Regarding the interventions in private buildings in the parish of Machico, since the completion of the PERU de Machico, in June 2018, around 20% (Figure 14) of the planned rehabilitations were carried out. Some support was required, especially with regard to the reduction of tax rates and taxation in the field of action of the ARU. Even so, the support requested was minimal compared to the one executed, possibly due to the lack of information regarding the tax benefits promoted by the municipality and, in specific situations, due to the lack of legality of the inherent process.



Figure 14. Interventions—ARU Machico (Source: Authors).

In the case of the Machico PE, Figure 15 shows some examples of private interventions with a before and after record. In the figures on the left there are two housing buildings that are currently in local accommodation, and two others on the right are commercial buildings.



Figure 15. Private buildings rehabilitated at Machico ARU. (Source: Authors).

Regarding the Porto da Cruz PE, 20% (Figure 16) of the planned renovations were also carried out, however only 4% of these renovations benefited from the reduction of tax rates and taxation within the scope of the ARU.

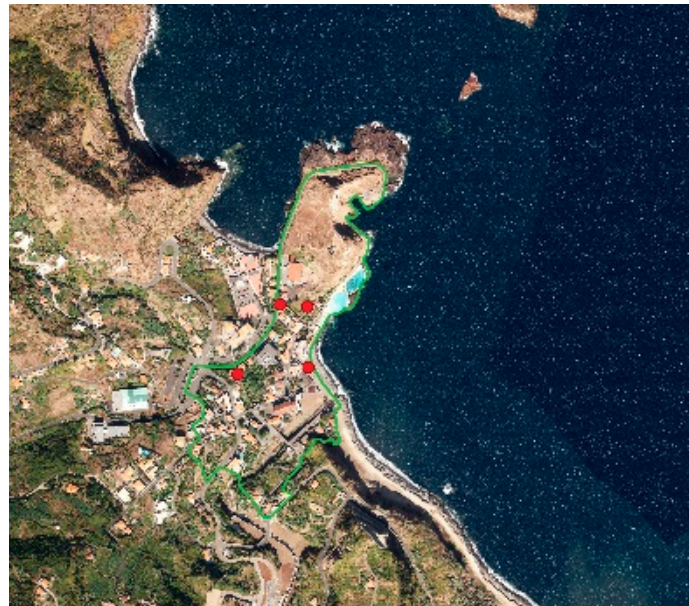


Figure 16. Interventions—ARU Porto da Cruz (Source: Authors).

Likewise, Figure 17 shows some examples of private interventions (before and after), all of them residential.



Figure 17. Private buildings rehabilitated at the Porto da Cruz ARU (Source: Authors).

For both Porto da Cruz and Machico, the following occurred over three years (2019–2020):

- 50% of the completed private works committed illegalities in the rehabilitation of the building;
- It is worth noting the tourist potential of some works in the historic center of Machico;
- Some support was requested, namely with regard to the reduction of tax rates and taxation within the scope of the ARU, and in a specific case the execution of projects was requested;
- A large-scale enterprise required support from IFRRU.

Even so, the support requested was minimal compared to what was executed, possibly due to the lack of information regarding the benefits promoted by the municipality and, in specific situations, due to the lack of legality of the inherent process.

4.2. Rehabilitation of Municipal Buildings

In terms of public interventions since 2018, several interventions have been counted in Machico, making up a total of 45% of the planned interventions, and some of these interventions are shown in Figure 18, such as:

- Partial rehabilitation of the Machico City Council building;
- Rehabilitation of public spaces with the design of a Sports Space;
- Rehabilitation of green spaces with the creation of a Dog Park;
- Rehabilitation of the municipal “Old Butcher and Slaughterhouse”.

In Porto da Cruz, only two interventions were recorded, visible in Figure 19, which were:

- Rehabilitation of Praça Velha;
- Rehabilitation of the Porto da Cruz Pier.

For both Porto da Cruz and Machico, the following occurred over three years (2019–2020):

- Regarding the other buildings and public spaces, none of them were fully completed, although some of them had specific interventions within their scope. This is essentially due to the Municipality’s budgetary unavailability and lack of European financial support.



Figure 18. Rehabilitated municipal buildings in Machico's ARU (Source: Authors).

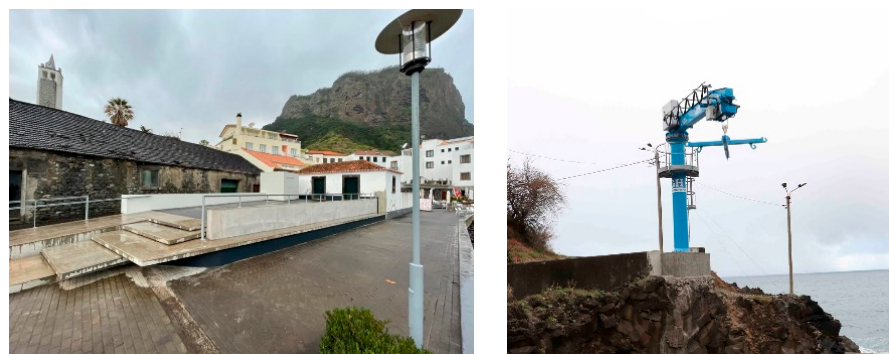


Figure 19. Rehabilitated municipal buildings and public spaces in the Porto da Cruz ARU (Source: Authors).

4.3. Analysis of the Sustainable Development of the Territory

The starting point for the analysis of this theme is related to the need to understand how interventions in urban rehabilitation are meeting environmental sustainability factors, in particular with the integration of measures that promote energy efficiency in buildings, contributing to the reduction of the energy bill, as well as carbon dioxide (CO₂) emissions, resulting in the improvement of health, well-being, and comfort of populations.

From the outset, it is important to bear in mind that the issue of urban rehabilitation has become a new dimension of urban policies, largely as a result of the crisis in the sector. Its role as an instrument of public policy that aims to respond to urban decline and that involves many other aspects in addition to physical rehabilitation, such as environmental requalification, economic revitalization, and social and cultural integration, which also contributed to this [47].

There is also a widespread awareness that one of the biggest problems facing contemporary society is excessive energy consumption. This is mainly due to the increase in standards of comfort and quality of life, which results in the mass use of products and equipment with high energy consumption [47].

In this perspective, it is urgent to emphasize that one of the sectors with the greatest weight in energy consumption is the buildings sector, which is responsible for the consumption of approximately 40% of final energy in Europe, and about 30% in Portugal, and

more 50% of this consumption can be reduced by introducing measures to improve energy efficiency [48].

What is at stake in this reflection, then, is knowing what will be necessary to achieve a more consistent relationship between urban rehabilitation and energy efficiency. It is at this level that the research carried out intends to make a contribution.

The integration of sustainability concerns in the construction of a building implies an ongoing process, consisting of a set of diversified measures that must be fully assumed and made compatible with the different stages of the life cycle. However, reality shows that the building envelope is one of the elements that most influence energy consumption for air conditioning, and this element is responsible, on average, for 25% of the total energy consumption of a residential building [49].

It is, therefore, in this context that the energy rehabilitation of buildings is considered to be a great opportunity to correct situations of functional inadequacy, providing an improvement in the thermal quality and comfort conditions of its occupants.

In the rehabilitation constructions defined in PERU of Machico and Porto da Cruz, sustainability principles were defined that consider the three dimensions of sustainability (environment, economy, and society) throughout its life cycle. It was these sustainability principles that served as a guide for the various rehabilitations to be carried out in order to contribute to the sustainable development of the Municipality of Machico, since in each of the rehabilitations there was always the commitment of all the intervenient to comply with the following Principles [50]:

- Rational Use of Energy: aiming to reduce energy consumption in buildings through the use of more efficient equipment and the use of renewable energies;
- Use of Passive Solar Technologies: aiming to make buildings more comfortable and reduce energy consumption, taking full advantage of natural heating and cooling techniques;
- Judicious use of materials: The selection of “environmentally friendly” materials can reduce negative effects on health, minimize waste, reduce the energy embodied in materials and eliminate other impacts upstream of construction;
- Water use: reduce water consumption inside and outside buildings by using more efficient equipment, capturing and using rainwater, water used in washing and designing gardens that require less water;
- Building placement: minimize the impact of the building on the construction site, promote integration into the urban environment, and protect occupants from noise pollution;
- Other impacts: Any other possible construction impacts should be carefully analyzed e.g., transport, health, and safety.

The importance given to the integration of sustainability principles in urban rehabilitation processes is remarkable as an imperative factor for the sustainable development of the Territory, enhancing the adoption and implementation of good sustainable rehabilitation practices, defined in PERU, that lead to environmental and energy performance, to the improvement of comfort conditions of users, with a direct impact on the reduction of the energy bill, with a view to an evolution towards the qualification of the built environment and, consequently, of the urban environment [51].

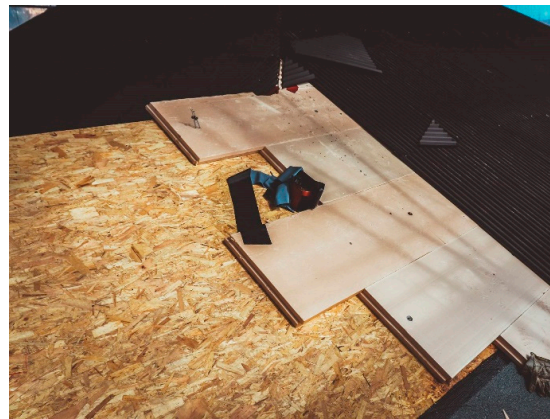
All rehabilitations oriented by PERU had energy rehabilitation as a maximum, emerging as an innovative and promising approach for correcting situations of functional inadequacy, providing the improvement of thermal quality and comfort conditions of its occupants, allowing to reduce energy consumption for heating, cooling, ventilation, and lighting, also contributing to the strategic objective of reducing the energy needs of the country and the region and enabling, in many situations, the correction of certain pathologies linked to the presence of humidity and the degradation of the visual appearance of buildings. Table 7 presents a brief systematization of the main energy rehabilitation measures adopted in the various renovations which contributed to improving the comfort of its residents and reducing energy costs.

Table 7. Energy rehabilitation measures (Source: Authors).

Exterior walls (Figure 20)	<p>Reinforcing the thermal insulation of exterior walls has the main advantages of reducing energy consumption and increasing thermal comfort, and can be achieved through three main options, characterized by the relative position of the thermal insulation to be applied:</p> <ul style="list-style-type: none"> - External thermal insulation; - Interior thermal insulation; - Thermal insulation in an air gap (limited to the case of double walls).
Floors (Figure 20)	<p>Intervention at the level of the floors is essential when they are in direct contact with the outside or with unheated interior spaces (garage, uninhabitable basement, etc.). There are three main options for reinforcing the thermal insulation of floors, depending on the location of the insulation:</p> <ul style="list-style-type: none"> - Lower thermal insulation; - Intermediate thermal insulation (limited to floors with voids); - Superior thermal insulation.
Roof (Figure 20)	<p>The roof is the constructive element of the building that is subject to the greatest thermal amplitudes. The thermal insulation of a roof is considered a priority energy efficiency intervention, given the immediate benefits in terms of reducing energy needs, and because it is one of the simplest and least expensive measures. In addition, an intervention on a roof, carried out to solve a waterproofing problem, could easily be “extended” to include the application of thermal insulation on that same roof, the extra cost of this solution being practically equivalent to the cost of the material.</p> <p>There are several constructive solutions for the application of thermal insulation on roofs, depending on whether they are inclined or horizontal.</p>
Glazed windows (Figure 20)	<p>Thermal rehabilitation in glazed spans aims, on the one hand, to reinforce the building’s thermal insulation, reduce uncontrolled air infiltration and improve natural ventilation, and on the other hand, increase the capture of solar gains in winter and reinforce the protection from solar radiation during the summer. All these measures will contribute not only to reducing energy consumption needs but also to improving comfort conditions and air quality inside buildings.</p> <p>Taking into account the stated objectives, there are several alternatives for constructive solutions for the rehabilitation of glazed spans, although we do not want to present them here.</p>
Lighting (Figure 20)	<p>In terms of energy and visual comfort, natural light is the most rational way to light up a space. The concern for optimizing the use of natural lighting must be present from the beginning of the development of the building project, whose spaces must be located, organized, and oriented in line with this objective and be equipped with lighting spaces suitably positioned and sized, taking into account the functions foreseen for these spaces and the activities that will be carried out in them. For example, it is impossible to naturally light spaces with a depth typically greater than twice the ceiling height. In these cases, it is necessary to foresee more than one opening, choosing the appropriate locations so that all areas receive natural light (two-way lighting).</p>
Ventilation (Figure 20)	<p>Natural ventilation in residential buildings should be general and permanent, with air entering through the main compartments (living room and bedrooms) and exiting through service compartments (kitchens, bathrooms, and pantries). The autonomous ventilation solution for each room is not the most suitable. Thus, solutions must be implemented that allow adequate natural ventilation and whose ventilation procedure must include:</p> <ul style="list-style-type: none"> Air intake openings in the main compartments (windows must not allow excessive air infiltration); Air passage from the main compartments to the service compartments; Service compartment air evacuation openings, connected to individual or collective air evacuation ducts to the outside; Limitation of the air permeability of the exterior envelope, namely in windows and shutter boxes.
Domestic hot water heating (Figure 20)	<p>Installation of a more efficient and appropriate water heating system, taking into account the number of users and usage patterns, it is possible to reduce energy consumption, with the inherent advantage of reducing energy costs.</p> <p>It is worth mentioning the contribution of solar thermal systems which, for most of the country’s climate zones, allows savings of around 50% in annual costs with the preparation of Domestic hot water heating.</p>

In Figure 20, it is possible to observe some of the Energy Rehabilitation Measures previously described.

The existence of a two-way relationship between urban rehabilitation and energy efficiency is highlighted, and the need for measures in terms of energy efficiency is an inducer of the development of urban rehabilitation. The need to rehabilitate degraded urban fabrics is a promoter of improved energy efficiency of the buildings and, consequently, of the sustainability of the City of Machico.



Roof isolation



Ventilation



Domestic hot
water heating



Floors

Figure 20. Cont.



Lighting



Glazed windows



Exterior walls

Figure 20. Public Buildings Energy Rehabilitation Measures (Source: Authors).

In this way, the implementation of measures in the area of energy efficiency, defined in PERU, contributes to a more sustainable urban rehabilitation, enabling the sustainable development of Machico and other several benefits, including [52]:

- Increased urban attractiveness and competitiveness;
- Increase in the number of dwellings available on the market and therefore in the number of dwellings for rent;
- Decreased consumption of natural resources;
- Reduction of waste in the use and appropriation of land, infrastructure, or urban space;
- Improvement of living conditions in urban centers;
- Fostering the more sustainable use of built environments;

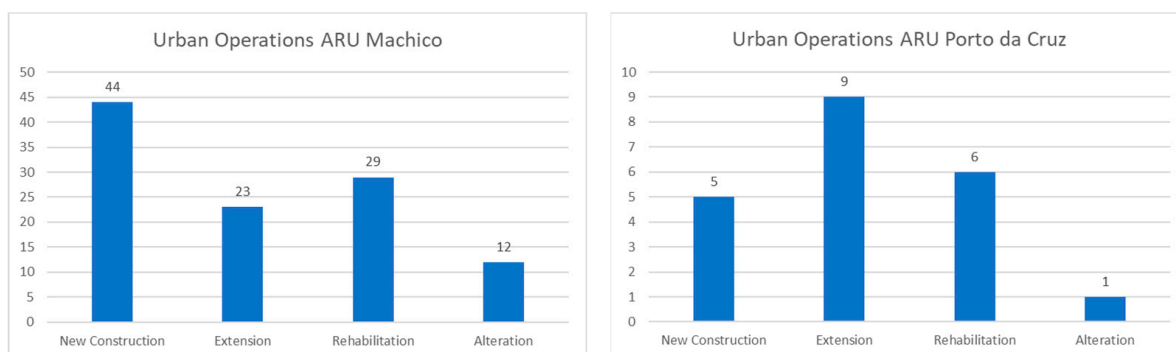
- Promotion of more sustainable urban socio-economic experiences;
- Improved management of built spaces.

It is understandable, therefore, that great attention is devoted to promoting energy efficiency in urban rehabilitation operations (covering, among others, buildings, equipment, communication routes and public spaces, or transport), as an alternative solution, capable of fostering sustainable urban development strategies.

5. Discussion

Urban rehabilitation is the third way between renovation and expansion. It implies lower costs than the expansion of the peripheral city, preventing and reversing the process of obsolescence, physical, functional, image, and location. It is a tool that will facilitate the valuation of buildings. It will respond to the problems of deterioration of urban fabrics, bridge the gap between the past and the future, provide financial efficiency despite the costs inherent to its realization and maintenance, facilitate the revitalization for the active use of the area, and contribute to the maintenance of elements of the local lifestyle (high density, interpersonal contacts and mixed land use). It improves the urban environment and creates an attractive positive image for investors, residents, and visitors, thus enabling the economic profitability of space and buildings in the municipality of Machico [53,54].

By observing Scheme 1, we conclude that the second most used urban planning operation after the approval of PERU is Rehabilitation, both for Machico and Porto da Cruz, thus demonstrating the positive effect of the document in the rehabilitation of private buildings.



Scheme 1. Urban Operations in Machico ARU (left) and Porto da Cruz (right) (Source: Authors).

Comparing the results obtained with other studies (with similar characteristics, the following is verified—Systematic ARU and ORU), only 20% of the studies conducted by Portuguese municipalities showed similar results, most of them being ARU areas that were particularly small. The other 80%, such as [55–57], proved that the definition of ARU has been a huge success.

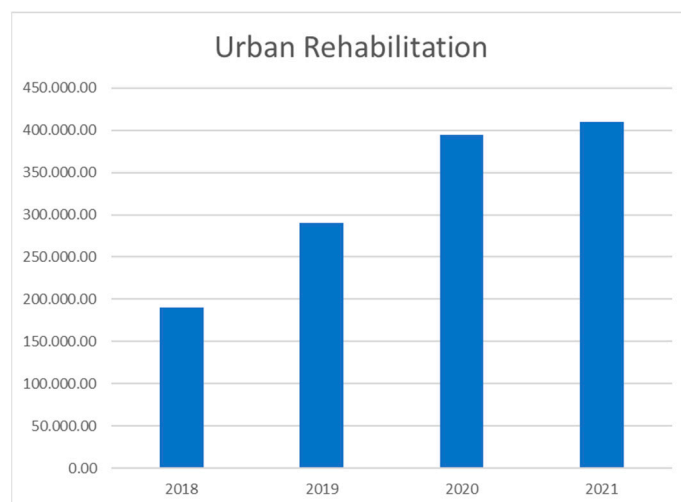
It is also possible to perceive that in Machico there is much more rehabilitation than in Porto da Cruz. This is due to the fact that Machico has a greater attractiveness. Machico is located to the south with a very pleasant climate, a greater historical atmosphere, more attractive architecture, and a greater variety of transport. It is close to the airport and close to essential services.

The “weak” adhesion of the population to urban rehabilitation could translate into little promotion of PERU among individuals. In order to promote rehabilitation, the Municipality will have to carry out awareness-raising actions among individuals, publicizing the tax benefits through seminars.

After analyzing the urban processes, it was verified that there are properties that need a distinguished reflection, within PERU and according to the RJRU, since it is noted that there are some empty plots within the ARU, which will be built, will be new construction, and to that extent many of these building situations will promote the rehabilitation of

the area where they are part of a whole. It is understood, therefore, that these particular situations must be analyzed on a case-by-case basis, verifying the existing urban context in the surroundings, whether or not these spaces can guarantee the rehabilitation of the area and, if necessary, also benefit from the incentives developed by the Municipality related to urban rehabilitation.

Regarding public works, it can be seen by analyzing Scheme 2 that since the approval of PERU, urban rehabilitation operations have increased significantly, with their highest value in 2021. In the last four years the rehabilitation processes had a significant increase, especially from 2018.



Scheme 2. Urban Rehabilitation, ARU of Machico and Porto da Cruz. (Source: Authors).

The increase in public works from 2018 to 2021 is verified in about 95% of other studies [58–60]. Public investment in areas that demonstrate diverse structural urban fragilities is essential. Through these investments it is possible to establish strong territorial connections, namely at a functional level, due to the fact that they are located near public equipment and services.

It appears that through coordinated work, based on the specificities of the territory and its strengths/weaknesses, it was possible to define this fundamental plan/project for the rehabilitation of the ARU in Machico and Porto da Cruz.

At the time of reviewing the Municipal Master Plan of Machico—PDM, this work has proved to be even more important in terms of the implementation of plans and projects for a 10-year horizon, which can be extended to 15 years if this is expressly demonstrated.

PERU thus assumes the role of engine for the development of the Municipality of Machico, albeit in a timid and little-systematized way. It is important to note that in relation to PERU, strategic monitoring is necessary in order to identify obstacles, synergies, and opportunities that present themselves over the years.

Among the two ARUs in the municipality of Machico, the existing ARU in the parish of Machico has potential for its redefinition, expanding its area since there are many buildings on the “border” with great potential to be rehabilitated. This new ARU will be one of the most important for the municipality, presenting several advantages for the rehabilitation [61]. Figure 21 shows the proposed expansion of the Machico ARU.

It is considered pertinent to a new delimitation of the Urban Rehabilitation Area in the Municipality of Machico to, referring to the previous strategic framework, update its incidence online with what has already been driven and supported by the municipality in this aspect of urban rehabilitation through multiple national programs. This is also in line with what has been envisaged, within the scope of the ongoing procedure, by the review of the Municipal Master Plan, with regard to consolidation strategies, clogging, rehabilitation, regeneration, and urban reconversion [62].



Figure 21. Redelimitation of the Machico Urban Rehabilitation Area (Source: Authors).

It will also add to blurring arising from supranational support and funding programs such as the Recovery and Resilience Plan (PRR), whose eligibility conditions have not yet been established, anticipating that both the financing lines and its scope will become significant and may determine different directions in what relates to municipal investment options [62].

6. Conclusions

PERU plays a strong role in the sustainability and vitality of urban centers, either through the regeneration and urban requalification associated with it, or through its intimate connection with the need for renovation and improvement of existing infrastructure (water supply networks, drainage networks, telecommunications and electricity supply networks, green spaces and equipment for collective use, among others), not forgetting the fundamental role of adopting energy efficiency measures in the rehabilitation of buildings, with a view to reducing energy bill and the simultaneous valuation of the final product in environmental terms.

PERU thus assumes a fundamental role in the sustainable development of the county, promoting the return of people to the cities, in particular to their historic centers, inverting the logic of expansion of cities to the detriment of the revitalization and requalification of the park and existing real estate. The commitment to urban rehabilitation in differentiated areas, as a way of reconvert public space and improving infrastructure, should arouse private interest in rehabilitation and foster the various existing experiences within the ARU.

It is also important to emphasize the dimension of PERU in local economic development, from the perspective of the real estate market and in public investment. The results of the study showed that the Municipality of Machico faces some challenges in the implementation of sustainable urban development programs. These challenges have intensified, largely due to the recent financial and economic crisis, which could limit the existing funding to fund sustainable urban development programs and the means available to carry out the necessary actions.

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