TRANSFORMATION OF INFORMAL SETTLEMENTS: CASE OF CAPE VERT

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Abstract

The non-existence of a land ownership database in most of the developing countries moves the inhabitants to the occupation of public lands. Some of this situation are the origin to areas of informal housing, commerce and agriculture and in the end into new informal settlements. Informal settlements become a serious problem in developing countries. The most common typology of informal settlements is that they are the population settled in public lands without any infrastructures and against the administrator's will. Thought this action the result in an uncontrolled land occupation process that promotes new informal areas without any proper built-up utilities, located in risk areas on the territory, barely ensuring the minimum requirements for a heaty living of the population and in various cases incentives to an informal economy. The process of build a cadastral map in informal settlement areas is a fundamental base to support the future transformation of illegal areas and to regulate the occupation of new subdivision planning and into the creation of new expansion areas. In this paper, it is presented a methodology developed to be applied to support a new register of land and to management. The transformation of informal settlement areas. The model to register the land tenure has been associated with allows the process application to multiple typology of informal settlements. The model to register land tenure has developed on a series of qualitative and quantitative data that determine the identification and classification of the buildings and its physical and functional description. The model was developed using Geographic Information System and with an initial survey of existing land titles of possession and public proposals to develop new expansion areas. A case study of the method is presented, where the land management model was implemented - Chã da Caldeiras in Ilha do Fogo an informal settlement in Cape Verde. The results are a great acceptance of the proposal by the population and local authorities and the starting of the implementation phase.

Keywords: Sustainability; Urban Planning; Parametric model, Informal Settlements, GIS

1. INTRODUCTION

Informal settlements present a large percentage of urban areas in developing countries with an important human occupation (Durovic & Nikolic, 2016). These settlements in general are composed of buildings without a construction license or legal and technical documentation, which promotes the destruction and contamination of land over time and the reduction of the capacity to clear planning activity in the territory and to developing new opportunities. One of the common settlements is the social segregation of the population: social, physical and spatial, between settlements and the surrounding formal areas (UN, 2015). In the last decades we have assisted to the transformation of the international thinking about this settlement and in the urgency to develops answers to solve immediate problems. For many years, those were an urban problem, promotes the demolition of these areas and defends the inhabitants' relocation into formal areas as the single way to solve them. However, this perspective has been changing, not only because the relocation becomes financially enforceable but also because these settlements had begun to be recognized the social and economic hubs at its own way, by having social and economic capital that should be encouraged to grow (Durovic & Nikolic, 2016; Anguita, 2006). However, it is well known that informal settlements without any ownerships and land management promotes large problems in terms of public spaces and utilities, transportations, hygiene, environment, organization and legal land solutions (UN, 2015; Holland, 2015; UN, 2018; Imbroscio, 2013; Wong, Thomas & Chan, 2010). In this way, it is essential to introduce or improve the land administration systems that allows achieving the sustainable development of those settlements. As referred in the 2030 Agenda for Sustainable Development, land should be protected and sustainably managed for social cooperation, security and order [UN, 2015; UN 2018, Roberts, 2000). The existence of a land administration system allows to identify, register and share information about the use of land, according to land policies, by using information technologies efficiently, to making this a key factor (Hofstra & Huisingh, 2014; Allaghan & Colton, 2008; Alison, 2012, Amado et al, 2017). Land policy is known as the way of governance approach to land issues, its access, administration and use (Aydinoglu & Bovkir, 2017; Paulsson & Paasch, 2015; UN-ECE, 1996). An effective land administration system is an essential element to ensure the correct use of the land and the sustainable development concerning the social, legal, economic, environmental and technical framework (Uzun & Simsek, 2015; Kuyucu & Unsal, 2010; Uzun & Cete, 2018). One of the land administration system element is the cadastre. A record is a public data register related to properties and ownership of the land (e.g., rights, restrictions and responsibilities), methodically organized, based on a survey of their boundaries (Dundar, 2001; Amado et al, 2017; Lemmen, Oosterom & Bennett, 2015) and legal title of possession. The cadastral system assists an efficient land market, effective land-use administration, and in an opened way, promotes the economic development, social cohesion and sustainable development (Steudler, Rajabifard & Williamson, 2004; FIG, 1995; Corlazzoli & Fernandez, 2004; Ali & Shakir, 2012) the informal economies growth is at least related to the population. Also, some authors consider the transformation of settlements as being a risk because it cannot be determined in the stark the return of the investment, but in another way the necessity to provide a better quality of live in urban areas makes compulsory to be implemented actions for stimulating the investment and the regulation of land occupation. Therefore, in this paper, a methodology has been developed and applied to generate a new land management system for informal settlement areas. The methodology developed is based on 4 fundamental steps: analysis and survey of existent land occupation; design of a parametric model; topologic definition of new parcels; and development of the cadastral model solution. These steps are described in detail in the next section. Chã das Caldeiras, located in Ilha do Fogo, Cape Verde is a good example of an informal settlement without land registration and regular cadastre. According to context Cal Boas has been selected to be a case study to apply the developed methodology, and is presented in the third part of this paper. By applying this methodology, it was possible to achieve the compact urban

area, ensuring the minimum living conditions and balanced social offer among the different land uses, ensuring equity to all stakeholders, through a transparent and fair process for both the population of the Fogo Island and the State of Cape Verde. The results obtained approval from the Government of Cape Verde, the Municipal Entity involved in the plan. The public participation of people covered by the plan led to a growing relationship between different sectors of the understandable population in decision-making. It's a reality that we cannot deal with all the complexity of the reality at the same time, so we use models who helps to reduce the complex and to promotes something we can understood (Cilliers, 2004).

2. METHODOLOGY

The necessity to coordinate and support the planning process requires the existence of a framework and a clear definition of all issues inside the task needs to be done (Rittel & Webber, 1973). Also, the approach to an interdisciplinary challenge to solve the problem allows to think as a system and not on individual subjects.

Since this, the conception of the cadastral model to an informal settlement intends to ensure, in a rigorous way, the limits area and the dimension, occupancy and the title of propriety of existing parcels in the settlement (Amado, 2018).

The proposed cadastral model is defined by a series of data that systematizes the identification and uses on the parcels and buildings, both urban, rustic and mixed origin, its physical and functional description, as well as their occupants. Besides that, creates the data base to support to the definition of new parcels and to design the expansion of the settlement area.

Step 1 - Analysis and survey of existent land occupation

The step 1 has the main base to the creation of a future cadastral record and an analysis point of the settlement topologic area's: physical, social, economic and environmental.

Regarding these goals the no-inexistence of any topographic survey map in this area who is necessary for support the creation of the database is the first action to be done. This database is composed of around raster images that allows a visual backdrop and by the building or parcel's polygons that allows the addition of a code identification to each parcel.

A land parcel is the basic unit number in the cadastral system. To each parcel a singular code is assigned, being that presented on a cadastral survey plan, along with its dimensions and geographic position.

The preparation of the register of existing occupation is based on an on-site work, mapping and characterising all the existing buildings and their limits and surrounding areas, inside the settlement limits. This actions and type of system will only be legit and credible if all the process is followed and the participation of local community (Amado et al., 2016; Abbott, 2003; Rao, Sharma & Rajashekar, 2014).

The cadastral surveys require that land occupants should be consulted to identify and localize the register cadastral boundaries. In addition to the parcel limits, is compulsory to collect all the physical-spatial data existent, as topographic and natural features and any additional characteristics such as water standpipes or latrine structure. At last, it is necessary to collect socio-economic data, as the chief of the family or household name and the number of people per dwelling.

It is essential to guarantee a rigorous survey of the existing land use, to ensure a future correct planning process. It is essential to identify common elements in the land use survey, as a correct

functional and activities identification on the territory to achieve a proposal urban model that reflects life's reality according the occupation area in present and future transformation.

All the collected data should be subsequently computerized, using Geographic Information System (GIS) and data base. Different authors (Abbott, 2003; Amado et al, 2017; Paulsson & Paasch, 2015; (Durovic & Nikolic, 2016) point the utilisation of GIS as fundamental to defined and support future land development, management and planning decisions.

All the collected data should be complemented with a set of environmental, morphologic, legal, risks and social-economic analyses, namely the identification of relations between the quantitative and qualitative data and their overlap by using geographic information systems (GIS).

A correct analysis and interpretation of the collected data, as the traditional social behaviours, is essential to achieve a logic and fair solution as a guarantee of an efficient model, accordingly to the settlement reality.

Step 2 - Design of a parametric model

Step 2 is based on the evaluation of all physical components that compose the existent occupation on the settlement and of the urban and rural living patterns, identified in the first step.

After understanding the structure, composition and the profile of the analysed community, it is necessary identify the parametric elements of the multiple existing parcels. Those elements will work as a base element that will allow identify the type of occupation pattern.

Also, the relation of the number of family elements, the activities promotes in housing or parcels helps to establish a referential pattern to future transformation of the informal settlement.

In this way, the parametric model created helps to the conception of a new parcel typology who after discussed with the population can be implemented in the intervention areas and make into to a participated process of transformation (Amado et al., 2016).

Those parameters are also essential to adjust the existent land use to a regular urban design. It should be made an adaptation of the parcels design to guarantee area for infrastructures channel and public spaces. These parameters should lead to fair and participatory adjustments of the occupied areas since the transformation to something that the population's needing.

Step 3 - Definition of new parcels

The step 3 has the main objective of implementation of additional parcels in the intervention area, to achieve a sustainable urban transformation of the informal settlement in an inclusive way.

One of the urban planning process is the urban land tenure solution. It is an organised method where the structure of the parcels boundaries is modified but keeping the landowners unaltered.

Urban land consolidation has been increasingly used in multiple countries as an instrument to implement measures to urban development ((Durovic & Nikolic, 2016; UN, 2015, Amado et al., 2017; FIG, 1995; Abbot, 2003) and to establish a base for future tax system.

In a planning process like the presented, it is necessary to interact with three different situations:

i. The first one is related to the potential relocation of the building, when the identified characteristics represent a potential restraint, putting the building in a risk classification;

ii. The second one, is related with the necessity to promote on the settlement a network of infrastructures;

iii. The third one is related with the necessity to identify the population needs in terms of services and equipment program and areas required.

The last two points could have impact in the parcels or at the existing buildings. In an informal settlement transformation is necessary to have in mind the fundamental characteristic of the number of existing people living in those settlements, and the individual or collective needs identify in the planning process.

Therefore, by the calculations of the second step, it is defined different typologies to be apply to insight with a transposition and improvement of the living to a new one with better urban spaces with infrastructures.

The description of the typology to be apply to new parcels should be presented in a map which should present the delimitation of the new parcels to reach a justice proposal in the land occupation.

Step 4 - Development of the cadastral model

In step 4 and after defining the new occupation model of the intervention area, it is necessary to register all the parcels (existing, new and transformed) off the cadastre that represents a complete list and documentation of the parcels possessors' rights and responsibilities.

The parcels should be identified, as does their systematization in codes (numbers and/or letters) for the definition of administrative composition. Some data is indispensable in a cadastral frame, in addition to the parcel code, the geodesic coordinates, the multiple dimensions, the use, and others.

Despite this data which characterises the different parcels, it is also necessary to calculate the urban parameters to legislate the occupation and the urban development phases and responsibilities.

The cadastral model should be register in a map, with legal force and its respective urbanistic parameters and cartesian coordinates frames. These three elements define in a geographically and geometric way the polygons of the transformed and of the new parcels as their reference codes.

3. CASE STUDY

The settlement of Chã de Caldeiras as not be planned to have permanent residence since is capacity to agriculture and wine industry. However, the number of local population increase on the last 15 years because the touristic activities and of the investment of national entities to investment in the recognition of Chã das Caldeiras as a World Heritage Site.

Almost the actual population born there and have a related family live by. Local family have a media of 8 persons and the opportunities to have a source of local income are very low. The occupation of the territory are not defined neither regulated or served with utilities.

The area of the study is pointed in red on the Figure 1, and shows area of Chã das Caldeira an informal settlement located on Ilha (Island) do Fogo at Cape Verde.

The Chã das Caldeiras settlement have all his area inserted in the Natural Park of Fogo (Parque Natural do Fogo) and have a rural classification. The settlements are in the interior of the volcano area and occupied an area of 57, 49 ha also all public lands.

Nearby this population, the Pico's Volcano rises, being the most natural remarkable characteristic of this area and of the island. The most recent eruption event was in end of the year of 2014, and the result affecting all the population of Chã das Caldeiras with a deep impact in housing and touristic facilities and agriculture areas.

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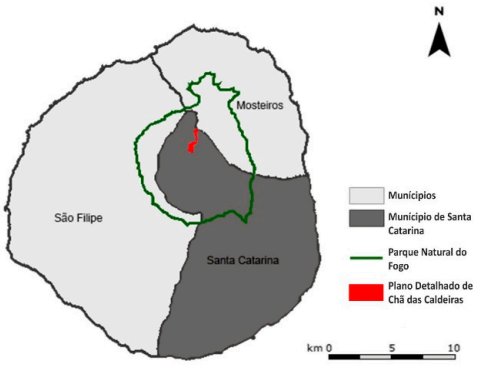

Figure 1. Location of Chã das Caldeiras, Fogo Island, Cape Verde

The settlement of Chã das Caldeiras is formed by two small parts of the informal settlement – Bangaeira and Portela – All the area allows to identify 231 buildings, in its majority single family habitations and a combined population of 675 people. The dominant activities in this settlement are the agriculture and the livestock.

To endow the population of the minimum infrastructures, required to proper living conditions, it was essential to reorganise the urban areas. To make this possible, it was created a methodology to identify the existing parcels and to promote the reorganisation of those.

In this section, it would be present the used method and explained step by step, the implementation of the 4 steps, in its application to the case study of Chã das Caldeiras.

Application of step 1 - Analysis and survey of existent land occupation

The main objective of collecting data about the two parts of the informal settlements are related with the construction of a database, who was initially created using the GIS functionalities as a tool with a preliminary drawing of the multiple elements and probably boundaries to the parcel. This take place based in an observation of orthophoto maps and additional data ceded by local Government.

In order to make the data collecting and organization simpler, the intervention area was divided into multiples sub-areas (19 in total), from A to T, as presented in the Figure 2 and a single code was given to each parcel.

In addition to the base map to be used on the field survey form were created a characterisation form was also created to each one of the parcels. Where the specifications of the parcel are register as the use, number of floors, structural condition, construction materials, and others notes. After, all information was synthesised in a table a summary writes of the analysis an been prepared.

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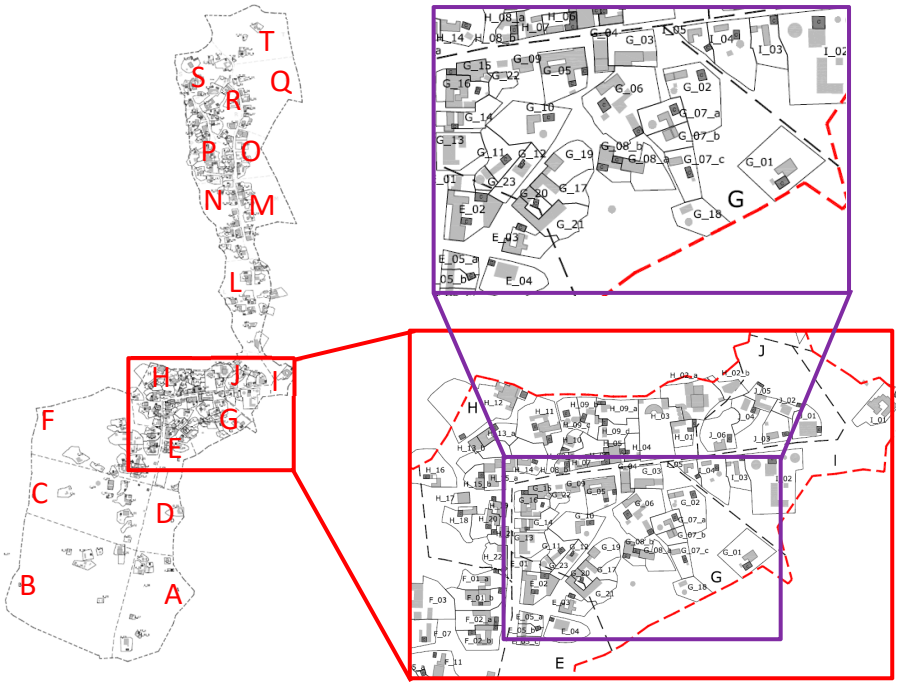

Figure 2. 19 Subdivisions of the planning area – A to T

As mentioned, an on-site survey was completed to provide a strong work base to the next step. The localization of the buildings was register as like as the characterisation of them and the exterior used area, one by one. This way, an on-site work was developed, alongside with the parcel's occupants, where the boundaries of the different parcel elements were actualised and the "users / owners" or their household names were registered as the existence of cistern, agriculture areas, toilets, sceptic holes, and other relevant information (Figure 3).

Figure 3. Correction of the cadastral base maps

In this way, thought the field work, is proceeded a treatment of the collected data, who makes possible to create a cadastral database of the existent occupation, with an actualised chart; a characterisation sheet to each parcel; and a synthesis table with all the relevant data (Table 1) for the next step.

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Table 1. Characteristics of the different parcels (extract)

Parcel code	Parcel area (m^2)	Building area (m^2)	Cistern area (m^2)	Use /Activity	Cistern	Agriculture	Sceptic tank	Floors	Conservation stage	Building materials	Owner	Family number	Possession title
A_04	502,8	80,1	-	Mix	No	Yes	No	1	Good	Concrete Blocks	José Lopes dos Santos	1	N
B_02	788,33	58,85	35,16	Habitation	Yes	Yes	No	1	Reasonable	Stone/ Concrete Blocks	Manuel Lopes dos Santos	3	N
F_03	3279,93	674,11	-	Tourism	Yes	-	Yes	1	Excellent	Stone	Hotel Montrond (Maria)	-	Y
G_06	1341,85	297,78	10,87	Habitation	Yes	Yes	Yes	1	Reasonable	Concrete Blocks	Hernana Fernandes	13	N
N_10	415,10	21,92	12,23	Habitation	Yes	Yes	No	1	Bad	Stone	Julia Pires	3	N

The survey must be complemented with an environment, morphologic, legal, risks and social-economic analyses, all introduce in the GIS (Ali, 2012; Abbot, 2001).

The most relevant analyses to be include in this methodology were (Figure 4):

i. Environment and Risks: Hypsometry, Slopes and strands exposure, geology and lithology, hydrology, climate, land occupation, erosion, seismic and volcanic risks and land slide.

ii. Socio-economic: Population, age and gender distribution, educational level, population structure and employment, economic activities.

iii. Morphology: Structure, buildings use, number of floors, construction materials, conservation, public spaces and natural areas.

iv. Legal: Territorial management instruments and tenure land model.

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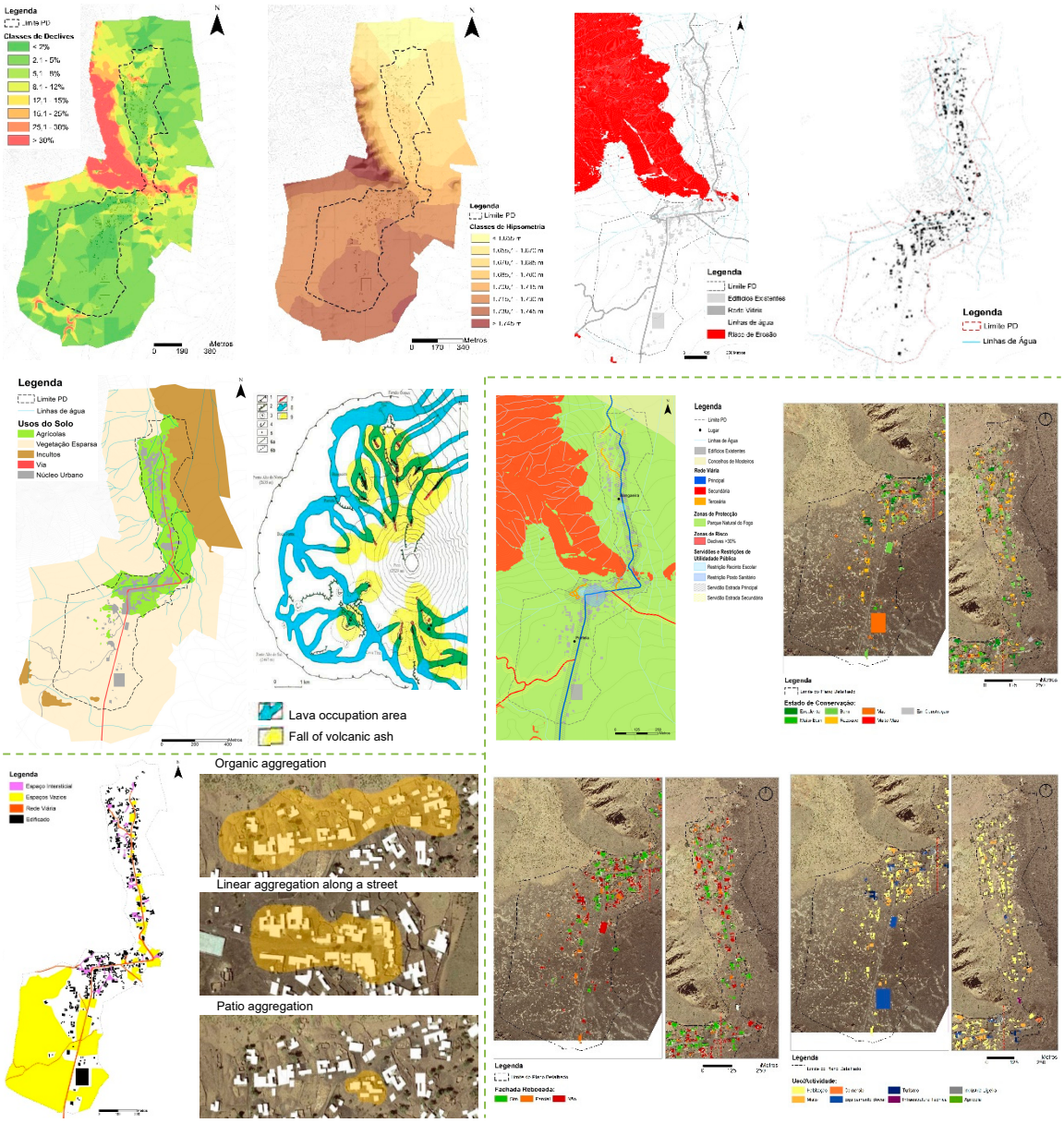

Figure 4. Analysis: environment, risks, legal and morphologic

Application of step 2 - Design of a parametric model

The analysis of the existing physical components, allows concluded that the cistern was the parametric element present in most of the parcels (73% of the parcels). Assume this element as a parametric vector it was joined to another two elements identified in direct observation – the building and the area to agriculture and livestock (Amado et al., 2017). According these three different typologies of land occupation were identified:

i. **Typology 1 (T1):** Composed by the building (house), the cistern and a free area with an unspecified use besides the everyday living.

ii. **Typology 2 (T2):** Composed by the elements of the typology 1 plus an area destined to the

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agriculture or livestock.

iii. **Typology 3 (T3):** Composed only by an area destined to the agriculture or the livestock.

Definition of the physic components of parametric model

In an operational way, the model definition was mostly based on the typologies T1 and T2. For each one of the typologies T1 and T2, the calculation of the parcel' total area (At) has been made defined as the area used by a family in the everyday living (Figure 5).

To each delimited At were identified the different existing physical components:

- Cistern area (Ac);
- Building area (Ab);
- Agriculture/Livestock area (Aa);
- Free area (Af).

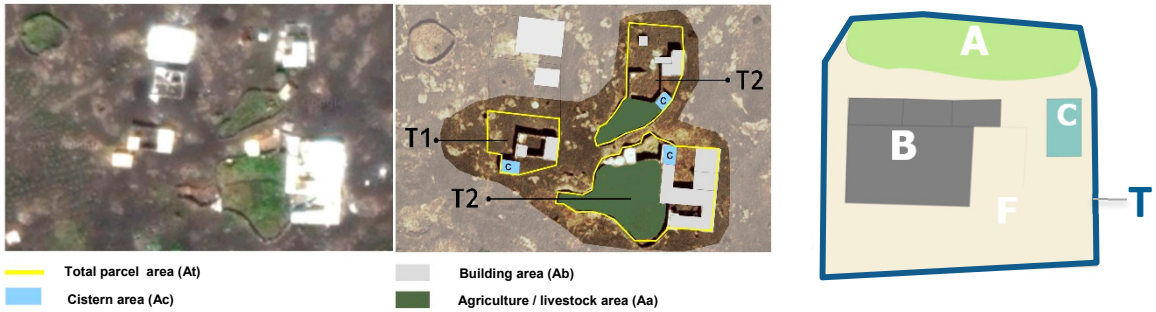

Figure 5. T1 and T2 and schematic identification of each existing physic components

The Af, based on its dimension in T1, was adopted as an unknown factor in the proposed parametric model. Otherwise, the Aa in T2, comes from the Ac and Ab, was adopted as an unknown sub-factor.

Unknown factor calculation – Af

To calculate the unknown factor Af, it was made a sum of the areas Ab and Ac, when the cistern exists, simply using Ab when it doesn't.

$$\boldsymbol{S = \sum_{i=1}^{n}(Ab + Ac)} \quad \text{or} \quad \boldsymbol{S = \sum_{i=1}^{n}(Ab)} \qquad \textbf{(1.1/1.2)}$$

After obtaining the sums (S), Af was calculated, as the differential between At and its respective S, calculated for each typology delimited inside the intervention area:

$$\boldsymbol{Af = At - S} \qquad \textbf{(2)}$$

Table 2 shows an extract of the Excel sheet created to make the data treatment of the different physical components identified in the intervention area.

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Table 2. Areas of the physic components in the different parcels

Parcel Code	At (m2)	C	Ac (m2)	Ab (m2)	∑ (Ab + Ac) (m2)	Agriculture or Livestock	Aa (m2)	Af (m2)
A_05	1317,54	Yes	39,39	276,97	315,36	Yes	818,27	?

Once determined all the Af's, an average Af (Afwa) was calculated as like as its ponderation with the propose of normalizing the multiple values obtained and the most significant deviation in terms of the maximum and minimum areas, resultant from the set:

- Free weighted average area: $$\boldsymbol{Af_{wa}} = \sum_{i=1}^{n}(\boldsymbol{min} < (\boldsymbol{Af}) < \boldsymbol{max})/_{\boldsymbol{n}} \quad (3)$$

Sub-unknown factor calculation – Aa

The Aa was studied in a non-autonomous way, associated to the building proximity, to the cistern, to the Aa and to the dimension which adjusts the habitational vocation wanted to the human settlement.

This way, the Aa of any T2 typology, was determined based on the free weighted average area defined:

$$\boldsymbol{Aa} = \boldsymbol{At} - \sum_{i=1}^{n}[(\boldsymbol{S}) + (\boldsymbol{Af_{wa}})]/_{\boldsymbol{n}} \quad (4)$$

Weighted average calculation of all physical components

Once completed the framework of physical components of the land occupation, the concept of "free weighted average area", has been applied by the formulation:

- Weighted average land area: $$\boldsymbol{At_{wa}} = \sum_{i=1}^{n}(\boldsymbol{min} < (\boldsymbol{At}) < \boldsymbol{max})/_{\boldsymbol{n}} \quad (5)$$
- Weighted average building area: $$\boldsymbol{Ab_{wa}} = \sum_{i=1}^{n}(\boldsymbol{min} < (\boldsymbol{Ab}) < \boldsymbol{max})/_{\boldsymbol{n}} \quad (6)$$
- Weighted average cistern area: $$\boldsymbol{Ac_{wa}} = \sum_{i=1}^{n}(\boldsymbol{min} < (\boldsymbol{Ac}) < \boldsymbol{max})/_{\boldsymbol{n}} \quad (7)$$
- Weighted average agriculture/livestock area: $$\boldsymbol{Aa_{mp}} = \sum_{i=1}^{n}(\boldsymbol{min} < (\boldsymbol{Aa}) < \boldsymbol{max})/_{\boldsymbol{n}} \quad (8)$$

The application of the parametric model to the average areas of the existing land occupation resulted in a normalisation as rigorous as possible of the fundamental elements that configure the new parcels.

Application of step 3 - Definition of new parcels

Multiple factors influenced the proposal, being preponderated those who are linked to the site, topography, urban morphology, land occupation, environmental and social elements.

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According the calculation method of the step 2, three distinct parcels typologies were defined, based on each one uses, aiming for an improvement of the actual living.

- **A-type parcel**

A-type presents a specific housing typology, being the parcels divided in the built area, with a preferential volume of 1 floor, cistern area and considering the remaining area as the free area. These values were obtained by a weighted average of all the referred components, originating the following framework (Table 3):

Table 3. A-type parcel parameters

A-Type	Ab	Ac	Af	Aa	At
Avarage area	122,25m^2	29,63m^2	176,80m^2	-	328,68m^2
Used values	125m^2	30m^2	175m^2	-	330m^2
Ratio	38%	9%	53%	-	100%

- **B-type parcel**

This typology is a mixed-typology divided into four components: A build area, with a preferential volume of 1 floor, cistern area, an area for agriculture and/or livestock and considering the remaining area as the free area (Table 4).

Table 4. B-type parcel parameters

B-Type	Ab	Ac	Af	Aa	At
Avarage area	122,25m^2	29,63m^2	176,80m^2	455,24m^2	783,93m^2
Used values	125m^2	30m^2	175m^2	460m^2	790m^2
Ratio	16%	4%	22%	58%	100%

- **C-type parcel**

C-typology is a typology committed only to the agriculture and live stocking (100% of the parcel area), with the propose of creating rural ordinated parcels, that could be given to typology-A's owners that don't have a area to this finality (Table 5) in his parcel.

Table 5. C-type parcel parameters

C-Type	Ab	Ac	Af	Aa	At
Average area	-	-	-	455,24m^2	455,24m^2
Used values	-	-	-	460m^2	460m^2
Ratio	-	-	-	100%	100%

The urban planning exercise was focused on the equipment definition, in the use of voids, seeking for a regularisation and standardisation of the future land occupation. Based on the multiple analysis process carried out, multiple categories of land use were defined, with the purpose to planning and controlling

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the limit of the settlement development. In this way, it was decided the condition the urban expansion zone and the provision of areas for agriculture and livestock.

Before the model of the land use, a regularisation of the existing parcels' boundaries takes place in order to achieve a consolidation of the settlement that allow defining the area to infrastructures simultaneously. At last, in the zones identified as voids, it was proposed a subdivision of this areas with new habitational parcels and agriculture and livestock parcels, based in the typologies previously defined (Figure 6).

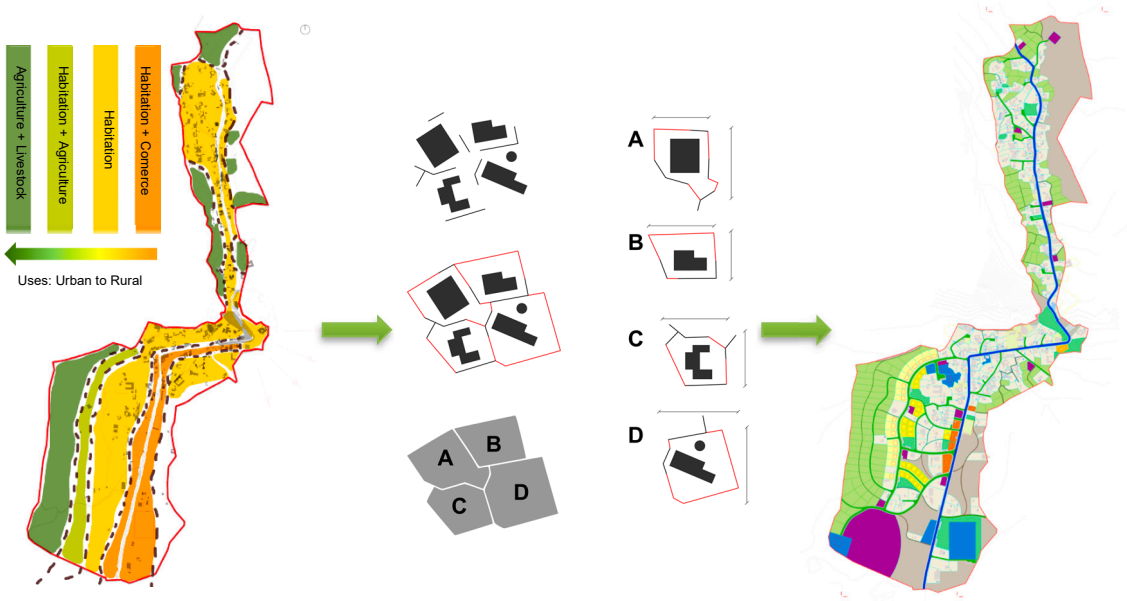

Figure 6. Process scheme

Application of step 4 - Development of the cadastral model

Based on the Cape Verde's regulations, a building characterization is given by its administrative and geographic location, geometric configuration and area, plus a numeric and unique code, designated by building identification number, which its utilisation is required in all public documents.

In this way and considered the characteristics in terms of the predominant land uses of the intervention area, the classification of two cadastral typology were created: urban and rustic. According to this division and considering Chã das Caldeiras in its own social line, it was divided in two different townships, Bangaeira (North) and Portela (South) and it has been elaborated the building and the rustic registration for which one of them (Table 6).

Table 6. Nomenclature adopted to the parcels codification

Township	Registration of the rural building	Registration of the urban building	Parcel
B	R	U	XX
P	R	U	XX

P: Portela
B: Bangaeira

In this way, to each existing parcel and proposed parcel, a code has been attributed, accordingly to their use and location.

Pointing to solution administratively the management and planning of the intervention area, the boundaries of the existing and future occupation were defined accordingly to the urbanistic parameters. In its definition, some factors as the territory load capacity, the land use compatibility and building limitation at the existing situation were defined.

In this way, the cadastral model proposed was transposed in a legal map, with the Urbanistic Parameters table and the Cartesian Coordinates list allowing to identify the boundaries and constitution of the parcels, their geographic location and reference code.

Citizens engagement in the co-design

the way the population participated in the process of co-design followed the whole process and allowed some rewarding results. The advantage of participation in design is real needs to obtain a series of designs that reflect the answers to the real needs and imagination how to live and share in community. It also allowed the local authorities to transcend the necessary moments of contact with the population. In view of the expected need for correctness in the occupied land areas and the reconstruction of walls and fences or the transfer of rights between land users, the participation model chosen by the team was that of plenary assemblies (Reed, 1997). Because of the economic and social context and political reasons, all the workshops and summits take place in the geographic point of junction of the two settlements (Birkeland, 2014; Pearson et al, 2014) with the population interesting and is participation in the formulation of the list of problems it was possible to establish connections between issues and underlighting the interdependence between them. The results were very positive in plenary discussions on subjects as if current settlements had the capacity to integrate new equipment and their location (Figure 7). It should be noted that the expectation of regularization of land ownership has helped the process and its success in dissemination (UN-Habitat, 2011).

Figure 7. Population plenary assemblies

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4. RESULTS

The application of this method resulted in the production of a land ownership database, composed by a cadastral model and a management register and maps.

The management solution obtained allows the municipality to manage the existing occupancy of the land of areas, uses, classes and categories of the land. The Table 7, presents an extract of the obtained result.

Table 7. Extract of the management solution obtained with the method created – Land specifications

Parcel code	Parcel area (m^2)	Land use class – Spatial class	Use category
P_U_1	1472,88	Buildable area – Rural	Tourism area 4.1
P_U_2	570,24	Buildable area – Rural	Tourism area 4.1
P_U_3	731,67	Buildable area – Rural	Residential area 1.1
P_U_4	466,23	Buildable area – Rural	Residential area 1.1
P_U_5	605,48	Buildable area – Rural	Residential area 1.1
…	…	…	…
B_U_103	203,21	Buildable areas – Rural	Residential area 1.1
B_U_104	379,06	Non- built areas – Agriculture/livestock	Agricultural area 6.5
B_U_105	900,00	Channel and Equipment – Technical equipment	Infrastructure area 10.2

The cadastral map obtained by the adopted method, allows a correct look of the land occupation, managing a correct data treatment and planning of the existing occupancy. Figure 7 shows the obtained map georeferenced and supported using GIS.

The correct and details mapping of the existing land occupation allows the municipality to list the existing situation to the further manage the occupation, to rearrange or order it in a fair way to both sides, the occupants and the municipality. An example of its potential is the management of the existing parcel areas and the reordering of the limits from the existing parcels to organise the area to guarantee the needed infrastructures and equipment.

Table 8 is an extract of a board where it was made the adjustments to the existing parcels limits to provided spaces to utilities according a transparent and participated process to the owner of the parcels.

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Table 8. Extract of the management board obtained by the method adopted – Parcels limit adjustments

Parcels Code	Assignment area to roadways hitches (m^2)	Area to roadway hitches (m^2)	Area to roadway hitches (m^2)	Observations
		increase	decrease	
P_U_21	13,02	23,59	-	Road/Public Domain
P_U_22	88,75	20,28	21,06	Road, sidewalk and P_U_26/Public Domain
P_U_23	1,30	-	4,92	Road, sidewalk and P_U_26
P_U_24	-	7,15	-	Public Domain
P_U_25	-	11,61	-	Public Domain

The correct identification of the land uses and occupation allowed, the creation of new parcels, according to the parametric methodology adopted, creating parcels accordingly to the existing needing and according to the existing parcel areas to create expansion area based on the verified occupation areas (Figure 8).

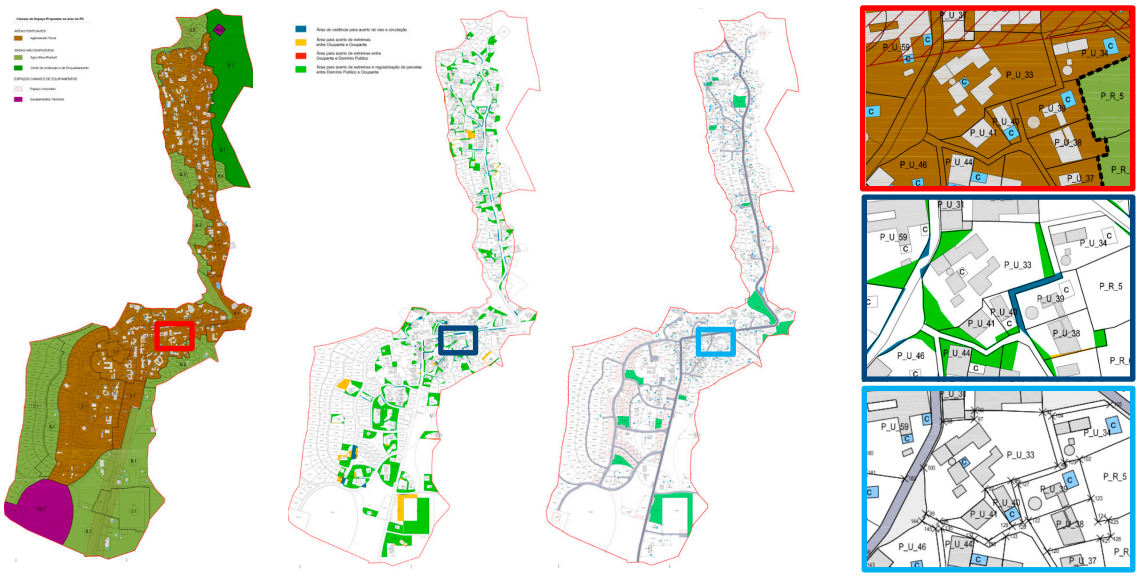

Figure 8. Map of the proposed parcels, land uses and legal regulation

This detailed information, allows the municipality to access to the building index of any parcel and control the creation of new building defining an index limit, locking the possibility of an uncontrolled expansion inside the settlements.

5. CONCLUSIONS

This experimental process reveals complex insights into how change can be fostered and supported in the context of the transformation of an informal area into a formal one.

The method and process carried out and its application accepted by the public entity and the local population show the viability of the method to answer to the designation of the existing morphology of the settlement and to the non-existence of a formal planning.

The intervention permitted the composition of a process of fair management of access and use of land. The creation of a detailed and complete database acceptable to an strong discussion and fair management from the existing situation of land occupation and the future proposal for the settlement in transformed into a formal area.

This method leads to a high, detailed and fair planning for the intervention area and created a basis for the management and control of land occupation avoiding future unplanned uses in the Chã de Caldeiras settlement. Also, ensuring a regulated expansion that is concerned with the needs of the population in terms of infrastructure of services as well as equipment planning and programming.

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