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Overcrowding and Adequate Housing: The Potential of Adaptability

Inês Ramalhete, Hugo Farias, Rui da Silva Pinto

***Abstract*—**Adequate housing has been a widely discussed theme in academic circles related to low-cost housing, whereas its physical features are easy to deal with, overcrowding (related to social, cultural and economic aspects) is still ambiguous, particularly regarding the set of indicators that can accurately reflect and measure it. This paper develops research on low-cost housing models for developing countries and what is the best method to embed overcrowding as an important parameter for adaptability. A critical review of international overcrowding indicators and their application in two developing countries, Cape Verde and Angola, is presented. The several rationales and the constraints for an accurate assessment of overcrowding are considered, namely baseline data (statistics), which can induce misjudgments, as well as social and cultural factors (such as personal choices of residents). This paper proposes a way to tackle overcrowding through housing adaptability, considering factors such as physical flexibility, functional ambiguity, and incremental expansion schemes. Moreover, a case-study is presented to establish a framework for the theoretical application of the proposed approach.

***Keywords*—**Adaptive housing, low-cost housing, overcrowding.

I. Introduction

HOUSING affordability in developing countries has been a widely discussed theme. Most of the current approaches often result in housing solutions that rely solely on economic premises dismissing important considerations of adequate housing and thus sacrificing end quality and long-term livability [1]. Moreover, one of the main problems is the dwelling size and usable space often resulting in overcrowding problems. On the one hand, when designing new schemes the housing areas are mainly dependent on economic premises [2], thus resulting in cheaper dwellings but sacrificing living conditions and resulting in situations where the house is often overcrowded [3]. Madge [4] and Akhtar [5] established the link between overcrowding and mental health, while Goux and Maurin [6] show that overcrowding has severe consequences in children's performance at school and their self-development. The latter points out the impacts of age and genre in overcrowded environments in housing. People might have a shelter and a place to live but need conditions to develop and leave poverty. On the other hand, overcrowding's definition and adequate indicators to assess it are still unclear. Some developed countries already consider overcrowding standards, based on local social and cultural features [7], when creating low-cost housing. There are also few international indicators made available by reputable institutions such as the United Nations, World Health Organization or European Commission that define some standards for overcrowding. The first has specific indicators for developing countries, while the second relies on health premises, and the third focuses on the European context. Nonetheless, developing countries do not consider any of these indicators mostly because they might compromise housing affordability and house-building objectives.

This paper is part of a larger research on adaptive housing and focuses on the potential of adaptability as a way to mitigate overcrowding. The concept of adaptability lays out principles such as incremental changes and expansion schemes and therefore promotes the physical flexibility and functional ambiguity of housing. A critical review on overcrowding indicators and adequate housing size is presented through case studies approach. The potential of adaptability to tackle this problem is then presented, and its theoretical application takes place in the case-study of a neighborhood in Pante Macassar, the capital city of Oé-Cusse Region, an exclave in Timor-Leste.

Inês Ramalhete is with the CIAUD, University of Lisbon, Portugal (e-mail: imramalhete@gmail.com).

II. Overcrowding Indicators: A Critical Review

The ambiguous nature of indicators for overcrowding has been leading to a discussion among academics and experts [8]. Overcrowding can be quantified through several indicators such as the number of people per dwelling/room/bedroom, the floor per person or the articulation between both. The first is more subjective insofar as it depends on factors such as the room sizes or the resident's choices on how to live them. Therefore, and according to Morrison [9], this overcrowding measurement can be misleading and the assessment of the ratio between the number of rooms (except service areas) and the total area of the house is needed. As Karmel [10] pointed out, the number of bedrooms can result from a household choice, becoming a misleading indicator.

The Urban Indicators provided by United Nations [11] define a maximum of two people per room (the rationale for rooms includes service and storage areas, porches, courtyards or any other spaces where domestic activities take place) regarding overcrowding in developing countries. However, the United Nations have been working on the *floor area per person* indicator due to the distorted results that the *people per room* indicator might generate [9], as will be shown later. In 2000, the United Nations conducted survey in 96 countries, that included both developed and developing countries, to find out what could be an adequate *floor area per person* [12]. From this survey, the median was 20 m^2, that is, in developing regions (Africa, Latin America and Caribbean and Asia and

Oceania except Japan, Australia and New Zeeland) 89% of housing units surveyed had a *floor per person* under 20 m^2 while in developed regions 58% had 20 m^2 or more. Moreover, of the nine countries surveyed in Africa, 100% had a *floor per person* under 20 m^2. Regarding the average, 40% of the sample from African countries returned a *floor per person* of 5-9 m^2 which followed the global average of developing countries. Although this survey was made with a sample of 96 countries, it helps to understand the range of values. Moreover, *floor per person* cannot be literally considered because it depends on factors such as the housing layout and the articulation between rooms.

The World Health Organization (WHO) also defines an indicator for overcrowding based on *people per bedroom area* (m^2) (Table I), which was designed with public health issues such as tuberculosis transmission in mind [13]. Children under 12 months were not considered and children between 1-10 years old are counted as 0.5 for the purposes of this indicator.

TABLE I
INDICATORS FOR OVERCROWDING IN HOUSING ACCORDING TO THE WHO [13]

Area (m^2)	No. people
≥11	2
9-10	1,5
7-9	1
5-7	0,5
<5	0

The European Commission shows more restrictive indicators based on people categories per number of bedrooms (Table II).

TABLE II
INDICATORS FOR OVERCROWDING IN HOUSING ACCORDING TO THE EUROPEAN COMMISSION [14]

Unit (bedroom)	No. people
1	One couple
1	One person >18 years old
1	Two persons, same gender, between 12-17 years old
1	One person between 12-17 years old not included in previous category
1	Two children under 12 years old

These categories are mostly based in socially constructed aspects such as gender protection and physical and emotional privacy of an individual which is, according to Pader [14] a feature of western culture. Mikelsons and Eschbach [15] claim that such restrictive values might compromise housing affordability in developing countries which may explain the reasoning behind the more flexible UN indicators. On the other hand, the WHO indicators, based on public health aspects and thus valid in any context, define minimum bedroom areas per person. Nonetheless, the gender category is an important feature to ensure one's privacy and development.

Overcrowding indicators and adequate housing size have been discussed around the world because it is a subjective issue that often relies on contextual issues. Therefore, and besides the international indicators previously mentioned, some countries have their own specific indicators on overcrowding. Table III shows the overcrowding indicators for housing in the United States of America [16]. These indicators were developed mainly due to the overcrowding problem in housing in African and Hispanic communities.

TABLE III
OVERCROWDING INDICATORS ACCORDING TO THE ICF INTERNATIONAL ANALYSIS OF AHS DATA [17]

Indicator	Description
Persons-per-room (PPR)	Most common indicator for overcrowding that considers overcrowding more than one person per room.
Persons-per-bedroom (PPB)	>Two people per bedroom is considered overcrowding (although there is flexibility regarding the gender and the age of the persons).
Unit square footage per person (USFPP)	Based on public health issues, the authors consider a standard of 15.23m^2 per person. However, this standard depends on the used rationale for the unit square footage that might include circulation areas, porches or other similar spaces.
PPR per USFPP	Articulation between PPR and USFPP was needed for situations not included in previous indicators.

In Great Britain and Canada, the overcrowding standard of two *persons-per-bedroom* is also used but with some differences regarding genre, age and kinship. The British standard considers two children of different gender in the same room up to 10 years of age while in Canada, the indicators refer to children up to 5 years old. On *ppb* with the same genre, the British standard considers that bedrooms can be shared up to 20 years of age, while the Canadian standard draws the line at 17 years old. Moreover, on *ppb*, a person should have his/her own room starting at the age of 18 according to the Great Britain standard, whereas in Canada that should happen at the age of twenty-one [17]. These variations result from social and cultural aspects of each society [7].

On the *floor per person* indicator, Lauwe [18] had two approaches when trying to assess overcrowding standards: an empirical approach through observation (space needed for domestic activities) and a subjective approach based on resident's satisfaction. In the first one, the author assessed a standard of 8.36 m^2, while in the latter the value assessed was 14.40 m^2. Madge [4], based on mental health principles, considered a minimum of 15.80 m^2 regarding the *floor per person*. Although these perspectives have been defined during the 1950s and 1970s of the 20th century, these values are remarkably close to the current American standard of 15.23 m^2 of floor per person.

The Portuguese indicator reveals yet another type of assessment for overcrowding. For each house typology (T*n*[1]) a certain number of people are assigned (Table IV) and the

[1] T*n* refers to the number of bedrooms in a dwelling, that is, a T2 is a dwelling with two bedrooms (and 1 living room, kitchen and bathroom).

living room and kitchen sizes (common areas) increase in proportion to the household size [19]. Tables V-VII show the area increment of the rooms whose minimum is established at 11 m^2 with up to two people, and the optimal at 18 m^2 for a household of nine people.

TABLE IV
NUMBER OF PEOPLE PER HOUSING TYPOLOGY ACCORDING TO THE PORTUGUESE REGULATION [20]

House typology/no. people
T0/1
T1/1 T1/2
T2/2 T2/3 T2/4
T3/4 T3/5 T3/6
T4/5 T4/6 T4/7
T5/7 T5/8 T5/9

TABLE V
LIVING ROOM AREA INCREMENT (M^2) ACCORDING TO THE HOUSEHOLD SIZE: T0, T1 AND T2 TYPOLOGIES [20]

Level	T0/1	T1/1	T1/2	T2/2	T2/3	T2/4
Minimal	11	11	11	11	11,5	12
Recommended	12.5	12.5	12.5	12.5	12	13.5
Optimal	14	14	14	14	14.5	15

TABLE VI
LIVING ROOM AREA INCREMENT (M2) ACCORDING TO THE HOUSEHOLD SIZE: T3 AND T4 TYPOLOGIES [20]

Level	T3/4	T3/5	T3/6	T4/5	T4/6	T4/7
Minimal	12	13.5	13	13.5	13	14
Recommended	13.5	14	14.5	14	14.5	15.5
Optimal	15	15.5	16	15.5	16	17

TABLE VII
LIVING ROOM AREA INCREMENT (M2) ACCORDING TO THE HOUSEHOLD SIZE: T5 TYPOLOGY [20]

Level	T5/7	T5/8	T5/9
Minimal	14	14.5	15
Recommended	15.5	16	16.5
Optimal	17	17.5	18

Moreover, Portuguese regulation defines requirement levels (minimal, recommended and optimal), where the minimal is usually applied to low-cost housing. Another overcrowding indicator relies on the *bedroom area per person* (Table VI). Portuguese regulation considers *bedroom areas per person* of 8 m^2, 9 m^2, and 10 m^2 according to minimal, recommended and optimal levels respectively. This means that a room for two people should have 16 m^2, 18 m^2 and 20 m^2, except the double room (for couples) that has 10.5 m^2, 12 m^2, and 13.5 m^2 (respectively minimal, recommended and optimal level), showing special concerns on keeping one's privacy in shared bedrooms (twin bedrooms).

In developing countries, overcrowding indicators and standards are not usually considered because they might compromise the affordability of the housing stock and growth rate. In 2013, a study developed by the Asian Development Bank (ADB) for new low-cost housing projects in Mumbai referred several overcrowding issues due to the dwellings size (29 m^2) [3]. Considering the average household size of 4.5 persons in Mumbai [20], the resulting *floor per person* was 6.5 m^2. The resettlement intervention in Banda Aceh after the 2004 tsunami, promoted by Uplink and the public sector, built houses with 36 m^2 [21] for an average household had 5.2 persons [22] which resulted in a *floor per person* of 6.9 m^2. These programs have shown that using solely economic premises may add needed housing quickly but will not further improve the economic and social situation of poorer communities.

Nevertheless, some developing countries have started to develop (or upgrade in the case of former Portuguese colonies) regulation to establish the minimum areas both for market and government driven social housing. These standards rely on the dwelling type (T*n*), total areas and room areas. For example, the General Regulation for Buildings in Angola (RGEU) (Executive-Decree nº13/07 26th February) is presented in Table VIII.

TABLE VIII
MINIMUM AREAS FOR ROOMS IN SOCIAL HOUSING ACCORDING TO RGEU [24]

Rooms	T0 (m^2)	T1 (m^2)	T2 (m^2)
Double room	-	10.5	10,5
Twin room	-	-	9
Living room	10	10	10
Kitchen	6	6	6
Additional area	6	4	6

Bathrooms and closets are not included as rooms in RGEU.

The creation of different standards for social housing shows more flexibility by having lower standards to avoid compromising housing affordability. Moreover, Angolan regulation also defines minimum areas for the dwellings (Table IX).

TABLE IX
MINIMUM AREAS FOR SOCIAL HOUSING ACCORDING TO RGEU [24]

T0 (m^2)	T1 (m^2)	T2 (m^2)
35	52	72

Although the limitation of dwelling type between T0-T2 would naturally result in overcrowding problems if the average household size in Angola of five people [23] or the household type (whereas 41.9% of the population lives with their siblings) [24], were considered. If the international indicators such as the UN (*persons per room*) and the WHO (*persons per bedroom area*) were applied to the several standards of Angolan regulation for social housing, the results might be misleading as Tables X and XI show.

TABLE X
COMPARATIVE ANALYSIS: UN INDICATORS FOR OVERCROWDING APPLIED TO RGEU

Dwelling type	T0	T1	T2
Total area (m^2)	35	52	72
No. of rooms	3	4	5
Persons per dwelling	6	8	10
Floor per person (m^2)	5,8	6,5	7,2

TABLE XI
COMPARATIVE ANALYSIS: WHO INDICATORS FOR OVERCROWDING APPLIED TO RGEU

Dwelling type	T0	T1	T2
Total area (m^2)	35	52	72
No. of bedrooms	0	1	2
Double room area (m^2)	-	10.5	10.5
Twin room area (m^2)	-	-	9
Persons per dwelling	2	2	3.5
Floor per person (m^2)	17.5	26	20.5

As Tables X and XI show, the direct application of these indicators might lead to underestimated or overestimated values (UN and WHO results, respectively). By including service areas, storage and circulation areas in the number of rooms, the UN indicator (two persons per room) results in six persons in a T0 (a house type formed by a living room/bedroom, kitchen and bathroom). Therefore, *floor per person* shows very low values when comparing with the reference value of around 15 m^2. On the other hand, the application of WHO indicators shows overestimated values such as the *floor per person* (17.5-20.5 m^2). Moreover, WHO results allow for the application of more restrictive criteria such as age and genre. However, if the average household size in Angola is considered (five persons), it becomes apparent that the using the WHO indicator will not accommodate that.

The social housing sub-program Prohabitar from Cape Vert (Decree-Law nº27/2010) is another example. This program considers dwelling types of T2 and T3 (with maximum areas of 72 m^2 and 90 m^2 respectively). The addition of T3 to social housing shows better adequacy to the social and demographic context of Cape Vert that has an average of household size of 3.6 persons [25]. When applying the UN indicators, the T2 has the same value of the Angolan case, while the T3 (with six rooms according to the UN rationale) will result in 12 people and a *floor per person* of 7.5 m^2, showing an underestimated result once more. On the WHO indicator, Prohabitar only considers the dwelling areas so the room areas of Technical Code for Buildings of Cape Vert (CTE) (Boletim Oficial, Série I, No. 2, portaria conjunta nº4/2012 12nd February) were considered.

TABLE XII
COMPARATIVE ANALYSIS: WHO INDICATORS FOR OVERCROWDING APPLIED TO PROHABITAR

Dwelling type	T2	T3
Total area (m^2)	72	90
No. of bedrooms	2	3
Double room area (m^2)	10.5	10.5
Twin room area (m^2)	10	10
Twin room area (m^2)	-	10
Persons per dwelling	3.5	4.5
Floor per person (m^2)	21.4	20

The positive outcomes shown in Table XII result from the household average size. T2 accommodates the average household size in Cap Vert (3.6 persons) and a *floor per person* of 21.4 m^2. On the T3, this dwelling type accommodates and exceeds the household size whose residents have a *floor per person* of 20 m^2. Therefore, the household size is an important factor to consider when dealing with overcrowding and the minimum housing areas. However, the use of averages, particularly at national level, might create misleading outcomesdue to the huge difference between urban and rural settlements in developing countries. Thus, the assessment of the household demographic features of the intervention area is crucial and includes not only the household size but also its type (no. of occupants according to genre and age).

In both examples, the UN indicator is misleading because it considers all housing spaces as livable rooms, that is, this indicator assigns occupants to *unlivable rooms* such as bathrooms, kitchen (although it will not count if merged with the living room), storage rooms, porches or courtyards, leading to severe overcrowding situations such as a T0 with six people as Table X shows. Therefore, indicators regarding *person-per-bedroom* might be more accurate to assess overcrowding. On the other hand, the WHO indicator based on the bedroom area might compromise the housing affordability by claiming that two people need, at least, 11 m^2 or more. Considering that one of the main premises for housing affordability relies on its size due to the land value and building costs [2], this indicator might be restrictive. Therefore, *ppb* is more flexible to work with, especially in incremental housing and expansion scenarios because minimum areas are initially considered and then expanded, according to the development of the household within an adaptive context. Therefore, incremental processes, and their expansion scenarios, might have an important role on solving overcrowding in housing without compromising their economic feasibility. Moreover, larger families do not equate to larger houses because they would not be able to afford them. Instead, expansion schemes, regarding the overcrowding factors and indicators, should be considered. Yet, these expansion scenarios should have a clear definition of the *unlivable rooms* (e.g. service, storage areas, porches, among others) and livable rooms, to better apply overcrowding indicator(s).

Based on this analysis and considering the conditions of developing countries and minimum quality requirements, the *people per bedroom* indicator is the most balanced. This indicator is more flexible regarding the room areas and their adaptability for future transformations. Moreover, the literature review shows common ground on two *ppb*. Age and gender are also considered (although not mandatory because it might compromise housing affordability) to meet one's privacy. Therefore, this research considers that one bedroom should be occupied by two people according to the following conditions: two *ppb* if they are a couple two *ppb* of the same gender over 12 years old; two *ppb* of the same gender until the age of 12. This means that these overcrowding indicators refer both to quantitative features (number of people in a bedroom) and qualitative (gender and age). These indicators result from the flexibility of the UN indicator for developing countries intertwined with the health criteria from WHO.

III. Housing Adaptability: The Overcrowding Factor

This paper shows part of a research on an adaptive housing model for developing countries that aims to support the architect when designing the dwelling. In this research, adaptability is considered as a "long-term adequacy", that is, the house is adaptive to the possible economic and social changes of its residents. Overcrowding is a main consideration here because the social and economic development of the residents will have impacts on the household regarding its size and features (gender and age). In fact, Friedman [26] claims that housing flexibility should be based on the household dynamic and its generational cycle (child, teenager, adult, elder) and housing projects should foresee the features of this cycle. On the other hand, Koolhaas and Mau ([27] consider that "Flexibility is not the exhaustive anticipation of all possible changes" but rather "(…) the creation of margin – excess capacity that enables different and even opposite interpretations and uses of space.". Moreover, development brought aspects that impacted household dynamics and lifestyle such as: Women's liberation in the 1950s that naturally changed the lifestyle in terms of domestic tasks [28] and the household size (less children) [29]; the increased life expectancy, meaning that people living longer which led to the rise of households formed solely by elders; emocracy that has opened the society to new household patterns (singles, students, one-parents families, among others) and the acceptance of minorities (ethnical, religion, etc..) and thus different lifestyles [30]; and Globalization, that changed the familiar pattern and lifestyle due to the easier mobility and access to information and thus a "rotating scheme of occupation" (a house is no longer for life, that is, a house might have several residents throughout its lifetime) [31]. Although developing countries are still keeping the idea of "house for life" (namely due to the housing policies with long-term amortizations schemes), these changes will occur anyway, and housing should be able to adapt to these new conditions. As [32] pointed out, "The problem is temporary thus the solution must be as well". Therefore, adaptive housing considers all these aspects with overcrowding as one of the main factors for adaptability.

The model is structured in principles, criteria and parameters that result in premises for adaptability that the architect will apply when designing the house. This paper focuses on the principles that directly deal with overcrowding when designing for adaptability.

Fig. 1 shows the structure of the model which formed by principles and criteria for adaptability, and parameters of the housing project. The model has seven principles for adaptability but only two, regarding overcrowding, will be presented. These principles are supported by several criteria such as Modularity (C1), Unfinished Design (C2), Ambiguity (C3) and Bioclimatic Design (C4). The application of these principles and their criteria is made through the parameters of the housing project, organized as baseline parameters (P1, P2 and P3) and project parameters (P4, P5 and P6). The articulation between them results in the final premises for the desired adaptive house suited for developing countries.

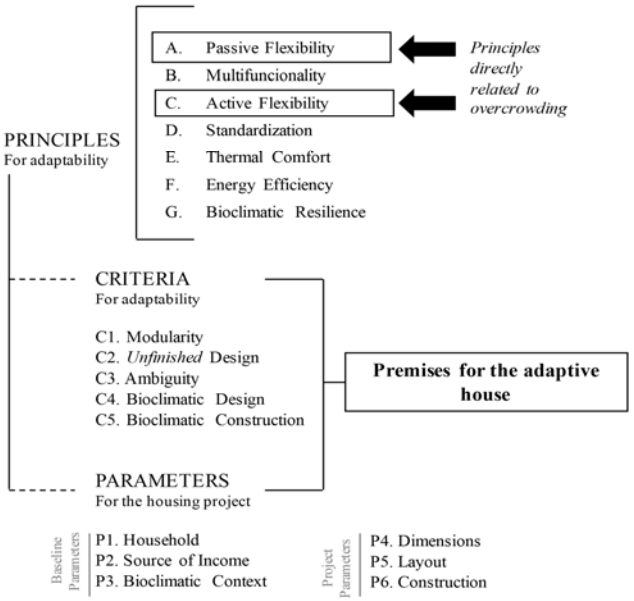

Fig. 1 Adaptive housing model

The principles that directly deal with overcrowding are Passive Flexibility (A) and Active Flexibility (C).

The first one refers to the functional flexibility of the house, that is, the possibility to change the room's functions (except service areas such as the kitchen and the bathroom that are considered fixed elements). This principle fully relies on Ambiguity (C3) that refers to homogeneous spatial features regarding quantity (dimensions) and quality – the idea of neutral spaces [33]. Whereas the first deal with similar dimensions between all rooms, the second is related to similarities in quality, namely ventilation and lighting. Residents are able to freely occupy the rooms with the functions they need most. When defining the pattern-size of the rooms, household features and the resulting possibility of overcrowding are the first considerations because it will define the standard size of *livable rooms*, considering age, gender and parentage. Although the room's size is not considered in the overcrowding factor used in this research because such rigidity might compromise the project viability, local legal mandatory issues (when applicable) are important when defining the minimum areas according to the number of people. Therefore, the pattern-size for rooms results from the capacity of the minimum areas to accommodate two *ppb* considering the following: if they are a couple; if they are over 12 years old and have the same gender; or if they are under 12 years old and have different genders. This rationale needs to work in association to spatial neutrality, that is, these considerations should be applicable to all *livable rooms* and thus a balance between them is needed. This balance is achieved through project parameters such as the position of the openings (P5) to maximize the *usable area* as well as different uses, and the materials regarding the finishes (P6) (related to homogenous indoors quality).

The other principle directed at resolving overcrowding is Active Flexibility (C). This principle corresponds to the

physical flexibility of the dwelling and, according to Eleb-Vidal, Chatelet and Mandoul ([34], it can be divided in to three concepts: "mobility" that refers to daily changes in the house, depending on different activities; "evolution" that corresponds to internal physical transformations; and "elasticity", which is the transformation of the usable surface by addition or subtraction. Overcrowding is an important consideration in these three concepts as far as the schemes of these transformations rely on household features. Overcrowding is the starting point when incorporating these concepts into design development. Within developing countries, with lack of financial resources, these three types of physical flexibility can be used to solve overcrowding in the short, medium and long-term. "Mobility" can have an important contribution to solve overcrowding in the short-term when dealing with larger households without "adequate" dwelling: when considering the two-ppb indicator, as well as age and gender criteria, these immediate changes can provide, at least, the minimum privacy requirements, that is, a larger room can be divided into small bedrooms at night. Although this is not an ideal solution, it can solve overcrowding and keep one's privacy until medium and long term solutions can be developed and implemented. Once again, spatial ambiguity is an important criterion to take into account to facilitate these partition processes.

On the "evolution" concept, this type of approach to flexibility is a medium-term solution to solve overcrowding as far as it considers internal changes inside the dwelling. These changes can be through the subdivision of a large room into smaller ones (partition) or merging small rooms into a larger one (merge). The difference between this process and the previous one relies on the timeline, that is, processes within "evolution" refer to lengthy and deeper transformations and not daily ones that can be ephemeral. These transformations might occur not only due to the addition of a new family member but also due to the qualitative changes in the household such as the reaching of the age limit to share a room. The definition of the size-pattern of the rooms is a crucial step for the success of this type of flexibility.

The "Elasticity" concept refers to long-term changes of the usable surface of the dwelling through addition or subtraction. These deeper changes add new parameters related to dimensions (P4) such as the size of the plot and the size of the usable area while considering future expansions. While the previous concept constitutes temporary solutions to solve overcrowding, "elasticity" provides the most adequate solution, although it is, obviously, more expensive and time-consuming.

Both "mobility", "evolution" and "elasticity" concepts can be supported by the Modularity criteria (C1) (not mandatory) while the last two can be associated to the *Unfinished Design* criteria (C2).

Overcrowding is an important factor when designing adaptive housing units and both qualitative and quantitative features should be taken into account. Within low-cost housing, this consideration is actually a challenge because, most of the time, adequate solutions are not viable ones economically and thus timed, incremental and anticipatory solutions are needed. Therefore, adaptability as long-term adequacy might be a viable solution for overcrowding.

IV. Case-Study: Pante Macassar (Timor-Leste)

To validate this research, the proposed model was applied in a case-study, with initial surveys directed with the support of local teams. In the absence of minimum legal standards for bedrooms (such as in the case of Timor-Leste), the minimum standards from Angola, Cape Verde and Mozambique (that have the same values, due to being base on the same Portuguese regulation) were used (Table XIII).

TABLE XIII
Minimum Areas for Rooms: Review of Mozambique, Angola and Cape Verde Standards

Room	Area min. m^2
Double room area (m^2)	10,5
Twin room area (m^2)	9/10

This case-study refers to a block in the neighborhood of Palaban, located in the capital-city of Pante Macassar, Oé-Cusse Region, an exclave of Timor-Leste. Although Pante Macassar is officially a city, its social, economic and urban context is still rural due to the current stage of development. The block is formed by single houses and 81.25% and 85% of the sample has a small agricultural area with animals present in the housing plot, respectively.

The sample corresponds to a block in the neighborhood of Palaban (8ha) and has 72 plots whose 60 are occupied (thus a low density settlement). This sample refers to 80 households and 484 people which 53% are over 17 years old, 20% are 12-17 years old and 27% are under 12 years old. This data shows that the majority of the population is formed by adults, followed by children under 12 years old.

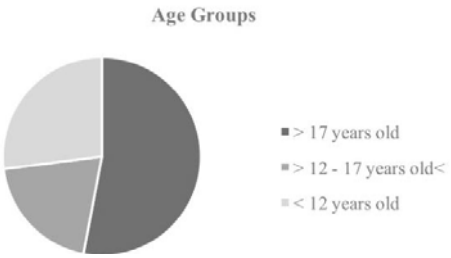

Fig. 2 Pante Macassar case-study: Age groups

Within these 80 households, 8 do not have any family ties, that is, households formed by students that came from the mountains to the capital-city. On the contrary, three households have two family cores living together (assessed through the number of couples). On the number of people per household (Fig. 3), the prevailing household's sizes are between four and eight people (both with 13.75%). However, the majority has five people per household (20% of the sample). Moreover, 12.5% of the sample is formed by households with 10 to 12 people.

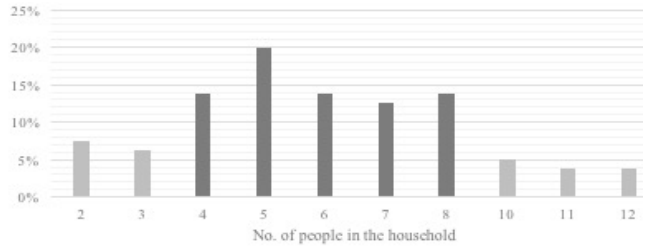

Fig. 3 Pante Macassar case-study: Number of people in the household

In this case-study, the household size and the age structure are the baseline data for assessing overcrowding. Timor-Leste does not have any legal framework for buildings standards and thus overcrowding can be used as a guideline. Both in Passive (A) and Active (D) Flexibility, the number of rooms and the standard-room size are the main considerations. Although five people per household is the prevailing household size, larger households (10-12 people per household) refer to 12.5% and thus show a relevant percentage to take into account. Considering that five people per household (prevailing situation) is formed by a couple and three people (predominantly over 17 years old), three bedrooms are needed (Fig. 3). However, in the *minimal* scenario, two bedrooms can be considered if one of them would be able to be easily changed during nighttime (daily spatial partition according to the "mobility" concept of active flexibility). Thus, a T2 that ensures one's privacy would be provided. Yet, pattern-size has a major role in the adequacy of this kind of temporary solution.

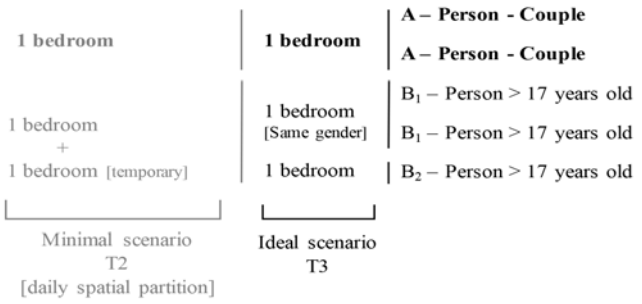

Fig. 4 Assessing the number of bedrooms for a household of five people (pattern)

For larger households (e.g. 12 people), six bedrooms are needed. However, it is impossible to provide such large housing typologies within low-cost housing development context (six bedrooms mean T7 typology), thus adaptability through Active Flexibility might provide a viable solution.

Pattern-size of rooms is the major parameter for adaptability in both principles. Firstly, Ambiguity (C3) considers spatial homogeneity, that is, rooms should be similar in size and shape (although only the first is considered in this paper). These rooms can accommodate bedrooms and/or the living room thus, their size needs to enable partition and merging processes which in turn can correspond to short/medium/long term operations. Although ambiguity is contrary to the process of labelling the housing functions (bedrooms, living-rooms), these will be used to assess adequate areas within overcrowding limits that will result in the standard room (the neutral room to be applied).

Considering the minimum standards of 10.5 m^2 and 10 m^2 for double and twin bedrooms, respectively, 10 m^2 is the starting point for the pattern-size. Therefore, by working with standard-rooms of 20 m^2, it is possible to have two bedrooms (BD) (10 m^2 each), a bedroom (BD) (10 m^2) and a living room (LV) (10 m^2) or a living room (LV) (20 m^2) (besides other functions that are not included in the scope of this paper). The adoption of 2 neutral rooms of 20m^2 will result in dwellings with 40m^2 of *livable area* (bathrooms, kitchen, corridors, porches or other service/external areas do not count as *livable areas*) that can accommodate up to 6 people. Fig. 4 shows the several possibilities which always take into account the issue of overcrowding within a livable area of 40 m^2: 1). A household of four people formed by a couple and two people > 17 years old of the same gender; 2). A household of four people formed by a couple and two people > 17 years old of different genders; 3). A household of four people formed by a couple and two people > 17 years old of different genders (minimal scenario based on daily spatial partition); 4). A household of five people formed by a couple, two people > 17 years old of the same gender and one person; 5). A household of five people formed by a couple, two people > 17 years old of the same gender and one person (minimal scenario based on daily spatial partition); 6). A household of six people formed by a couple, two people > 17 years old of the same gender and another two people > 17 years old of the same gender.

Although not an ideal solution as the household gets larger, the living room (LV) is always at a minimum of 10 m^2 (which meets the most conservative standards for low-cost housing previously analyzed). Over six people per household, another standard-room needs to be added, and the same rationale is applied, resulting in the livable areas shown in Table XIV.

TABLE XIV
LIVABLE AREAS USING THE STANDARD ROOM OF 20M^2 AND CONSIDERING OVERCROWDING INDICATORS (THE PREVAILING HOUSEHOLD SIZE IS HIGHLIGHTED IN GREY)

Household size	Livable area (m^2)
2	20
3	20
4	20
5	40
6	40
7	60
8	60
9	80
10	80
11	80
12	80

It is important to note that over nine people, the living-room should not be only 10 m^2 but rather 20 m^2, that is, a full standard room. This situation refers to the importance of the living room increment as the household gets larger and thus the *livable area* will need to grow concurrently. This metric can also be used as the *standard area* within the *Unfinished*

Design criteria (C2) as far as it allows for the creation of new bedrooms and/or living rooms to mitigate overcrowding concerns (besides other possible functions that are not within the scope of this paper). In fact, *Unfinished Design* is an important criterion for the adaptive process when dealing with overcrowding and larger families. In this case-study, this criterion can be considered when dealing with household sizes that fall beyond the *livable area* requirements of the local averages (five people), that is, from households formed by 7 people up to 12. This will improve the housing solution's economic viability without compromising the minimum conditions (shelter, health and privacy).

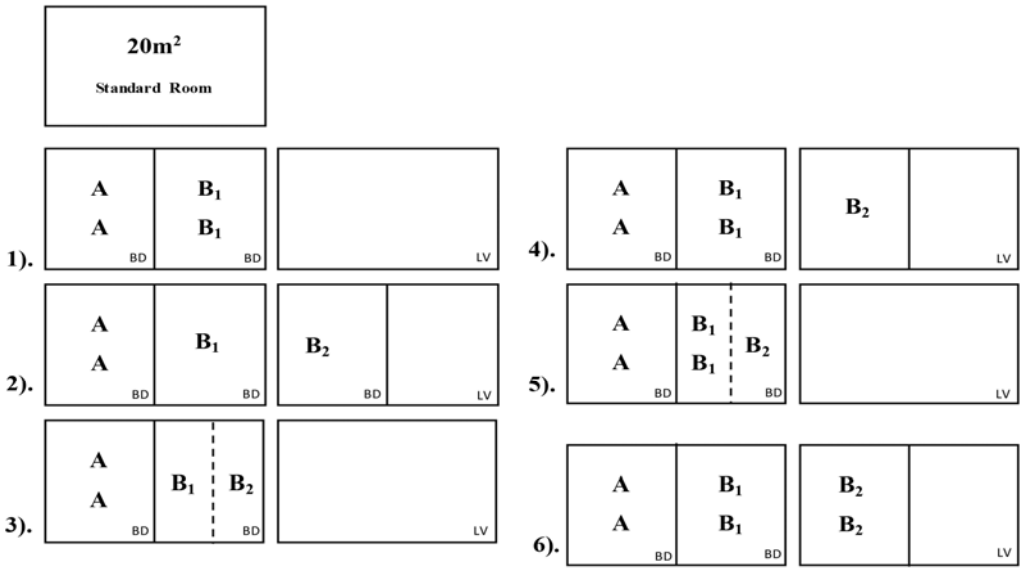

Fig. 5 Possible distribution of people according to overcrowding considering the standard-room of 20 m^2

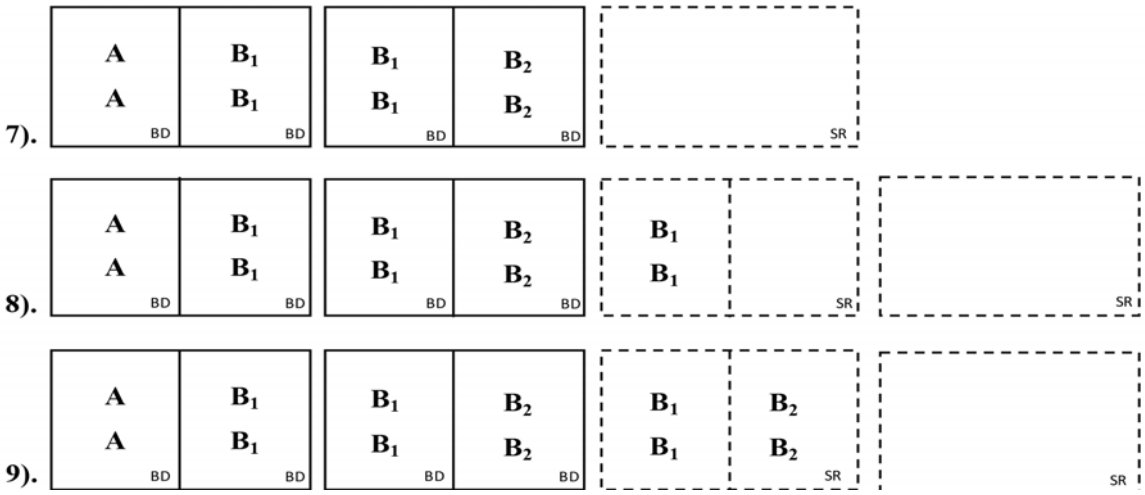

Fig. 6 Standard rooms (SR) within *Unfinished Design* criterion (C2)

Fig. 6 shows the application of Standard Rooms (SR) within the *Unfinished Design* criterion. This approach means that the promoters need to provide 40 m^2 of *livable area* (two standard rooms) fully built and equipped and the remaining area as unfinished living area. However, the notion of unfinished design needs to be clear: this concept can correspond to the provision of a structural frame that the owner can improve within an incremental process such as the Elemental project in Chile [35]; or can be a room fully built as a shelter (walls, windows and roof) but without finishes (paint, plaster or floor, among others) [36]. For this case-study, overcrowding in larger families would be solved by using the second option (Table V): people would have a shelter to solve the immediate problem of overcrowding (by avoiding shared bedrooms by more than two people) as well as the basis to incrementally improve and upgrade the *livable area* over time. This consideration is particularly important when providing houses within housing programs or similar initiatives. Usually, housing models in these contexts are similar to optimize the process, accelerate it as well as reduce costs. By considering

this approach, a fully built and equipped *livable area* (neutral rooms) of 20/40 m^2 (besides service areas, circulation areas or storage) is provided while extra areas are upgraded incrementally. Thus, this premise is the starting point for the plot and house dimension as a bottom-up approach based on the household features and the need to mitigate overcrowding.

Fig. 7 Vernacular building system and materials in the sample of Pante Macassar: straw roof, palm leaves wall and window

Although not mandatory, Modularity (C1) has an important role in all these considerations because it facilitates the whole process both of Passive and Active Flexibility. In some contexts of developing countries, such as this case-study, modularity is not always a viable solution due to the technology that it normally requires and may be difficult to implement. As in many developing countries, cement block masonry (which in fact is a modular solution) is the main building system in Pante Macassar because it is a cheap and durable material, and easily assembled and produced locally (in fact, one of the house plots in the sample has a small cement block workshop). However, this solution is not suitable for Active Flexibility, namely within "mobility", because the system itself is a permanent solution. Nevertheless, it is an appropriate solution for the structure and building shell due to its durability when comparing to other local vernacular solutions that use palm leaves, wood or straw for walls and roofs (Fig. 6).

Moreover, lack of technology, financial resources and skilled labor do not allow for solutions such as movable panels, normally produced in steel, that move on ceiling tracks. Therefore, there is a potential on considering vernacular materials and solutions for the Active Flexibility within "mobility" and "evolution". These easily handled materials, cheap and produced locally, can work as internal walls when implementing partition processes to ensures one's privacy and health.

V. Conclusion

This paper, focused on overcrowding and adequate housing, is part of a research on an adaptive housing model for developing countries. This model is formed by principles, criteria and parameters for adaptability. The main objective of this model is the creation of a design tool to support the project phase. The considerations generated by the model should be seen as guidelines for the adaptive house and not as restrictive rules, that is, it is important to keep the architect's create freedom otherwise similar and repetitive solutions will become norm and innovation can be stifled. In this model, the two principles directly linked to overcrowding - Passive (A) and Active (C) Flexibility – were presented and then applied to a case-study in Pante Macassar, Timor-Leste. These principles are related to criteria such as Modularity (C1), *Unfinished Design* (C2) and Ambiguity (C3).

Overcrowding's definition and its indicators are still subjective because it deals with many variables based on social and cultural aspects. Some countries had already developed overcrowding standards and indicators based on their cultural and social features when dealing with low-cost housing. These features are mostly associated to health and respect for one's privacy and thus household size and age and gender structure are key considerations. On the other hand, some other examples like Portugal do not define overcrowding by gender and age but rather by assigning the household sizes to house typologies.

Nonetheless, developing countries avoid considering such overcrowding factors because they might compromise housing affordability due to the restrictive values they have. Therefore, some entities developed international standards for this issue such as the UN and WHO: whereas the first has specific overcrowding indicators for developing countries and thus more flexible standards (two people per room, including service areas and porches), the latter developed standards based on public health considerations (number of people per bedroom, considering two people in a bedroom with, at least, $11m^2$).

However, when applying literally these standards to the current housing legislation of developing countries (such as Angola and Cape Verde, for example), several issues arise, mostly because these indicators do not consider the household size. Therefore, the UN standard, by considering service areas, storage, circulation and porches as "rooms" results in an underestimation such as 6 people living in a T0 dwelling. This also results in misleading values when assessing *floor per person*. On the other hand, the WHO indicator based on bedroom area per person results in overestimated values between 17.5-20.5 m^2 when dealing with small households (the Cape Verdean example) but fails when applying to larger households such as the Angolan case (whose the prevailing household has five people).

Based on this review and considering the financial constraints of developing countries and quality standards, this research considered the 2 people per bedroom indicator the most balanced and easy to apply. Although not mandatory, age and gender are important factors to ensure one's privacy and public health. Thus, for the adaptive housing model developed in this research the overcrowding standard of two people per bedroom has the following conditions: 2 people per bedroom if they are a couple 2 people per bedroom of the same gender

over 12 years old; 2 people per bedroom of different gender until the age of 12. Basically, this indicator results from the intertwining of UN flexibility standards for developing countries with the public health principles of WHO.

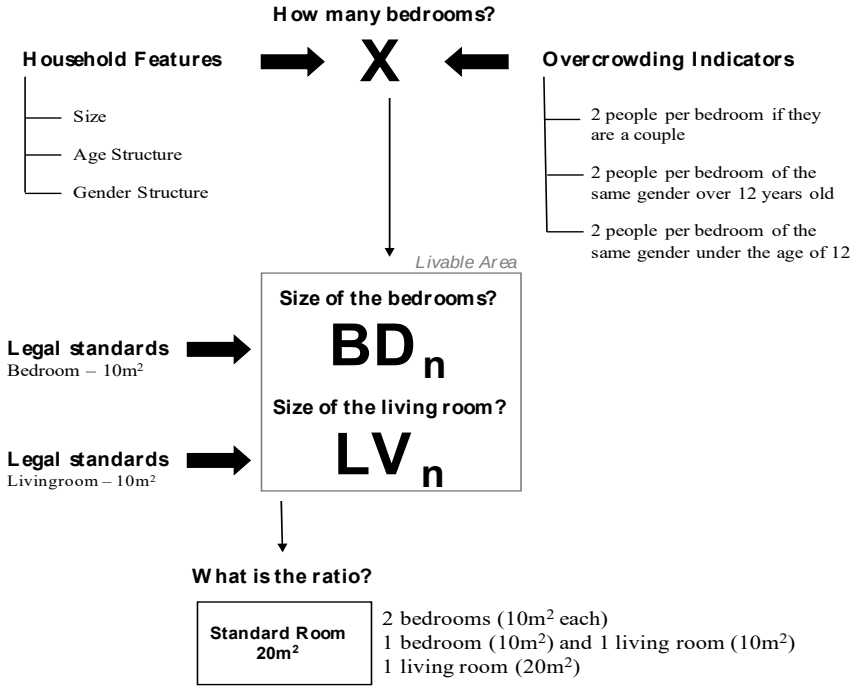

Fig. 8 Assessment of the standard-room: a bottom-up approach

In this paper, a bottom-up approach for adaptive housing, based on overcrowding considerations, was presented. Based on the household features (size, age and gender) and overcrowding, the standard room was assessed. This standard room relies on the Ambiguity (C3) criteria that considers homogenous spaces to allow their free appropriation by the household. By using $10m^2$ as a bedroom size and the minimum size for a living room (considering common ground on legislation for low-cost housing because Timor-Leste does not have any), the neutral roomwill be the sum of both, totalling $20m^2$ room allowing for 2 bedrooms ($10m^2$ each), a bedroom ($10m^2$) and a living room ($10m^2$) or a living room ($20m^2$). This refers to the *livable area*, that is, all the areas that weigh in overcrowding and thus kitchens, bathrooms, corridors or other similar areas are not included.

Floor per person was not assessed in this case-study because the assessment of the total area was not important for overcrowding but rather the *livable areas*. Several possible distributions of people within the framework of overcrowding mitigation in the standard-room of 20 m^2 are presented. These variations consider the household sizes of the case-study with a special emphasis in the prevailing household size of 5 people.

Moreover, this standard room can also applied to solutions within the *Unfinished Design* criteria (C2) with two approaches: the creation of a structural frame that the resident can improve over time; the provision of a shell without finishes that can be upgraded and improved over time. Both solutions are suitable for larger households (in this case-study between 10-12 people) when it is impossible to provide a fully equipped dwelling that respects overcrowding standards.

This paper only refers to the two principles of the proposed model directly linked to overcrowding and its indicators and supported the assessment of the standard-room for adaptive housing. Further research will articulate the standard-room to the Multifunctionality (B) principle that will add more variables to the model.

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