



Future scenarios for housing (re)settlements in Ecuador

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Abstract

Post-earthquake (re)settlements are too often the results of political decisions, driven by the urgency of housing survivors in emergency. There is very limited evidence of strategic decisions made for the long-term wellbeing of the displaced communities. This has certainly been the case, for the post-earthquake reconstructions developed in the aftermath of the 2016 Muisne earthquake in Ecuador. Previous research has indeed demonstrated, through qualitative empirical research, the failure of the developed resettlements from both a technical and a social perspective. This paper aims to re-think the way to conceive (re)settlements with the aim to co-produce with local experts and inhabitants possible future scenarios. A first pilot case, that adopts design solutions at the urban and housing unit level, which are strongly connected to the local geographic and cultural context, is discussed. This paper presents and discusses the design evolution of the proposed pilot case, posing the attention to the urban development and the housing design, articulated imagining the (re)settlement as a new neighbourhood of the city, with a combination of private and public spaces, that will grow and be fully integrated to the consolidated city as population grow.

Keywords Post-disaster reconstruction · Housing · Earthquake · Ecuador · Bamboo

Introduction

Global population is exponentially growing, with an expectation of having 230-billion square-meters of new constructions, over the next 40 years, which would be like adding the equivalent of Paris to the planet every single week [1]. At the same time, climate change and natural hazards are increasingly affecting the existing infrastructure and built environment, with the poorer areas of the global South paying the most. Earthquakes, specifically, affect millions of people every year. Despite a large number of studies developing technologies for the seismic retrofit of existing buildings [2–4] to reduce the vulnerability of the built environment, and many more looking at improving the post-earthquake management [5, 6], still appears that post-earthquake reconstructions are very much driven by political decisions, with very limited capacity of conceiving any new resettlements as a new part of existing cities. Many newly built post-disaster resettlements appear to fail in learning from previous events and re-constructions. It is essential to continuously

scrutinize recent post-earthquake management and resettlements with the intent to provide key learning to inform better future scenarios.

According to several researchers who, indeed, scrutinised post-disaster management, reconstructions are often led by a single or few actors, which are primarily governmental organizations or NGOs, involved in a process where the amount of responsibilities is not easily manageable, under emergency conditions. The stakeholder participation and the empowerment of the residents, in alternative to a concentrated decision making process, represents one of the key to better conceive post-disaster reconstructions and achieve positive impacts in terms of community wellbeing [7–9]. The inclusion of the beneficiaries in the post-management and reconstruction process, as well as, the study of informal constructions, can facilitate the understanding of local communities habits and needs [10] and, hence, the definition of specific local requirements, to be addressed in the reconstruction. Indeed, too often, “concentrated decision making processes” have determined the definition of a single housing typology as response to large reconstructions, which is usually too small, repeated on a rigid grid, and deployed without any attention to the space in-between [10, 11]. Moreover, the lack of attention to the urban and spatial design, the

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lack of infrastructure and facilities, poor site selection and location very often hinder the development of a community feeling [11]. Some examples built in Sri Lanka, India and Indonesia, analysed by Zetter and Boano, demonstrate the quality impacts of indoor and outdoor spaces, when the design is developed with the due attention to spaces and places. Despite the usual rigid grid which hinders the development of the community, one the precedents mentioned by [11], and built in Aceh, Indonesia, shows a design, that well respond to the local flooding risk and thermal conditions, in terms of housing layout and infrastructure. The same, also pays attention to the urban and landscape design, with the intent to promote community development and increase the quality of the built environment.

In an attempt to rethink future resettlements, the international NOVA VIDA research project, funded by British academy in UK, aims to critically evaluate the (re)settlements built after the 2016 Muisne earthquake in Ecuador, looking specifically to the cities of Portoviejo, Manta, Bahía de Caráquez and Pedernales, which accommodated 90% of the resettlements built by the central government. The learning obtained in the first investigative phase [12] are currently informing the definition of new scenarios for future long-term reconstructions in Ecuador, which is the main topic discussed in this paper. In the future, the proposed scenarios will be developed in virtual reality and brought in Ecuador to be experienced by local inhabitants to understand the impact they could have on the local populations and also to review them as required.

As such this paper, after summarizing the key learning from the first research project investigative phase, which analysed the existing resettlements (Section 2), it presents the urban and building design proposal of a first pilot case, articulating the overall design methodology (Section 3), presenting the city of Portoviejo as case study through a morphological and typological analysis (Section 4), the project for a potential new future resettlement (Section 5), and the initial review process, enabled by focus groups discussion (Section 6). The future studies (Section 8) and conclusions (Section 9) highlights the importance of continuously questioning the design process, to enable some level of co-production with local inhabitants and local experts.

Critical analysis of the existing resettlements in the Manabi province

The investigation of the cities of Portoviejo, Manta, Bahía de Caráquez and Pedernales, which accommodated about 90% of the permanent resettlements built after the 2016 Muisne earthquake highlighted some key criticalities connected to the geography of the resettlements, the material condition of the housing and the

social condition of the urban environment [12]. Interviews and field work, indeed, highlighted the lack of connectiveness of the current resettlements with the existing cities centres, the total disengagement in planning for economic and civic growing of the inhabitants, as well as the lack of any proper urban planning of the new areas. Looking at the buildings, the adoption of standardised building, arranged in infinite replicated rows, showed lack of flexibility, (in)capacity to accommodate future families growth and evident thermal discomfort. Finally, the analysis of the current conditions of the house, demonstrated how inhabitants, although strongly limited by the adopted housing typologies and technologies, still attempted to (re)appropriate the spaces in the intent to provide additional areas for their families, too often ignoring the increased vulnerability at which they are exposing themselves and their future generations.

Development of future scenarios: Methodology

In the attempt to rethink how to conceive and plan future post-earthquake resettlements, this paper presents the first proposal for a new redevelopment in the city of Portoviejo, which is the capital of the Manabi province and centre of many provincial administrative offices, and has been chosen for the study of a first pilot case of the NOVA VIDA research project.

This paper presents the design approach, from: *a.* the analysis of the built environment, through morphological analysis of the city of Portoviejo, and the typological analysis of Ecuadorian vernacular architecture; *b.* the project of the new resettlement, including both urban and building design, aimed to overcome the criticalities defined in the first part of the study; *c.* the analysis of the proposed concepts, through focus groups with local experts. The proposed methodology aims to be adopted for the design of the other future scenarios in the Manabí Province.

In the first phase, the morphological analysis of the city of Portoviejo [13, 14], allowed analysing the structure of the city, including public spaces, infrastructure, public buildings and the housing, and capturing their relationship with the natural elements. The study of the foundation city and its current developments allowed understanding the historical evolution and expansion of Portoviejo. The typological analysis and the study of the local architecture both in the rural and urban areas, allowed the recognition of the principal reiterated architectural elements, as well as the principal local materials, and construction techniques that have been historically adopted in the area to respond to local climatic conditions.

The second phase of the work consisted in the development of a urban and housing design proposal, to respond the key questions: how can we design settlements responding to the Sendai principles of Build Back Better, and develop proposals that can be resilient, have low environmental impacts and facilitate long terms social wellbeing of the inhabitants? The main proposed strategies have been the use of local materials, passive thermal strategies and the possibility to allow incremental growth, as presented in the detail in Section 5.

The proposed design has been interrogated within focus groups in order to verify the feasibility of the project. The focus groups were conducted remotely, due to COVID restrictions. Each participant received, in advance to the meeting, the proposal and the topics of the discussion. The proposal was presented starting with the urban design, including the residential schemes, the housing design and the functional program, and at last, the construction and technology solutions were discussed. The feedback and recommendations of the expert architects and engineers, were collected to improve the design proposal. These last will be presented in a future phase of the research within in-person workshops with the current inhabitants, who will experience it through immersive virtual reality.

The pilot case: analysis

This section presents the morphological analysis of the city of Portoviejo together with the study of Ecuadorian vernacular architecture, with a special attention to those implemented in both urban and rural area of the Manabi province.

Morphological analysis

Portoviejo is a city of about 280.000 inhabitants, founded around the XVII century, and having a major expansion during the first decades of the XX century. The first step toward the design proposal was a *morphological analysis* of Portoviejo in order to highlight the main characteristics of the city and its relationship with the surrounding areas. Geographic Information System (GIS) was adopted to analyse the natural and anthropic environment. The contemporary shape of the city is strongly characterized by the surrounding mountain and the presence of the *Rio Portoviejo*, the river which divided the city from north to south (Fig. 1). The analysis of the built environment (Fig. 2), elucidated the density of the constructions, the system of connections and the presence of the public and private spaces in the urban fabric. It appeared evident that, during the centuries, the development of Portoviejo was not consistent with the original layout of the city centre founded by the Spanish, which

Fig. 1 Portoviejo morphological analysis: natural systems

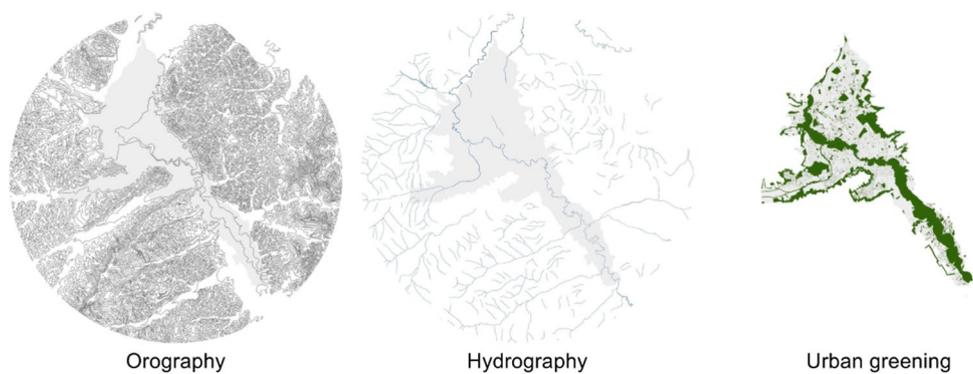


Fig. 2 Portoviejo morphological analysis: anthropic systems



was characterised by a “gridorium” system of orthogonal streets and rectangular residential/public sectors [15, 16].

Typological analysis

An essential aspect of the design process was the choice of the right typology in order to meet the inhabitant needs and habits. The *typological analysis* of the vernacular architecture, demonstrated the strong presence in the city of Portoviejo, as well as in the entire Manabí Province, of a recurrent typology: the *vivienda-comercio*. This housing typology was diffused since the colonial era and found its roots in an Arab-Spanish typology, which was developed and adapted to the local climate conditions and considering the materials available in the Ecuadorian coast [15–17]. As in the cities, also in the rural areas of the coast, there was a strong identity of the vernacular architecture, related in particular to the use of the local materials and construction techniques, to face the hard climatic conditions and catastrophic events such as floods and landslides [18–20]. The *vivienda-comercio* was adopted as a basis for the development of the design proposal, because it well relates to the urban areas, and also because, thanks to its functional program, is suitable for different functions. The *vivienda-comercio* is usually structured over two floors, with the retail spaces at the ground floor and the residential at the first floor. The historical studied houses (Fig. 3) presented many recurrent elements, such as the *galería*, a covered porticus, aiming to protect from the

sunlight and the heavy rain, during the rainy season, the *patio* to facilitate any cross ventilation, and in many cases, an hybrid structure made of wood and bamboo. The *galería*, in the front of the main building façade, was used not only as protection from the sunlight but also as urban element, able to expand the commercial activities at the ground floor in the semi-public realm and as a threshold between the public and private spaces. The *patio*, essential for the passive thermal strategies, was located either at the centre of the building, in the case of the most important house, or towards the rear of the building.

The pilot case: new scenarios design

The design proposal for Portoviejo offers scenarios for an alternative (re)settlement, developed both at the urban and at the architectural scale, that can be compared, in terms of size and location, to the resettlements realized after the 2016 earthquake in the Manabí Province.

Design strategy

The objective is to design a new part of the city rather than an enclosure. This is in direct antithesis to the resettlements logic adopted by the Ecuadorian central government after the 2016 earthquake. A new *barrio* with small public buildings, residences, facilities, able to give place to a new



Fig. 3 Portoviejo urban vernacular architecture, typological analysis

community after the losses caused by the catastrophic event. According to the NOVAVIDA research program, the general aims of the design proposals are (i) the reduction of the vulnerability, according to the Sendai principles of Building Back Better [21], (ii) improving the environmental and social sustainability through the use of local resources and boost the local economy, (iii) involve the communities in the design of the resettlements, in order to define a new *bottom-up* strategy for the post-disaster reconstruction.

In an attempt to overcome the criticalities discussed in Sect. 2 of this paper, the new urban and architectural design aims to: (i) design the new resettlement as a proper *urban part* of the city, made by private and public spaces, housing and collective buildings, amenities and facilities, (ii) provide some degree of flexibility to the housing, to allow economic development with the creation of small retail activities, as well as future housing development to accommodate new inhabitants needs, (iii) the adoption of the vernacular knowledge to face the climate conditions, pursue a passive thermal strategy, and the use local materials to optimize available resources.

Design proposal

An area located in the south of Portoviejo, that is listed among those for social housing developments, and located not in risk areas has been chosen for the new design proposal. The characteristics of the existing city elucidated with the morphological analysis, represented an important reference for the design of the new urban scenarios. Our aim is to define a new piece of the city, made by different parts, each with precise characteristics, with collective and private

spaces, streets and different housing typologies. Therefore, a variety of housing typologies is proposed to accommodate a range of families, and allow them future expansions. Starting from the principles highlighted during the typological analysis of the vernacular architecture, it was developed a contemporary proposal able to meet the inhabitants needs and the requirement of a more sustainable architecture.

Urban proposal

In order to carry out the design proposal in a real environment, it was selected a development area in the district of Portoviejo that was comparable for size and characteristics to one of the resettlement already built in this city (Fig. 4). The area *Empresa Publica Agua de Manta* is a void already designated by the local authorities for a residential development, presenting low risk of natural hazards, and already partially connected to the existing city through public infrastructures. Rather than the indiscriminate repetitions of the houses, the new resettlement was conceived as a new part of the city, made by the urban elements, housing, amenities and public spaces. The recurring cross section of the streets in the city centre of Portoviejo, common also to many cities in the Manabí Province, with the main road at the centre and the buildings facing each other with the *galería* at the ground floor (Fig. 5), was the starting point for the urban proposal. With the intent to extend this character in the new urban scenario, the residential buildings were conceived as terraced houses, with a portico on the main façade and the opportunity to house small commercial activities on the ground floor. A variety of buildings arrangements has been considered, and finally defined, considering the intention

Fig. 4 Map of Portoviejo with the location of the city centre, the existing resettlements and the new development area

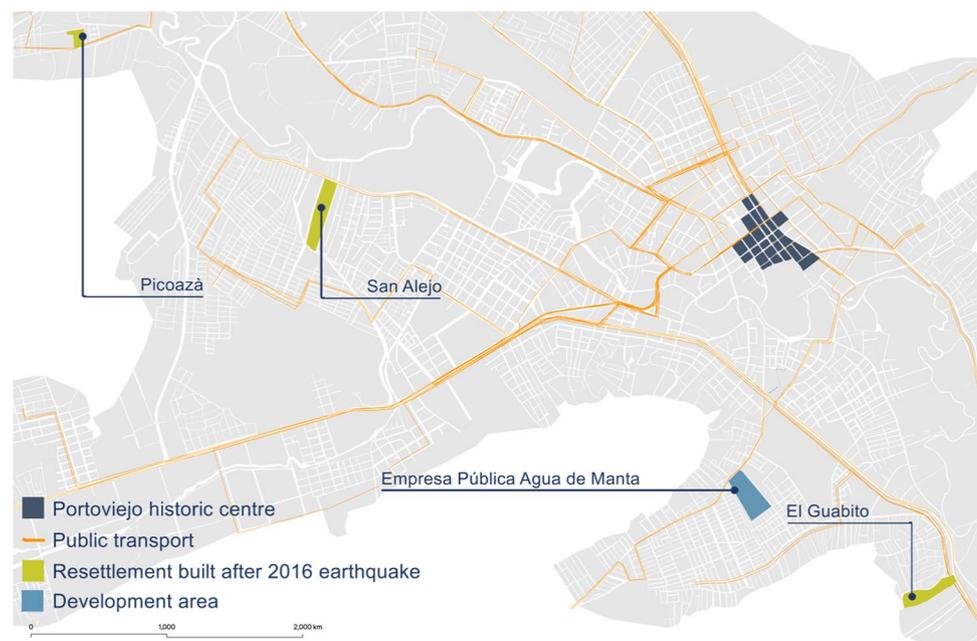
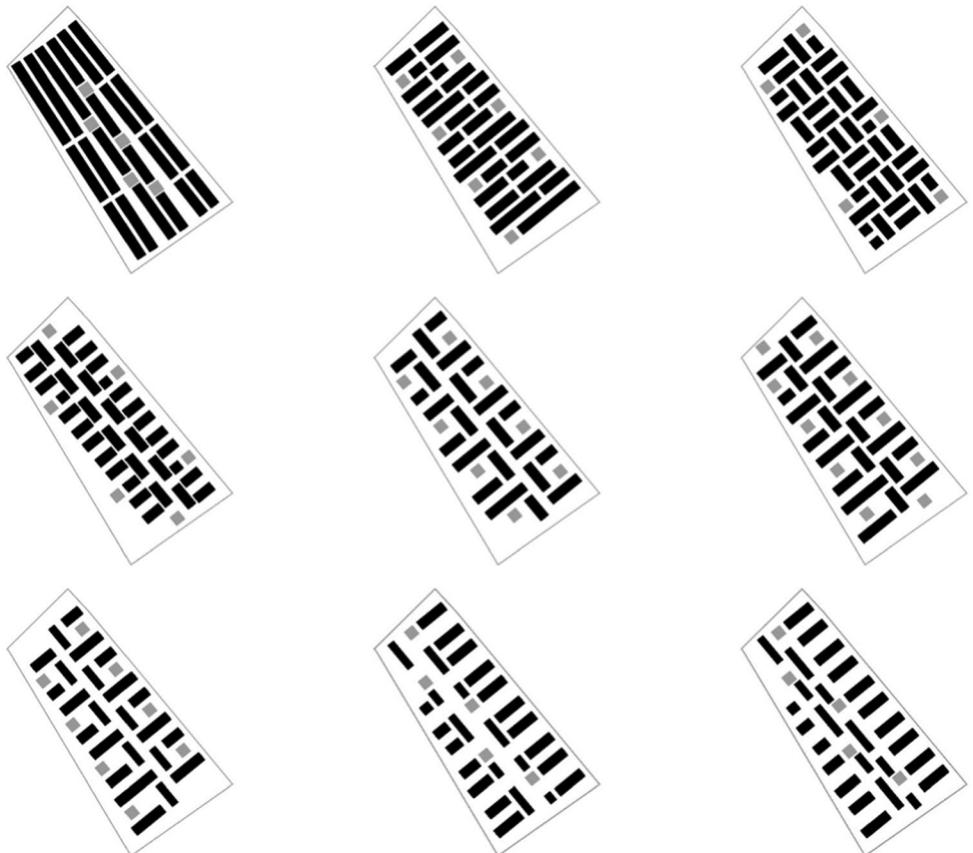


Fig. 5 Representation of the terraced housing system with the road in the middle and the portico on both sides



to reach a low density built environment for better living conditions (Fig. 6). Four different housing typologies, presented in the next paragraph, were combined in the urban environment in order to alternate residential buildings to public spaces and amenities. Green areas, parking lots and small public buildings such as community centres, nurseries and shops, are all integrated in the new (re)settlement to foster a healthy social development and attract people from the surrounding areas to increase connectiveness with the consolidated city (Fig. 6).

Fig. 6 Resettlement design schemes with the terraced houses in black and the common buildings in grey



Architectural proposal

The vernacular architecture study strongly influenced the design proposal for the new housing in terms of layout, tectonic and thermal strategies. The *vivienda-comercio* (Fig. 3), as well as many characteristic elements, such as the *galería* and the *patio* have been included in the new proposal in order to meet the inhabitants habits and needs. The housing are conceived as flexible systems, able to accommodate a variety of uses, to expand in future, and

to be built in phases. The houses are all two storeys high, to be combined as terraced houses, on a structural model of 3.60 by 3.60 m with the opportunity to grow on the side. The request for future development and modification of the houses was a very common requirements expressed by the inhabitants interviewed during the first part of the research project, so the *incremental housing* became a central topic of the design proposal. In order to better understand the dynamics linked to the participatory practices and the level of acceptance by the inhabitants in the short and the long term, some examples built in South America in the last 20 years [22] and in other global south countries [23] were examined. As a result of that investigation, an array of incremental houses were developed, to respond to a variety of potential functional programs, until four of them were selected for further development. The type A, is a two storeys house suitable for a family of three people at the initial stage, that can double its initial size and home up to 6 people. The type B, is a two storeys patio house of 78 m², suitable for a family of 4 at the initial stage and that can be expanded to accommodate up to 8 people. Both typologies (A and B) are suitable to home some commercial activities within either part or the entire ground floor. The type C is a two storeys patio house, suitable for two small families, with an initial size of 39 m² each floor that can be extended up to 65 m². The last type (D) is a 78 m², which was developed to be a wheelchair accessible home for four people (Fig. 7).

Focus groups feedback

In other to co-produce with Ecuadorians experts the new (re) settlements, urban proposal, housing typology, technology and construction materials were discussed and reviewed during two focus groups. The Portoviejo proposal was presented starting from the analysis and the design concept, in order to illustrate the entire framework and verify the goals with the experts. The urban proposal for the new (re)settlement and the housing design were discussed in depth in order to avoid any possible mistake already experienced by the survivors in the post-disaster reconstruction of the Manabí Province. The focus groups were of fundamental importance to improve the design proposal before further development and presentation to local inhabitants.

Urban and architectural design focus

The first focus group was dedicated to the analysis of the urban and architectural design, with special attention to the impacts that they could have on the inhabitants. Using as critical lens, the topics underlined in the first part of the NOVA VIDA project investigation, the group focused on the social impacts of the proposed urban environment and the quality of the housing.

In the evaluation of the urban environment, key attention was given to safety and capacity for community development. The experts highlighted the importance to review the spaces to allow the safety of the inhabitants within their houses (for

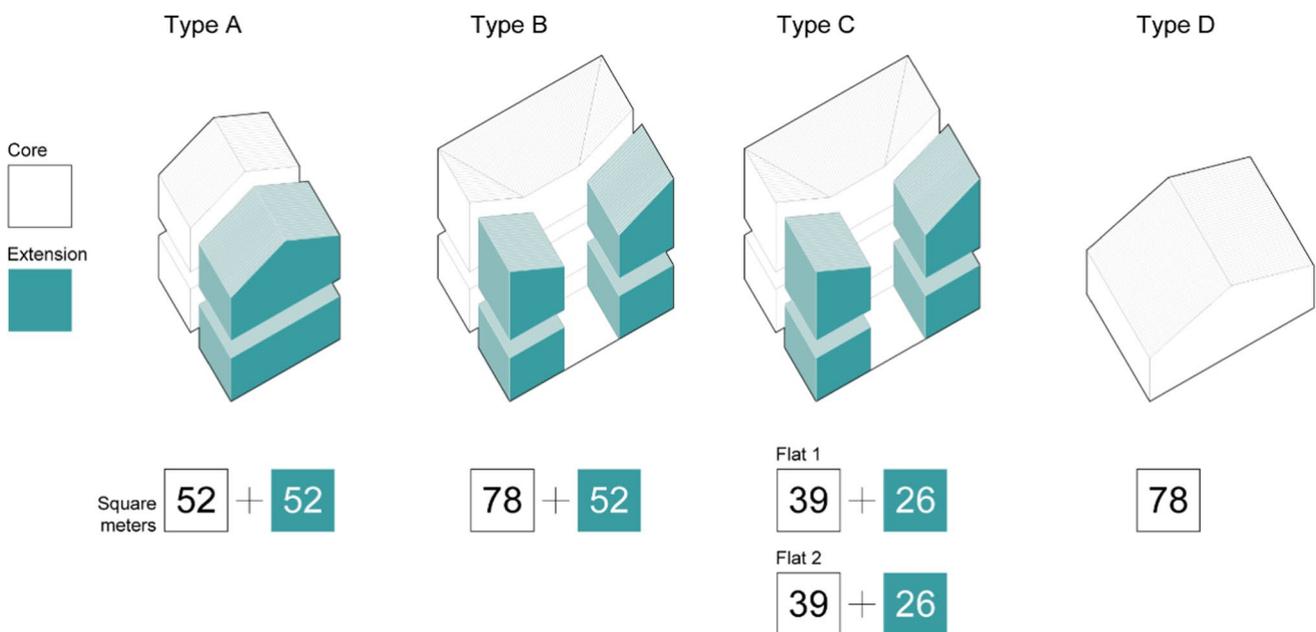


Fig. 7 Portoviejo proposal, housing typologies

instance, by always including a back door, as escape in case of domestic abuse or fire) and in all the common areas, as well as they underlined the importance to include communal services and amenities close to the housing, for a safe and healthy development of the neighbourhood.

The housing typologies, their layouts and their flexible use, which is capable to integrate small commercial activities, were well embraced by the experts, who recognised in them a potential solution to the needs claimed by the inhabitants of the existing resettlements.

The last part of the discussion was related to the possibility to involve the communities in the construction process and boost the local economy through the use of the local materials and construction techniques. The experts proposed the use of alternative materials, such as wood and bamboo, which are materials belonging to the Ecuadorian tradition, and also present in few cases of community-led initiatives in Manabí in the aftermath of the 2016 earthquake.

Materials and construction techniques focus

The second focus group was specifically dedicated to the technical aspects of the project, i.e. the materials and the construction techniques. After the analysis of the different opportunities offered by the local construction market, a draft proposal was developed and presented during the meeting with the experts, in order to discuss the opportunity to work with conventional and unconventional systems. The benefits offered by bamboo are starting to be worldwide recognized, with growing interest for future developments in both rural and urban areas, of conventional and advanced engineered techniques [24, 25]. The bamboo represents a great local material resource for Ecuador and in particular for the Manabí Province [26], for its abundant availability and its diffused use in the construction industry. Among the variety of bamboo structural systems, the experts suggested the adoption of a specific construction technique called *bahareque* in Spanish or *bamboo shear walls*, which is largely present in Manabí vernacular architecture as well as in many contemporary experiences of social housing in the Global South [27]. Moreover, the most recent studies cited in the 2016 INBAR post-earthquake report, demonstrate that the *bahareque* system can provide very high seismic performance if properly designed and built [28, 29]. As result, of this focus group the *bahareque* system was adopted for the future scenarios development.

Design analysis

The focus groups feedback were integrated in the further development of the urban (re)settlement and the buildings proposal. These were combined with data about the

demography of Ecuador population, and average size of families in Portoviejo. Based on the last census, by the *Instituto Nacional de Estadística y Censos*, the national average of members per family is 3.78, instead the Manabí Province counted an average of 3.97. This data was considered for re-balancing the housing proposal and re-evaluate the number of each housing typology to be placed in the (re)settlement to offer appropriate solutions for accommodating future families. The initial proposal was also re-verified against the local urban development policy, the building regulations [30] and the seismic standards.

The housing type A was further developed, conceived as a hybrid construction, built in different materials, and with the opportunity to be extended on the side (Fig. 8). Specifically, as shown in (Figs. 9 and 10) the foundation is designed in reinforced concrete, with an upstand at least 400 mm high on the ground level to preserve the bamboo walls from water and dampness [31, 32]. The walls and floors are in bamboo, with the *bahareque* system adopted as shear walls. This last consists in frames of large diameter bamboo canes completed on both sides with a layer of bamboo laths, a metal wire mesh and mortar as finish layer. Several studies confirm that the bamboo shear walls if properly maintained could represent a valid and durable technique for seismic constructions. Moreover, the external layer made by mortar can provide a good protection in case of fire [31]. The roof is designed as a double pitch with a gap at the ridge to favour natural ventilation inside the house. The bamboo roof structure is completed with corrugated metal sheets outside, to contain the roof weight and facilitate the anti-seismic behaviour of the building.

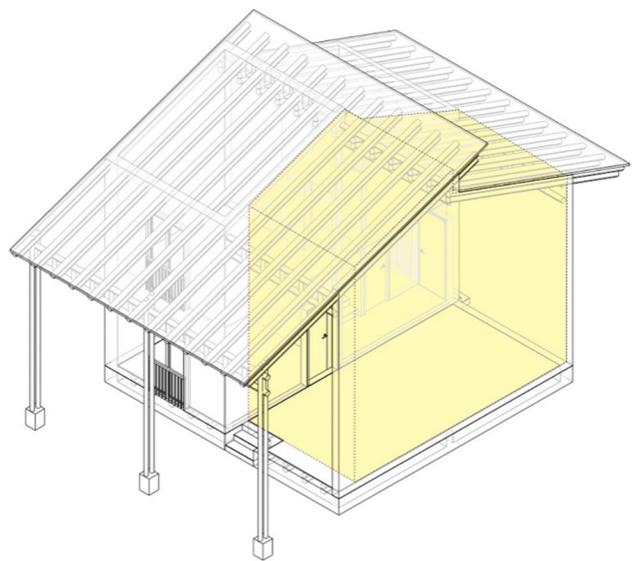


Fig. 8 Portoviejo proposal: incremental type A house

Fig. 9 Type A housing typology: definition of the main construction elements

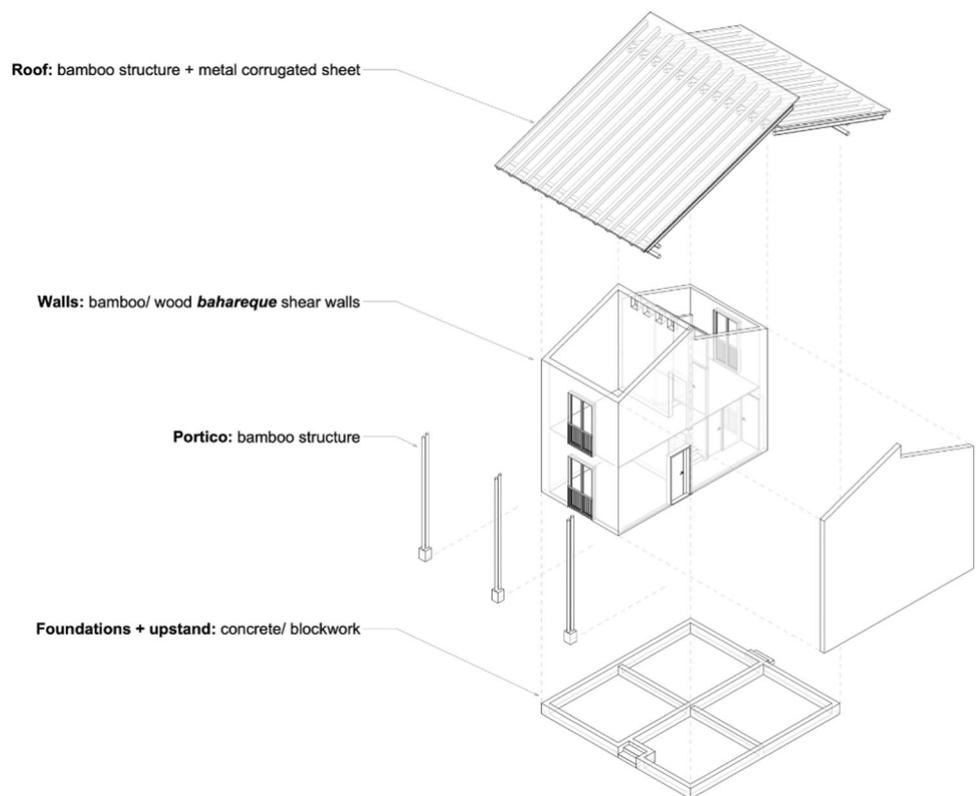
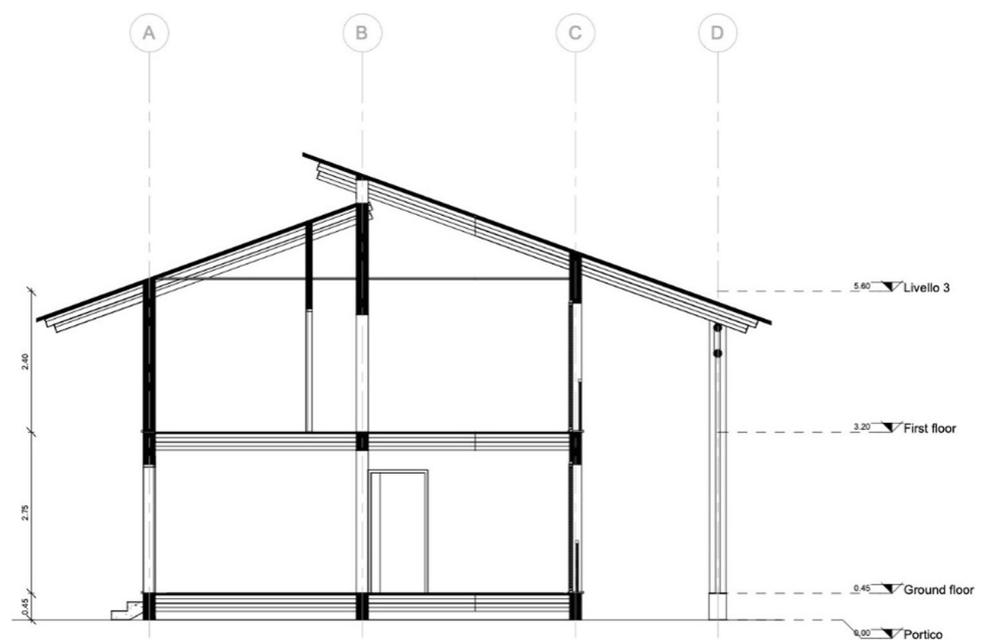


Fig. 10 Type A housing typology: cross section



Future studies

The general aim of the research program was the production of alternative reconstruction scenarios, that could allow the long-term wellbeing of the survivors. Therefore,

the principal objective of the design proposal was to critically consider and develop through a participative process new urban and domestic environments, and understand their acceptance through workshops with the municipality and local inhabitants. The NOVAVIDA team aims to continue the work toward the detailed design of a prototype,

Fig. 11 Urban scenarios with type A Buildings: **a** before extensión; **b** after extensión and the integration of small commercial activities



that could allow the verification of the production process, as well as it could provide the opportunity to re-skill local builder in the use of *bahareque*. Currently, in the coastal area, bamboo is an abundant available material and there is a proliferation of suppliers for construction use. However, the technique of *bahareque* is no longer common, so it was not yet possible to compare the building costs with any precedents. Relevant information about Ecuadorian construction costs are illustrated in several documents issued by INBAR [33] including illustrated built examples of low-cost bamboo based houses. In the future the feasibility of adopting the *bahareque* bamboo system on a large scale will be investigated.

Conclusions

The occurrence of natural disasters require decisions to be taken in short time, including the housing of displacement populations. Too often, the rapidity of construction and the market costs are among the main decision drivers, and they result in the development of heavy cramped reconstructions with houses built with poor materials, without any involvement of local population, and limited considerations for future generation needs.

This is certainly evident in the reconstruction program deployed in the Manabi province after the 2016

earthquake. A review of the impacts of the reconstruction strategy [12], indeed, highlighted the inadequacy of the built resettlement due to the location and the urban program (geography of the resettlement), the quality of the house in terms of thermal comfort and flexibility (material condition of the housing), and the lack of planning for future economic and social grow (social condition of the urban environment).

With the intent to re-think the way (re)settlements are conceived, this papers proposes new scenarios for Ecuadorian social housing, that combine local urban knowledge, vernacular architecture, local material and sustainable social integration. The vernacular architecture played a fundamental role in the design process, the strong identity of elements such as the patio and the portico, extensively influenced the housing design which answer to the local life habits of the Ecuadorian coastal communities, where people usually spent the daytime outside their houses in outdoor and/ or neighbour activities. The proposed urban development works on three levels of spaces (I) public, (II) semi-public and (III) private, in order to ensure the wellbeing and the privacy of inhabitants in the course of all the daily activities. Moreover, in order to guarantee not only the social wellbeing but also the local economy, the design proposal takes into account the opportunity to have some small economic activities at the ground floor as in the houses of the Portoviejo historic centre.

This paper proposes a co-production methodology for social housing development, that starting from the critical analysis of the most recent resettlements, based on interviews with the inhabitants, sees the design process as an iterative process, that includes morphological and risk analysis, initial urban and architectural proposal, review with local Ecuadorian experts and (re)development of more detailed schemes, which will be further developed in immersive virtual reality to be brought to the current inhabitants to provide the opportunity for further modifications. This paper presents and discusses the design evolution of the proposed future scenarios, posing the attention to the urban development and the housing design, articulated imagining the (re) settlement as a new neighbourhood of the city, with a combination of private and public spaces, that will grow and be fully integrated to the consolidated city as population grow. The housing, itself, reflects the idea of incremental growth by guiding the future extension within defined construction elements (Fig. 10), while adopting elements and bamboo construction techniques of the local tradition, to facilitate the emotional connections of the inhabitants with the new place, and foster a healthy development (Fig. 11).

Declarations The work is the outcome of a transdisciplinary multi-scale approach, developed through the NOVA VIDA research project (UWB190207) funded by British Academy, coordinated by Professor Ornella Iuorio.

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