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Article

Designing for a Flow: Navigating Temporalities in Housing Considerations in Low-Income and Hazard-Prone Caribbean Contexts

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Abstract: The urgency of addressing housing challenges in low-income areas is increasing due to widening socio-economic inequalities and the worsening impact of natural disasters. Saint Martin, a small Caribbean island, is struggling to provide affordable housing amidst hurricanes, floods, and heat waves. As a result, there has been a rise in self-organized housing units, which are built incrementally and are susceptible to risks. The main challenge is to balance durability, functionality, and esthetic appeal over time. Inspired by St. Martin's self-organized units, this article explores housing considerations in low-income, hazard-prone contexts by emphasizing their temporalities. Integrating insights from a formative study, including a literature review and ethnographic research, the paper draws on Stewart Brand's "Layers of Change" and the concept of "Flow". The study identifies layers within self-organized units corresponding to durability, functionality, and esthetic appeal. It delves into their connection with building activities over time, unveiling the temporalities of housing considerations. This exploration leads to the proposition of "Designing for a Flow" as a novel design approach. Offering practical insights within a concise framework, the study provides nuanced perspectives on mitigating housing challenges in low-income and hazard-prone contexts.

Keywords: incremental housing; low-income housing; resilient design; climate change; extreme weather; layers of change; Stewart Brand; sustainability

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1. Affordable Housing and Self-Organized Housing Practices

In many areas where access to affordable housing is limited, people resort to building their own homes. While this is a common practice, the unprecedented growth of cities has led to an increase in the scale of this process [1,2]. In fact, most of the world's dwelling delivery is organized in this way, including housing on various Caribbean islands [3,4]. These units are typically small, standalone structures, that are built by households with limited professional support [5,6]. They are often referred to as self-built, self-initiated, self-organized, auto-constructed, or informal housing units. As the process often involves assistance from neighbors, families, or paid labor, this article emphasizes the collectiveness and proactivity of this practice by referring to such units as self-organized housing.

The process of procuring self-organized housing differs from typical dwelling development. It is often initiated in response to the urgent need for shelter, as seen, for example, in lower-income individuals who relocate to major cities in search of better job prospects [7]. The process starts with occupying a piece of land, followed by building a basic unit, setting-up infrastructure, and potentially obtaining the land title as the final step [8,9]. These developments usually take place on vacant land that has been underdeveloped for various

reasons, such as being located in or near higher-risk areas [10,11]. It includes, for instance, steep hillsides, flood-prone areas, sites near landfills, and railway or road reserves [12,13]. Building in such locations increases the risks of being affected by hazardous events and requires additional adaptations during construction to ensure the households' safety [14].

Self-organized housing often develops incrementally, becoming an ever-ongoing, gradual process driven by individual resources and needs [15]. It can begin with the development of a small unit using temporary materials to reduce costs [16,17]. Limiting the expenses can also be achieved by using fewer materials or replacing them with lower-quality alternatives [18]. Over the years, the house may undergo modifications, adaptations, or enhancements based on the owner's needs, preferences, and specific site conditions. Those changes happen when the household gathers sufficient funds or construction materials, allowing the building process to continue [19]. The houses are constructed with diverse materials and building techniques often without complying with building regulations [20].

Although self-organized housing often lacks planning and has technical shortcomings [21], it possesses vital characteristics that, when combined with institutional support, can generate a base for feasible and valuable housing proposals. It offers a practical alternative to mass social housing, which can be more expensive, and culturally inappropriate [22]. Since the 1960s, incremental housing approaches have been drawing inspiration from self-organized building practices. Experts such as Jacob L. Crane, John Turner, Charles Abrams, and others have advocated for proposals accommodating growth and change over time [23] by mimicking how self-organized houses are developed [22]. These design approaches include, for instance, aided self-help, sites and services, or core housing. Overall, implementing incremental housing approaches can support households in developing homes that allow for modification and growth, accommodating specific needs and lifestyles [8].

2. Housing Design and Planning Considerations

Self-organized housing, while proven to be a practical alternative to affordable housing provision, often lacks important planning and design characteristics [21]. To address this, architects can play a relevant role in supporting the planning and development of such housing. For many decades, this support revolved around the housing process, seen as an activity of creating a house. It has been focused on facilitating the gradual process of building a house, rather than the final form it will take. This perspective is linked to Turner's concept of "housing as a verb" [24]. Nowadays, both the housing form (product) and the process are considered crucial components in dwelling assistance [23]. By supporting residents in developing incremental housing that enhances safety, comfort, and overall experience, architects can contribute to the process of self-organized housing.

Addressing both the process and form of housing requires revisiting key design and planning considerations. The architecture triad, introduced by Vitruvius, the first writer on architecture [25], established the key design considerations that also fit the discussion on low-income housing in hazard-prone contexts. In the book *De Architectura*, he outlined three design considerations: *durability* (Firmitas), *functionality* (Utilitas), and *esthetic appeal* (Venustas) [26]. To provide a better understanding of Vitruvius's ideas in the context of modern architecture, Guyer supported them with a series of questions [27] (p. 5). Durability is the key concern and refers to how (well) the building is constructed. Functionality is the second important aspect, which is connected to how well the house meets the needs of its users. Lastly, esthetic appeal, despite being often associated only with visual aspects, is also related to housing perception and answers the question of how the house is experienced.

The three key considerations—durability, functionality, and esthetic appeal—are commonly taken into account during the housing design process. These considerations are challenged and influenced by the inexorable passage of time. Their intricate relationship with time extends throughout the construction, use, and interactions with housing units. Notably, these relations manifest in self-organized houses, evident in the phases of construction, gradual development processes, the permanency of structures, material and infrastructure consolidation, and community and political dynamics. Users actively

contribute to addressing these considerations over time through various building activities. Despite the acknowledged relevance of these spatial–temporal relations [25,28–32], referred to as "temporalities", they tend to be overlooked when addressing design considerations.

In the design and planning of low-income housing in hazard-prone contexts, *durability* often becomes a primary consideration, particularly in the ongoing discourse on the resistance and resilience of designs and communities [10,33–39]. In many designs, durability is addressed through structural resistance and integrity, ensuring the ability to withstand risks without making irreversible changes to relevant characteristics [36]. However, this resistance is typically guaranteed at the moment of a unit's development and may not extend into the long term. Over time, as materials wear off, there can be a gradual decline in durability. This approach raises concerns, especially in cases where modern building techniques, while enhancing initial resistance, may involve more costly solutions unfamiliar to local builders [35,37]. The consequences of such choices become apparent in the long run, impacting the ability to maintain and repair the units, which is crucial for ensuring structural safety over time [38]. These choices may also lead to self-organized modifications, driven by a misalignment with the design preferences and needs of residents, sometimes resulting in a compromise to structural safety [39,40].

In such contexts, the consideration of *functionality* is closely tied to addressing the needs of residents, ensuring convenience in using the space. Initial low-income housing designs often fall short of meeting these criteria, given the dynamic nature of residents' needs. To address this, the approach shifted toward designing housing units with the capability to be modified, adapted, and expanded over time. This approach provides residents with the flexibility to gradually develop their homes, recognizing the evolving nature of their requirements. Various approaches, such as incremental housing, core housing, open building, support, and infill, are employed to ensure adaptability and functionality which are able to stand the test of time [23,41–45]. Additionally, the concept of adaptability is being explored in risk-prone areas, with a focus on building temporary and half-built homes that provide safety and a path to permanent residency [46–48]. The considerations related to functionality are relatively closely connected with the aspects of time, going beyond the initial design phase to accommodate changes and growth in residents' needs.

Discussions about the temporal aspects of *esthetic appeal* are rarely encountered in the context of housing design in low-income and hazard-prone areas. Even though esthetic appeal extends beyond physical and material aspects to include culture, social relations, and individual expression [2,49], it is frequently given a lower priority to the debates on durability and functionality. If esthetics are taken into account, the focus typically lies in customizing provided units, allowing for minor modifications such as colors, ornaments, or external elevations [41].

Housing designs lacking the planning for changes and neglecting the influence of time in the considerations have been deemed impractical, especially given that self-organized building practices are dynamic and proactive, requiring an approach that can adapt to changing circumstances. The housing units must be durable while also being functional, esthetically pleasing, and able to withstand the test of time. As time goes by, how does the durability of a house change considering the wear and tear of materials? What happens to the functionality of a house when the size or dynamics of the family change? How would the house accommodate an income-generating activity? Additionally, how is the esthetic of the house affected by technological advancements and changes in fashion trends and aspirations? Recognizing the contingent nature of self-organized housing practices and understanding their intricate connection with time can offer valuable insights in the ongoing discussion surrounding housing design in low-income and hazard-prone contexts.

Considerations of durability, functionality, and esthetic appeal of self-organized houses are challenged and addressed over time through building activities. However, the extent to which housing temporalities, manifested through time-bonded building activities within self-organized units, can inform considerations in the design of housing for low-income

and hazard-prone contexts, remains unclear. This research endeavors to bridge this gap by delving into the temporal aspects of housing to uncover how the considerations of durability, functionality, and esthetic appeal evolve over time through users' activities interacting with various building elements. This study contributes to a nuanced comprehension of the dynamic interplay between self-organized housing practices and temporalities of housing considerations, offering valuable insights for the development of resilient and culturally responsive housing solutions in low-income and hazard-prone communities.

This paper proposes a novel approach for enhancing the durability, functionality, and esthetic appeal of self-organized houses by emphasizing their temporal aspects. Drawing inspiration from Stewart Brand's conceptualization of a building as a composition of layers with varying lifespans [50], the proposed approach seeks to address affordable housing challenges, specifically focusing on self-organized building practices (Section 1). Additionally, it explores leading housing design approaches that intend to tackle these challenges (Section 2). The paper provides a comprehensive overview of the research methodology and materials employed in the study (Section 3) before delving into an examination of housing practices on St. Martin Island (Section 4). Building upon this foundation, the paper introduces Brand's concepts of "Flow" and "Layers of Change" (Section 5) and applies these ideas to the context of self-organized housing, discussing the relationship of building layers with time (Section 6). The subsequent section (Section 7) engages in a discussion regarding housing considerations such as durability, functionality, and esthetic appeal in conjunction with the identified building layers. Next, the paper proposes a novel approach titled "Designing for a Flow" (Section 8), which connects these considerations with building layers and time-based factors. The final part of the article encompasses a reflection on the study's limitations (Section 9) and synthesizes the key findings into conclusive insights (Section 10).

3. Materials and Methods

This study adopts a comprehensive methodology, drawing insights from a theoretical foundation established through a literature review. The research design for this study is both formative and exploratory, intended to examine the temporal aspects shaping considerations in housing in low-income and hazard-prone contexts, specifically drawing insights from the unique context of Caribbean housing. The formative nature of the study aligns with the exploratory characteristics as defined by Singh [51], emphasizing the testing and refinement of conceptual ideas before their potential implementation.

The study is grounded in the insights derived from a comprehensive literature review, which delved into various aspects of affordable housing approaches in low-income and hazard-prone contexts. This thorough exploration encompassed resilient and resistant housing designs, along with studies on self-organized housing practices. To perform the literature review, databases were searched for articles, books, reports, and written documents. Additional references were acquired through the snowballing method, utilizing relevant citations to identify pertinent sources. This foundational step serves as the base, informing subsequent fieldwork and analysis.

Drawing on the knowledge gained from the literature review, the study progressed to the examination of self-organized housing examples in St. Martin. This exploration was underpinned by an extensive review of the literature pertinent to the island's housing situation. To deepen our understanding of the island's low-income housing dynamics, an analysis of research papers and dwelling reports was undertaken. This information was further enriched and validated through iterative ethnographic housing studies conducted during field visits in the second quarter of 2022 and 2023. Employing classical ethnographic methods, including observation, visual mapping, photography, and interviews with residents [52], played a pivotal role in this ethnographic research. The study involved semi-structured interviews with households residing in 28 units located in various areas inhabited by low-income residents of the islands. Ethical considerations were paramount throughout the study, ensuring participant consent, confidentiality, and adherence to ethical

protocols. The investigation revealed notable inhabitation patterns, prompting a focused exploration of the temporal considerations in relation to the durability, functionality, and esthetic appeal of the units.

Building on the inspiration gathered during the field visits, the research led to an additional literature review. This phase focused specifically on time-related aspects of self-organized housing and affordable housing designs. The emphasis was on incremental housing solutions and building approaches that account for the temporal dimensions of housing practices. Inspired by Stewart Brand's concepts of "Flow" and "Layers of Change", the paper systematically explored the dynamic relationship between housing components and temporal aspects. Information gathered on self-organized housing through ethnographic research on St. Martin was fundamental in relating the literature with building practices to identify building components and relate them with housing considerations and time-bonded building activities within this specific typology.

In summary, this multifaceted methodology integrates literature reviews, fieldwork, ethnographic studies, and iterative approaches to comprehensively investigate the temporal considerations in self-organized housing within low-income and hazard-prone contexts. The investigation led to proposing a new design approach titled "Designing for a Flow".

4. Housing in the Caribbean: St. Martin Island

The Caribbean islands and their residents have faced numerous hazardous events and their implications since the initial settlements [53]. Due to their geographical position, the islands often experience seismic activity and earthquakes, which can cause tremors and even generate tsunami waves. Additionally, the islands are exposed to various climatic hazards that are exacerbated by climate change [54]. The main concerns that affect the Caribbean islands are rising relative sea level and sea temperatures, severe heat weaves, intensified extreme events including hurricanes, and precipitation variability [55,56]. In 2017, the major hurricanes Irma and Maria swept through the east of the islands, bringing along high-speed winds, torrential rains, tornados, and floods. Apart from climatic and geographic impacts, the islands are dealing with physical challenges related to rapid urbanization and industrialization [7,53,57]. Despite the efforts to prevent the damages caused by the various challenges, in the past 70 years, almost all the residents of several islands, such as Montserrat (1989), were left homeless in the aftermath of a hazard [7].

St. Martin Island (Figure 1) is located in the northeastern Caribbean and is administratively divided between the southern side, a constituent country in the Kingdom of the Netherlands, and the north which belongs to France. The houses on the island are exposed to various hazards, such as hurricanes, severe weather fluctuation, and rising sea levels. Unfortunately, many units, particularly those belonging to low-income households, are underprepared for them. In addition, the high cost of hurricane insurance makes it unaffordable for low-income households, leaving many of the residents without assistance [58,59]. The last hurricanes that made landfall in 2017 caused life loss and significant damage to the dwellings on the island. Even though most of the houses were (re)built in the aftermath of category 4 Hurricane Louis (1995) to withstand similar risks [60], the World Bank estimated that Irma and Maria damaged around 70–80% of residential buildings [58]. Since then, a lot of houses were repaired or rebuilt, but many households living in self-organized housing did not qualify for housing support [58,59].

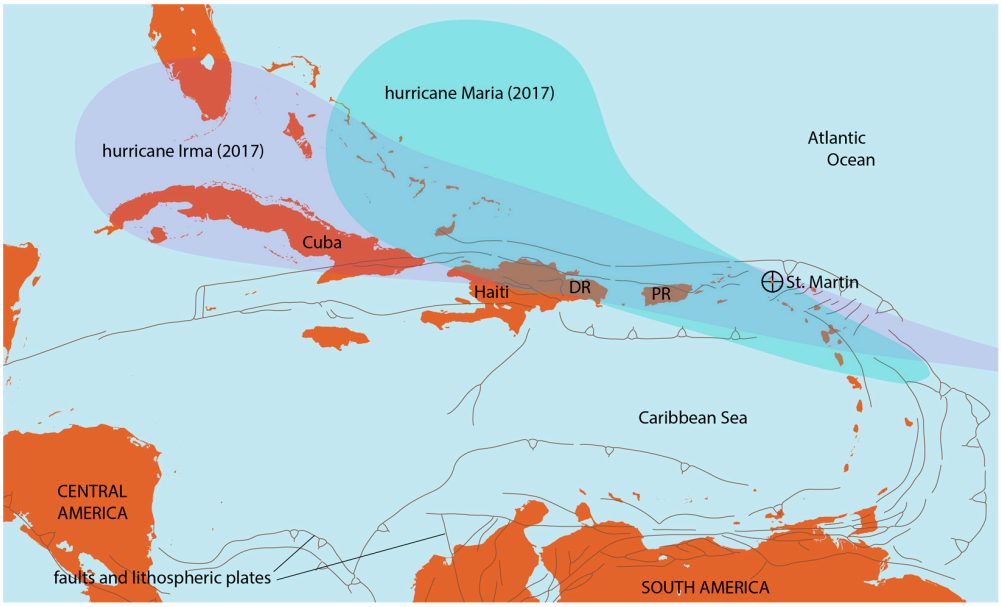

Figure 1. Map of the Caribbean islands indicating St. Martin Island. Source: Adapted from: Free Vector Maps [61]; faults and lithospheric plates [62] (p. 21); the approximate path of Hurricane Irma [63] and Maria [64].

On the southern side, social housing is provided by a local organization, the Sint Maarten Housing Development Foundation (SMHDF). It offers several typologies of buildings, including single-standing houses, multi-family housing, and apartments. Those buildings were also affected by Irma. They are built in diverse locations, together summing up to 796 dwellings [58]. After Irma, the demand for social housing grew rapidly, increasing the number of applicants from 1500 to more than 9000 (almost 25% of the population); however, a large proportion of the applicants did not meet the aid requirements [58]. The reasons for increased social housing demand include large-scale damage caused by the poor structural quality of housing which has been cyclically impacted by tropical storms [60].

For many low-income residents living on St Martin, self-organized housing is the only available housing option. The government estimates that in the southern (Dutch) side around 20–25% (10,000 people) live in such units [58] (Figure 2). These residential units belong to low-income households, which include recent migrant families and people who are not registered as residents of St. Martin [58]. The majority of the units are self-organized and have inadequate access to basic infrastructure, such as electricity, water supply, and sewage [58]. Additionally, they are often positioned in high-risk locations, and the housing lacks structural qualities adequate to the risks [3]. Those units are primarily single-standing houses, clustered in a few different districts of the islands.

Self-organized housing in St. Martin can have varying levels of permanence depending on factors such as the residents' intentions to stay and the security of tenure. The construction materials used for building these structures also vary, with some structures using temporary materials like reused timber or corrugated iron (Figure 3A), especially in contested tenure areas like Pond Island. Backyard units, which are rental apartments that provide extra income to households, often feature similar materials. Another type of self-organized housing is constructed using a light balloon-frame construction, as in the Caribbean vernacular style (Figure 3B). These timber units are rare and have mostly been modified or extended by adding extra rooms behind them. Some units were developed around formal cores, like the 'temporary' prefabricated houses that were erected after Hurricane Louis in 1995. Individuals have modified and adapted these houses over the years (Figure 3C). The most common type of self-organized housing is constructed using concrete blocks (Figure 3D). These houses are built incrementally, with rooms added around the ini-

tial units or expanding vertically, often thinking about the next generations. However, not all of them were finished, and some have been left incomplete due to family circumstances.

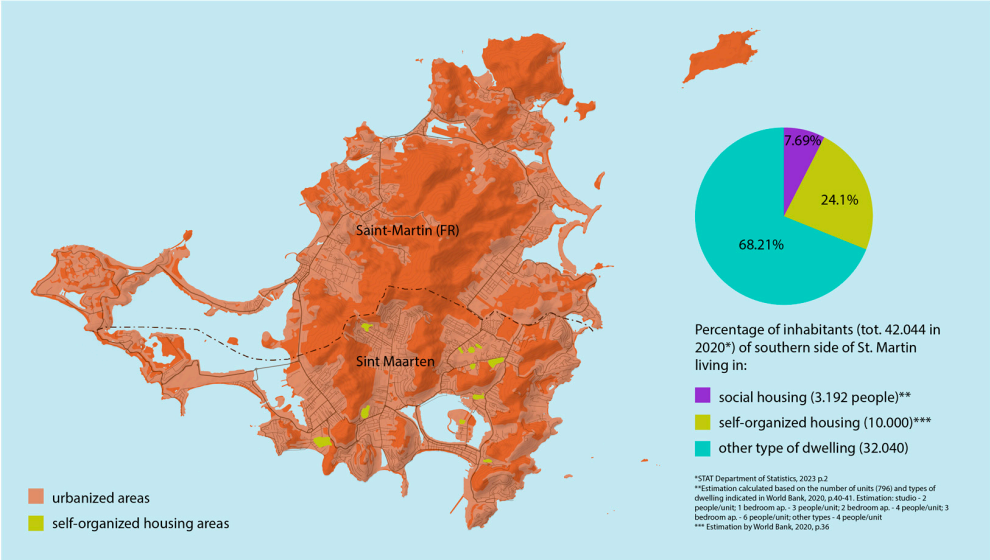

Figure 2. Map of St. Martin Island indicating urbanized areas and self-organized housing areas with a diagram presenting the percentage of inhabitants of the southern side living in various types of dwellings. Source: Adapted from: map [65]; population data [66]; and social housing data [58].

Figure 3. Impressions of different types of self-organized housing on St. Martin. (**A**) small housing unit at Pond Island using temporary materials; (**B**) light balloon-frame timber house with a porch and concrete extension in the back; (**C**) pre-fabricated concrete house with porch built as an extension; (**D**) house built with concrete blocks with an unfinished upper floor. Source: authors.

5. "Flow" and "Layers of Change"

Self-organized units tend to change more over time than other types of housing. This happens due to limited initial financial resources, constantly evolving needs and priorities, and other aspects [67]. Unfortunately, design practitioners often fail to consider the contingency and unpredictable forces that will inevitably change the designs over time [25]. Stewart Brand, an acclaimed author, proposed a practical solution to accommodate uncertainty and a building's relationship with time. He argued that designs discount time and are planned based on one life scenario envisioned by the architect [50]. Moreover, "ALL BUILDINGS are predictions. All predictions are wrong" [50] (p. 365). Acknowledging that it is not possible to predict the future, he suggests dropping the concept of "permanent architecture" and instead inviting designing for change.

In the first chapter of his book, *How Buildings Learn: What Happens After They're Built* [50], Brand introduces the concept of "flow". Using a quote by Rina Swentzel "Flow, continual flow, continual change, continual transformation", he argues that all buildings are continuously altered and the designs must accommodate these changes [50]. To achieve that, he suggests thinking of a building as a collection of layers that vary in their rate of change, rather than a consolidated building [68]. He puts this concept forward, building on the work of Frank Duffy, who was a theorist of layers of change [69]. These "shearing layers of change" are organized based on their longevity, noting that the longer-lasting ones have a greater influence on the ones that do not last as long [50] (p. 47). The order of these layers is the site, structure, skin, services, space plan, and stuff (Figure 4). This approach addresses each building layer individually, according to its lifespan length.

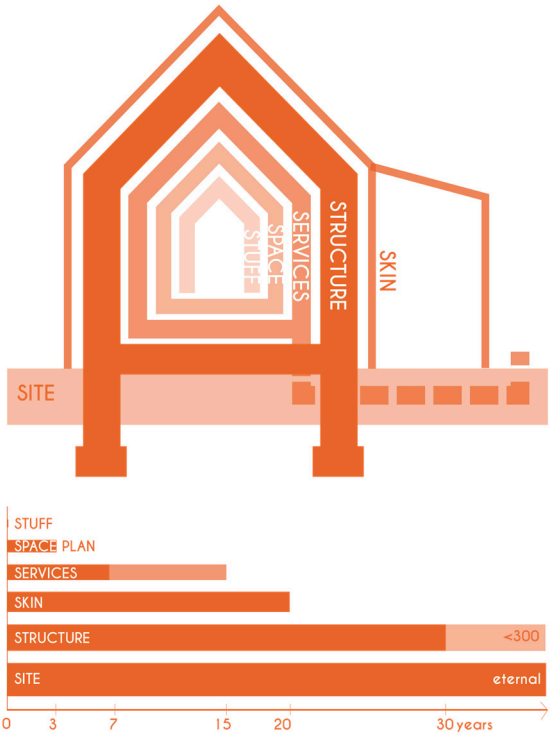

Figure 4. Shearing layers diagram. Source: adapted from [50] (p. 38).

Brand defined the layers and their expected longevityin relation to their purpose [50] (p. 38). He considers "site" as eternal, regardless of the challenges it may encounter. It is followed by "structure", which is related to structural elements and dated to last between 30 and even 300 years. The third category is "skin", which describes exterior surfaces that last up to 20 years. The next one is "services", including wiring, piping, and also communication, dated from 7 to 15 years. "Space plan" refers to the interior layout and partitions comes next. Brand suggests that they usually change around every 3 years,

except the case of "exceptionally quiet homes" where they may remain the same for up to 30 years. The last layer is "stuff" which may change daily without disruptions. Brand used this concept to propose a shift in design thinking, aiming to keep the time-laden layers disconnected from each other allowing for modifications.

Layering is an approach that was developed to ease facilities management and reduce the expenses of modifications in a building [69]. It facilitates making changes, replacements, and repairs of a building. It also helps to determine accountabilities within the building by using the layers to define the boundaries of user interventions and responsibilities [69]. This approach can increase sustainability by maximizing the use of each layer and limiting the production of unnecessary waste. As it aims to extend the building lifespan to reduce negative environmental impacts, it is often implemented in various sustainable design strategies, including Circular Economy [70]. Applying this concept to housing design in low-income and hazard-prone contexts could help incorporate time aspects into design considerations.

6. Layering Self-Organized Housing

In his work, Brand discusses the changes that occur over time in three different types of buildings: institutional, commercial, and domestic. He highlights the distinct dynamics that exist in each type. Brand characterizes houses as the "steadiest changers" [50] (p. 24) noting that "[h]omes are the domain of slowly shifting fantasies and rapidly shifting needs." [50] (p. 31). Given this logic, self-organized buildings, which are characterized by frequent change, require special attention, as the relationship between layers and time appears to be more complex.

Brand explains that the layering sequence is also followed through design and construction [50] (p. 46). Typically, the building process begins with preparing the *site*, erecting the *structure*, and then covering it with the *skin*. After that, the *services* are installed, and the *space plan* is organized. Lastly, the residents arrange their *stuff* in the space. This sequence is followed in building self-organized housing to a certain extent (Figure 5). The process begins with moving onto the land, followed by gradually building a house, installing the services, and eventually obtaining the right to the land [8]. The house-building is commonly an incremental process [22], based on the dynamic and productive efforts of residents [28].

Moreover, Brand's proposal suggests that all layers of a building start their life cycle at the same time—during the building's development [50]. After this, each layer continues its life in a linear form (Figure 4), with its longevity depending on its characteristics and how quickly it becomes outdated due to changes in fashion and technology. This is different for self-organized housing as households often adopt a "build as you go" approach [71] and reuse materials [72]. As a result, each layer may have a different starting point, and the layers may comprise elements in diverse life cycle stages, including new, reused, or repurposed parts. The development of layers in self-organized houses is often iterative, as the elements are changed from temporary to more permanent. This results in units that can be conceptualized as an assembly of not necessarily linear temporal layers of the building elements.

Accessing the *site* is often the first step in the development of self-organized housing [73]. The *site* is also the most long-lasting layer in Brand's hierarchy, and the changes to this layer affect all the other layers [50]. This layer is characterized by its location and its unique features. Those characteristics may include geographical, political, institutional, socio-economic, and other aspects, influencing tenure security or hazard exposure. Lot size and geometry determine possible housing development, including its orientation, which is relevant for sun exposure and ventilation [21].

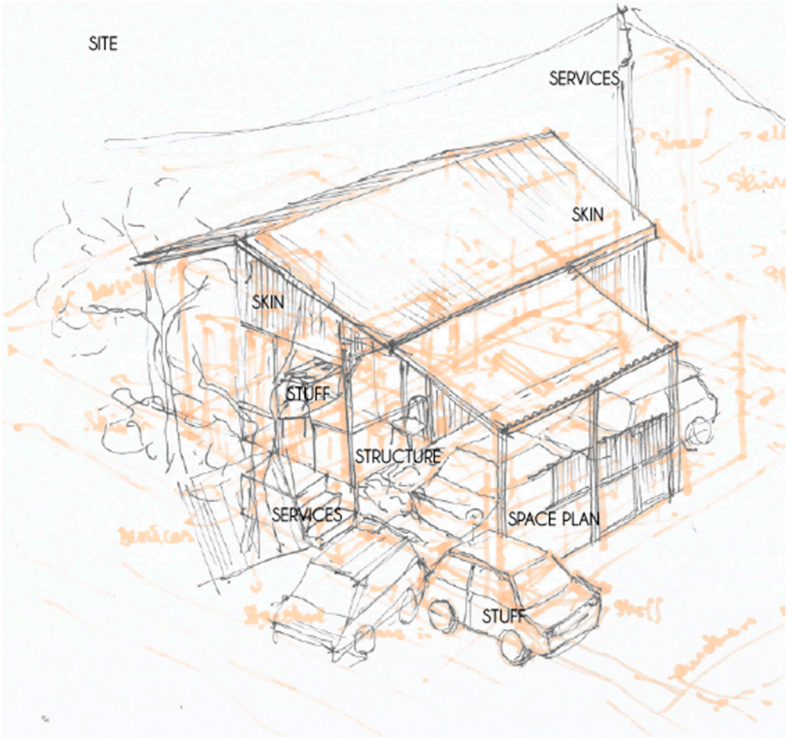

Figure 5. Sketch of an example of self-organized housing on St. Martin.

After obtaining access to a plot, the next step is building a basic unit. The purpose of this unit is to meet the basic needs of the household [22]. It starts with *structure*, which pertains to the load-bearing elements like foundations, columns, walls, or slabs [50]. In the case of self-organized homes, it can also include a pre-existing structure, such as prefabricated cores, containers, or old trailers or buses. The longevity of the structure is determined by individual circumstances and is reflected in the materials used and building techniques employed. The temporal materials include iron sheets, cardboard, reclaimed wood, and others. Over time, those materials are replaced with more permanent ones like concrete blocks or poured concrete. The decision to change materials is often related to factors such as financial availability, security of tenure, or perception of hazards. When materials are replaced, they can be disposed of, reused for a different purpose, given away, or resold to other residents.

The structure is covered by the *skin*, which covers it from the outside. This layer is often made with diverse components, including new, reused, or repurposed elements, such as windows, planks, iron sheets, or others. This layer contributes to weatherproofing and thermal control. The used materials will affect the lighting and shadowing conditions, radiation reflection, ventilation, and acoustic aspects. The skin also plays a role in providing privacy and has an esthetic role. Over time, the residents often adapt the skin by applying textures, colors, details, and other elements according to their preferences.

After ensuring weatherproofing, the *services* are arranged. This layer is mostly related to comfort and its type and scale vary depending on the building's purpose. For residential buildings, it includes electric, gas, plumbing, heating, ventilating, air conditioning, and other types of systems and wiring. In self-organized houses, the services may be limited at first. Gas is often provided by a bottle, and electricity depends on the level of formality of the unit. In some cases, the rainwater may be collected in underground cisterns. Initially, toilets are often located outside and not necessarily connected to the sewage network. Over time, as the building becomes more consolidated, the services are improved, and the bathrooms are moved inside the houses.

The layer of *space plan* or perhaps space organization is made of the elements creating the layout. This layer represents the spatial division that is related to the function of each

area. It includes non-structural walls, ceilings, floors, and doors. Initially, the interior space may be compact with temporary or permanent divisions, and it may also include external, not fully enclosed spaces. As time goes by, the space often undergoes modifications due to changes in family circumstances or the inclusion of economic activities. These changes in the space plan usually lead to changes in the structure. The space is filled with *stuff*, which is the last layer, and includes all the possessions of the residents, such as cars, furniture, decorations, clothes, etc.

7. Housing Considerations and Layers of Change

7.1. Durability

Building on a Brand's concept of layering the building, we can link various building layers with design considerations. Durability refers to how (well) the building is constructed and relates to the building process and structural performance of the unit over time. In housing in hazard-prone contexts, it is closely connected to safety and house-building practices that elevate the building's ability to weather various hazards [74]. Ensuring durability aims at designing and building units with qualities that protect inhabitants from location-specific hazardous conditions over time. The layers which primarily affect the durability of a unit are site, structure, and skin (Figure 6).

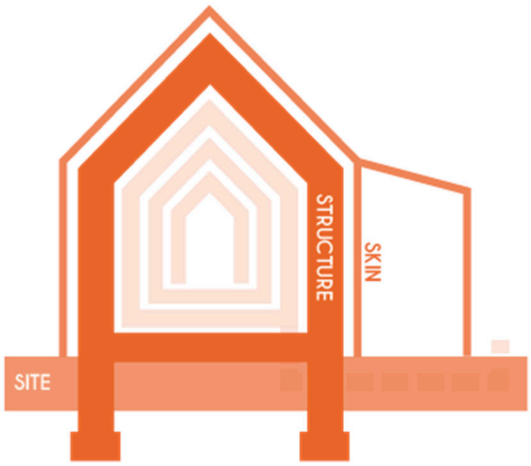

Figure 6. Layers related to durability.

Changing environmental factors can influence durability. Depending on the site, it can be compromised of climatic, geographical, environmental, and other challenges [7,56,75]. Houses can also be exposed to multiple or compound risks, making it more challenging to ensure durability. For instance, dwellings in many of the Caribbean islands are exposed to diverse risks, including earthquakes, hurricanes, and the implications of climate change. Hurricanes are examples of compound risks, as they may cause significant wind speeds, torrential rains, storm surges, flooding [7], and even a possibility of tornados. They may affect the houses differently and may cause immediate damage or trigger a cascading effect. Over time, the site conditions may contribute to increased wear and tear of materials, damaged building components, structure destabilization, or others [75,76].

The durability of housing in high-risk areas largely depends on the structural characteristics. The structure is the first layer that is built, and it is characterized by form, building technique, and type and quality of materials [6,75]. In the Caribbeans, the structures of self-organized units are most commonly erected using pre-existing cores, poured concrete, concrete blocks, and timber (Figure 7A–C). Various parts of the structure are often built with materials; for instance, concrete blocks are used for walls and foundations, while the rafters are made of timber. To reinforce the lightweight materials, residents often secure them with concrete [58,77]. This is related to the households' perception that concrete structures are more durable against hurricanes and wooden structures are safer against earthquakes [77]. They make the design and construction decisions based on risk perception, available re-

sources, and individual building knowledge and skills [5]. Those choices often require navigating between the costs and building performance. They are made in consultation with local builders and result in using fewer reinforcements, applying quicker building methods, or reducing the costs of materials [6,18]. This process also leads to building with lower quality or homemade materials [18], making it challenging to assess the durability of the structures based on material types.

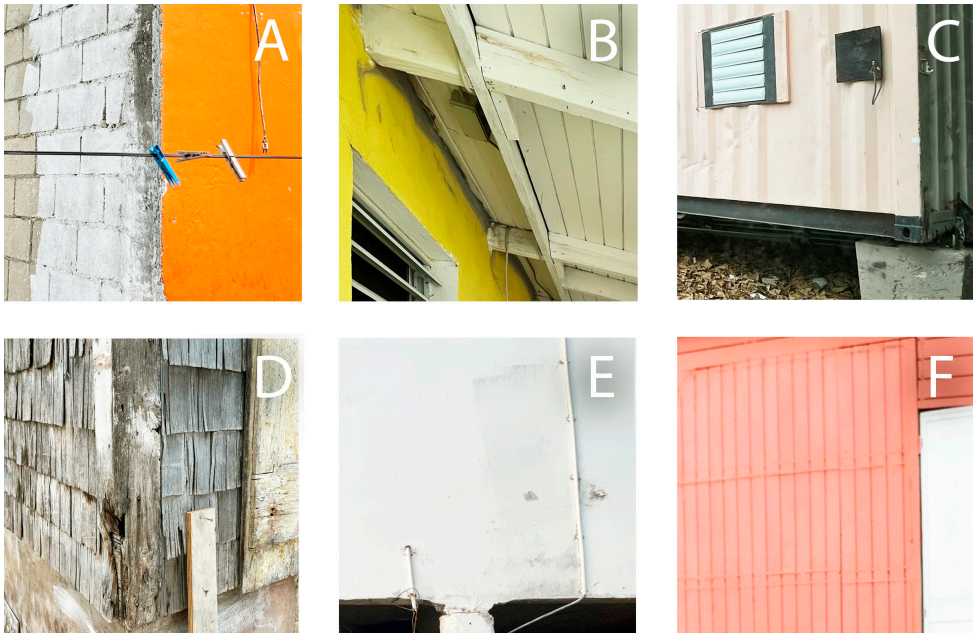

Figure 7. Building materials used for a structure: (**A**) concrete blocks; (**B**) concrete wall and timber rafters; (**C**) container on poured concrete pillar. Materials used for the skin: (**D**) wooden shingles; (**E**) cement; (**F**) wooden cladding.

The durability can be affected in several ways. Households may modify and expand the units over time, which can weaken the structure [5]. Additionally, the passage of time can cause materials to wear down, reducing the structure's resistance to hazards. Even structures that were designed to be resistant and had received engineering support are vulnerable to these factors. While controlling these aspects is almost impossible, steps can be taken to mitigate the risks. One such step is to maintain, repair, and replace damaged components regularly, which can be completed by households themselves or with the help of skilled local builders [34,78]. The required maintenance depends on the materials used in construction and implemented building techniques. For example, wood must be protected against water and insects [76,79]. Although it is a common belief that concrete needs nearly no maintenance, it requires cleaning and resealing to ensure its safety. The use of advanced building techniques, which are often expensive and unfamiliar to the local builders may also affect the ability to maintain and repair the units [35,38].

In the Caribbean, the primary focus of durability enhancements for the structure is on the wind resistance of rooftops against hurricanes and connections between rooftops and walls [80–82]. The durability of self-organized houses varies, depending on the type and strength of the event, site characteristics, and building features [82]. If damages occur, most households fix or rebuild the units themselves using their resources and help from neighbors, friends, and family members [5,67]. This is often an incremental process, and includes reusing undamaged building elements to reduce costs [72,74]. While the majority of households rebuild in the same way as before the hazard [83], some households implement modifications to prevent damages. These modifications often mimic formal solutions or practices applied in units that were undamaged during the hazard. Some of these practices tend to repeat unsafe building practices, often due to not considering the changing circumstances between cases [18]. As noted by Venable, the most common

modifications are strengthening the roof and reinforcing the walls [84]. These modifications only focus on individual elements and do not consider the relationships between them [84]. As a result, the structure of the house may not be durable as a system of elements.

The last layer that plays a major role in the durability of the unit is the skin. It serves as an external envelope that protects the layers inside. It is made up of various components such as cladding, plaster, rooftop tiles, windows, doors, and others (Figure 7D–F). In the Caribbean islands, the skin of a house may be directly related to its structure, as in the case of a plaster house. Strong connections between the skin and structure are essential to prevent risks, such as when strong winds rip off the rooftop and affect the structure [75,85]. Similarly, if any element of the skin, like door handles or shingles, are ripped off, this may affect other parts of the building or damage other houses [85]. If the skin of the building is compromised, the structure and other layers may be affected by secondary damage.

7.2. Functionality

Addressing functionality in design is a complex and ongoing challenge, especially when it comes to low-income housing. Functionality is associated with how well the house meets the needs of its users. The main scope is to create spaces that cater to the needs of its inhabitants, ensuring comfortable living by allocating the appropriate type and size of space for each function over time. Insufficient or inadequate aspects, such as lack of comfort, safety, or privacy, can significantly impact the functionality of a living space. Functionality is mainly related to the layers of the space plan, services, and skin (Figure 8).

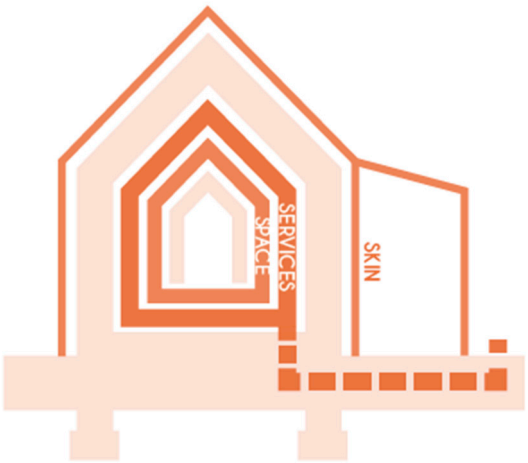

Figure 8. Layers related to functionality.

The functionality of a house is closely linked with its organization. The non-structural elements, which make up the layer of a space plan, help to create spatial divisions. Users interact with the space over time through activities based on needs, habits, and traditions. This information can be visualized into "patterns of use" [27]. The space plans of self-organized houses are often formed by overlapping patterns of use that are framed by social and cultural contexts.

A functional space plan aims to meet users' needs by creating spaces that are suitable for their intended functions. However, predicting the possible functions of a space and defining the spatial needs of the users can be a challenging task. In the design process, this is often addressed by anticipating these needs, but the assumptions made about the spatial requirements are often too general or inaccurate [50]. As a result, attempts are made to rationalize the use and control it through design, which can lead to housing projects that are not suited to the inhabitants' needs [31]. In such cases, the users, looking for a better fit, resorted to adapting those spaces. Looking for an explanation for the modifications made by occupants of one of the modernist landmark residential buildings, Lefebvre concludes, "[. . .] And what did the occupants add? Their needs." [31,86].

The space plan of the self-organized houses changes gradually. What contributes to answering the needs of the households is the ability to accommodate incremental changes. Those changes are motivated by the household's frequently shifting spatial needs, which may arise due to various factors such as changing family circumstances, size, income, and available resources. The units are commonly erected to meet basic household needs and take the form of a small unit [22] or an extension of an existing house [43]. At this point of the building process, the functional space ensures weather protection and provides a safe place to rest. With time, the houses change and grow. The possibilities of growth are dependent on the site conditions, influencing the orientation, position, and access to the roads [21,87]. The initial development of the house also impacts the opportunities for space expansion [73]. Not considering the economic, social, climate, or health aspects may also result in expanded units that are unfunctional or uncomfortable to live in.

Over the years, the houses change by adding spaces, making modifications and adaptations following the unpredictable and unavoidable changes in spatial needs. This relates to spatial rearrangements created by walls, floors, ceilings, and other indoor or outdoor components that do not compose the main structure (Figure 9A–C). It happens by extending, attaching, replacing, dividing, connecting, and infilling (enclosing) the spaces [43]. Some of the alterations in a space plan layer also influence changes in structure. Growing space plans incrementally may not always end up functional. When the household decides to add additional spaces to a unit without proper planning, they may compromise the quality of the existing ones. Since communication and access are often overlooked and the units are developed around the initial core, they may result in pass-through rooms that limit privacy and convenience of use.

Figure 9. Examples of space organization: (**A**) outdoor leisure space; (**B**) extended porch; (**C**) repair workshop. Examples of services: (**D**) gas bottles; (**E**) pipes in front of a unit; (**F**) gas and electricity meters.

Changes in the needs of the households can also result in the need to alter the function of the house. This may happen by changing, upgrading, or including new ones [88]. Those changes are often motivated by economic aspects. This may include adding a space of work such as a small shop, workshop, bar, or other type of income-generating space (Figure 9C). The household may dedicate a part of a house, construct an extension, or build a separate unit on the plot which will be rented out for additional income or be used by other members of the family [21].

The organization and functionality of the space plan are influenced by various factors such as the economic, social, and climatic needs of the households. Societal aspects refer to the household's relationship with the societal context, such as family, neighbors, and other groups. In St. Martin's dwellings, there is a distinction between public, semi-private, and private places, which is often highlighted by the presence of various objects. Due to the weather conditions, a significant amount of daily activities take place outside, under the shade in front of the house. In addition to shading and weather protection, porches are frequently used as transitional spaces and for socializing [21] (Figure 9B). Ceilings also play an important role in heating aspects, reducing overheating. The location of windows, doors, and partitions also affects the circulation and ventilation of the units, which impacts the comfort of using these spaces [87].

The layer of services also plays an important role in providing comfort. This layer includes electricity, water, sewage, air conditions, and other systems (Figure 9D–F). Not all of the services are always connected to the initially developed unit, and they often change over the year, with the progress of technology, accessibility in the area, and resource availability. Some of the units may remain off-grid, or partially off-grid by using rainwater collection, and electricity supply through solar panels.

The last layer related to functionality is the skin. It contributes to providing comfort by protecting the residents from external weather conditions, controlling temperature, ensuring proper ventilation, allowing natural light, and maintaining privacy. The essential elements of the skin layer that increase functionality are windows, roof overhangs, wall finishings, and insulation. These elements such as windows, shading devices, and roof overhangs, help provide comfort to residents by protecting them from rain and sun exposure. They may also reduce overheating and allow natural ventilation to cool the space. Additionally, the use of double skin can provide extra protection against heat [89]. The skin layer is often upgraded as per financial opportunities or technological advancements. With the significant impacts of climate change, the skin layer may require upgrading to cope with changing weather patterns and temperature increases.

7.3. Esthetic Appeal

Esthetic appeal relates to how the house is experienced, and it is usually associated with visual aspects. In the past, low-income housing was not always designed with esthetics in mind [2,49]. Instead, the focus was on creating durable and functional buildings or emphasizing the building process itself. However, it is important to recognize the relevance of esthetic appeal in housing. Esthetic aspects are not limited to the physical and material aspects of the project but extend to culture and social relations as well as individual expression [2] (p. 5). This allows for the houses to have meaning and for individuals to express their unique identity. How the house is experienced relates mostly to the layers of skin and stuff (Figure 10).

The skin of a unit plays an important role in the visual aspects. Usually, those aspects are considered esthetically pleasing due to a shared design language with individual variations expressed by their owners [2]. The similarities can be compared by observing characteristics related to form, detail, quality, context, style, size, and status [90]. The lack of these consistencies, as well as the lack of diversity, maintenance, and decorations, may lead to perceived ugliness [49] (p. 2). These inconsistencies are often the case for self-organized houses, where despite shared aspects, such as street layout, vegetation, building height, and materials used, the units remain distinctive [2,15]. reflect variations in income, cultural values, household structure, building longevity, and function [2].

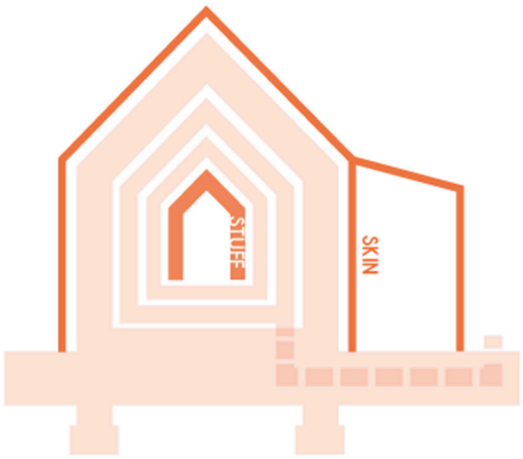

Figure 10. Layers related to esthetic appeal.

The Caribbean houses come in various styles. The two most popular types of single-standing houses are wooden framed houses and concrete units. The wooden structures in the Caribbean, commonly known as "Caribbean vernacular" [91], are made of balloon frames, elevated from the ground, and covered with a gable roof made of corrugated iron [92]. These houses are often painted in bright colors, which gradually soften due to sun exposure. They have windows with shutters and ample porches [92] and sometimes are decorated with fretwork. Over the years, some of them were additionally wrapped in corrugated iron. In Saint Martin, few such units remain due to unfavorable environmental conditions. In the hurricane-prone Caribbean islands, light-frame wooden housing has been gradually replaced by either concrete block infill or reinforced concrete frames, covered by flat, concrete slab roofs [82].

The longevity of a housing unit has a significant impact on its visual aspects such as form, materiality, and details. Initially, basic units come in different forms depending on the household's circumstances, resources, and abilities. They can be makeshift homes built with temporary materials like cardboard, iron sheets, or other similar materials, or more permanent houses constructed with durable materials, like concrete [22,93,94]. Over time, the house built with temporary materials is consolidated, and the temporary materials are replaced with more permanent ones [32,71,95]. If contextual conditions, such as tenure security, allow for it, the house may gradually develop into a typical middle-income house [22]. Time plays a significant role in shaping the collective and individual identity of both a house and neighborhood, as it connects the past, present, and future narratives of the home and the place [28]. This connection leads to the creation of places that hold personal meaning and memories [28].

Houses have a significant cultural and social significance, and how they are perceived and experienced play a vital role in this. In contrast to social housing, self-organized houses often reflect certain characteristics of the household living in it [96]. The ability for expression through visual aspects contributes to the articulation and validation of identity [92]. The visual aspects of a home reflect the social status perceived by neighbors and state officials [15]. This can lead to a particular visual esthetic being chosen, including mimicking middle-income houses or using materials that are associated with a particular social status like concrete or certain cladding materials [15,77].

In addition, the appearance of a house, especially that of a self-organized one, reflects the personal taste and style of its inhabitants. These changes are mostly related to the layer of skin. They express themselves through the choice of various elements, such as details and emblems, as well as the selection of materials for the exterior, such as tiles or cladding (Figure 11A–C) [41,49]. Architects usually leave this aspect to the users as preferences can change quickly [71]. Over time, people often make minor modifications to the skin of their houses, such as conducting paint jobs, changing the elevation materials, and making other

modifications to improve the building's skin. Such modifications also contribute to the sense of ownership of the house [45].

Figure 11. Examples of skin: (**A**) painted wooden cladding; (**B**) floor tiles mosaic; (**C**) porch covered with painted lattice. Examples of stuff: (**D**) repair and material recovery; (**E**) stock of building materials; (**F**) armchairs on a porch.

Another layer that is related to how the house is experienced is the stuff. The presence of certain elements can indicate the function of the space and influence the way one feels in the space. This includes the type of stuff and its arrangement, for instance, chairs, armchairs, tables, cars, sun-shading devices, toys, and other elements (Figure 11D–F). It provides information on the kind of interactions and activities happening in that space. It is also the layer that the households can change and reorganize most easily, making it suitable for them.

8. Designing for a Flow

Self-organized housing units tend to grow and evolve at a faster rate than other types of dwellings. This difference can be attributed to the dissimilarity in the building process. Self-organized houses develop gradually, commonly starting by erecting a basic covered structure, which grows and changes over time by shearing and consolidating the building layers. Building in hazard-prone environments adds to the rate of changes due to an increased need for fixing and replacing building elements. Designing for a Flow proposes facilitating those changes by using layering.

This approach questions the feasibility of implementing permanent building solutions and instead proposes making changes through a design approach based on layering. Layering building components mimics the gradual construction process of consolidating the layers in self-organized houses. This approach connects the users' activities through time (time-based factors) with housing considerations through building layers (layers of change) (Figure 12). It can also help to define roles and duties by distributing responsibilities within the building between the residents, owners, and builders, depending on the layer. This approach could help tackle some of the issues of commonly applied affordable housing strategies and could bring environmental, economic, and societal benefits.

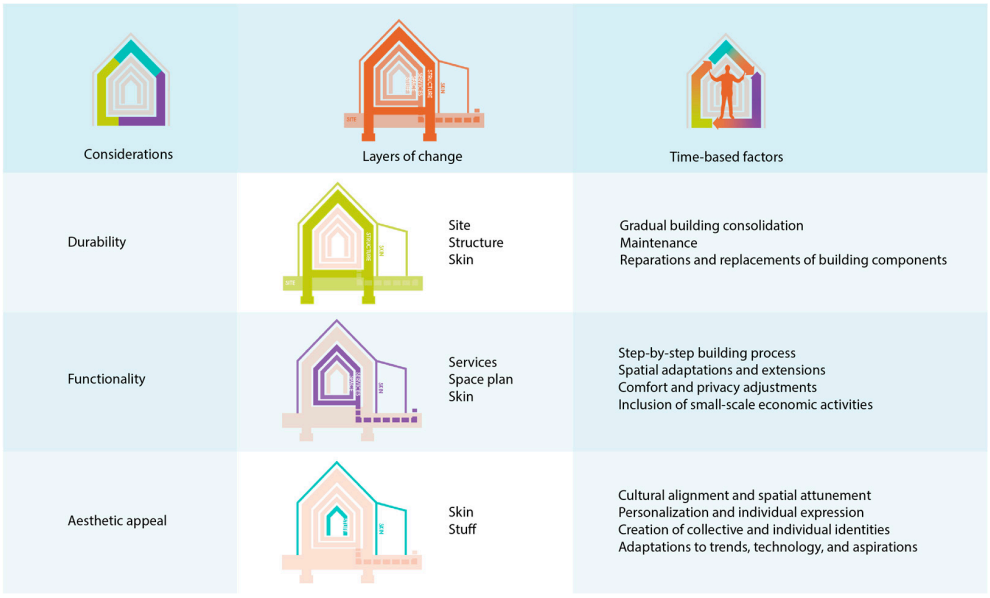

Figure 12. Diagram summarizing the relations between housing considerations, layers of change, and time-based factors.

Enabling layering influences the technical aspects of construction as it requires the use of building methods that allow for easy connection and disconnection of layers and the individual elements, such as interlocking the elements or bolting them. This is achieved by separating the building elements, which canlead to positive environmental outcomes. It allows for easy access to these elements, making predictive control and maintenance simpler. In the event of any damage, it facilitates repairs and replacements without affecting other parts of the building. Easy changes can be made to implement more permanent or technologically advanced materials without discarding the previous elements, thereby increasing the lifespan of the building and its elements.

Designing for a Flow using layering facilitates step-by-step development. Households can start building using temporary materials and upgrade over time, element by element. This decreases the burden of the initial financial contribution and may bring long-term economic gains. It also allows for the construction of a simple unit with extensions and adaptations made over time as finances become available. Each element is considered separately based on its life cycle, which can lead to reduced costs of replacements and allow households to resell unwanted elements. Approaching housing in such a way could strengthen community bonds by creating the possibility of material exchanges within neighborhoods, bringing societal benefits. It could also increase the expertise of local builders by redefining responsibilities to actively engage them through the unit lifespan. This approach allows for personalization and accommodates individual preferences, contributing to the level of satisfaction and sense of ownership. It also facilitates the ability of households to shape the space based on their expression of individuality. Additionally, in the aftermath of a hazard, this approach allows for the reuse of undamaged elements, making it a sustainable and practical solution.

Although Designing for a Flow has many potential benefits, implementing it in low-income housing can be challenging. To address these challenges, we suggest focusing on three key aspects: the process of space formation, collaborations in house-building, and layering practices. Firstly, examining the process of space formation of self-organized homes can help us understand the long-term relationships and influences between the layers and the temporalities within the layers. Secondly, collaborations in house-building relate to the responsibilities within each of the layers over time. Exploring these relationships is important in defining accountabilities between the authorities, builders, and residents in relation to building layers. Lastly, layering practices examine the techniques of an iterative

process of consolidating and shearing the layers. This involves currently applied solutions of bringing the layers together and searching for possible enhancements to facilitate that process adequately to the context. Exploring these concepts can further improve the approach's tangibility and context-appropriateness.

9. Limitations

This study, focusing on temporalities in housing considerations within self-organized units, has several limitations. Firstly, it is crucial to recognize that this research serves as an exploratory study, focused on the temporal dynamics of housing in self-organized units. It has drawn from the case of St. Martin, a specific region in the Caribbean with unique socio-economic conditions. It is essential to acknowledge that different contexts may present distinct temporal dynamics, influencing housing practices in varied ways. Secondly, the exploration of the St. Martin case was constrained by the study's exploratory scope. A more comprehensive examination of this case would be beneficial for refining and testing the proposed framework further. Thirdly, while the applied theoretical frameworks and methodologies have proven useful, they may not entirely capture the complex dynamics of self-organized housing. It is vital to recognize that alternative approaches may exist for addressing the temporal aspects of self-organized housing, and this study chose to delve into the layering concept developed by Brand, despite its inherent limitations. Moreover, although specific layers have been identified as the most important for certain considerations, it is crucial to understand that these layers are interconnected and affect each other, and layering does not guarantee the long-term durability, functionality, or esthetic appeal of houses. These criteria are inherently qualitative and context-dependent. Furthermore, while the layering concept has demonstrated functionality in top-down organized buildings, its application in the context of low-income houses, primarily self-organized, poses unique challenges. Acknowledging these limitations is essential to ensure a nuanced and contextually sensitive approach to housing design in diverse low-income and hazard-prone contexts.

10. Conclusions

In this study, our exploration of the considerations for designing low-income housing in hazard-prone areas was grounded in recognizing the intrinsic connection of self-organized housing practices with time. We aimed to provide valuable insights into the ongoing discourse on housing design in low-income and hazard-prone contexts. Our goal was to bridge the research gap by focusing on the temporal considerations of durability, functionality, and esthetic appeal within self-organized houses evident through users' interaction with units. Inspired by self-organized housing in St. Martin and guided by Stewart Brand's concepts of "Flow" and "Layers of Change", we identified layers of change in housing typology and discussed their characteristics in relation to time and users' activities. This approach aimed to unravel the complex relationship between self-organized housing practices and temporalities, contributing nuanced perspectives to the development of resilient and culturally responsive housing solutions in low-income and hazard-prone communities.

Our analysis of the temporal aspects of durability, functionality, and esthetic appeal revealed layers corresponding to each consideration, shedding light on the intricate temporal dimensions influencing housing. These temporal dimensions were manifested through time-bound building activities that addressed the considerations, becoming a central theme in our research. Durability, intricately entwined with the layers of site, structure, and skin, plays a pivotal role during the initial building process. The consolidation, maintenance, repairs, and replacement of damaged components strongly influence a building's durability over time. Functionality, closely tied to space plans, services, and skin, evolves through spatial adjustments, extensions, and considerations for privacy, comfort, and small-scale economic activities. Esthetic appeal, often overlooked in the literature on self-organized housing, is linked to the layers of stuff and skin. Expanding upon the experience of the

building's units, esthetic appeal over time is shaped by cultural alignment, spatial attunement, personalization, and individual expression, contributing to the creation of collective and individual identities, and allowing for easy adaptations to accommodate changing trends, technology, and aspirations.

In proposing the notion of "Designing for a Flow", we presented a novel approach to enhance the durability, functionality, and esthetic appeal of self-organized houses by emphasizing their temporal aspects. This design approach accommodates the dynamic nature of self-organized housing, facilitating alterations and supporting incremental housing practices. By acknowledging temporalities, "Designing for a Flow" aims to ease the process of changing components and making adaptations throughout the lifespan of a unit. The integration of this concept offers potential environmental, societal, and economic benefits, presenting a practical alternative to current affordable housing approaches.

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References

1. Smets, P.; Bredenoord, J.; Van Lindert, P. Introduction: Governance, Sustainability and Affordability of Low-Income Housing. In *Affordable Housing in the Urban Global South: Seeking Sustainable Solutions*; Taylor & Francis Group: Abingdon, UK, 2014; Volume i, pp. 1–14, ISBN 9781315849539.
2. Kellett, P.; Napier, M. Squatter Architecture? A Critical Examination of Vernacular Theory and Spontaneous Settlement. *Tradit. Dwell. Settl. Rev.* **1995**, *6*, 7–24.
3. Mycoo, M. Opportunities for Transforming Informal Settlements in Caribbean Small Island Developing States. In Proceedings of the International Conference on Emerging Trends in Engineering and Technology (IConETech-2020), St. Augustine, FL, USA, 1–5 June 2020; pp. 652–662.
4. McTarnaghan, S.; Collazos, J.; Srini, T.; Collazos, J. Literature Review of Housing in Latin America and the Caribbean. 2016. Available online: https://www.citiesalliance.org/sites/default/files/Global%20Housing%20Research%20Initiative%20-%20ENGLISH%20-%20FINAL%20-%20Oct%202016_CitiesAl.._.pdf (accessed on 19 December 2023).
5. Goldwyn, B.; Asce, S.M.; Javernick-will, A.; Ph, D.; Asce, M.; Liel, A.; Ph, D.; Asce, F. Dilemma of the Tropics: Changes to Housing Safety Perceptions, Preferences, and Priorities in Multihazard Environments. *Nat. Hazards Rev.* **2021**, *22*, 04021012. [CrossRef]
6. Lochhead, M.; Goldwyn, B.; Venable, C.; Liel, A.B. Assessment of Hurricane Wind Performance and Potential Design Modifications for Informally Constructed Housing in Puerto Rico. *Nat. Hazards* **2022**, *112*, 1165–1189. [CrossRef]
7. Prevatt, D.O.; Dupigny-Giroux, L.-A.; Masters, F.J. Engineering Perspectives on Reducing Hurricane Damage to Housing in CARICOM Caribbean Islands. *Nat. Hazards Rev.* **2010**, *11*, 140–150. [CrossRef]

8. Wakely, P.; Riley, E. *The Case for Incremental Housing, Cities Alliance Policy Research and Working Papers Series*; Cities Alliance: Washington, DC, USA, 2011. Available online: https://www.citiesalliance.org/sites/default/files/CIVIS_3_English.pdf (accessed on 19 December 2023).
9. Pimentel Walker, A.P.; Arquero de Alarcón, M. The Competing Social and Environmental Functions of Private Urban Land: The Case of an Informal Land Occupation in São Paulo's South Periphery. *Sustainability* **2018**, *10*, 4160. [CrossRef]
10. Schilderman, T.; Lyons, M. Resilient Dwellings or Resilient People? Towards People-Centred Reconstruction. *Environ. Hazards* **2011**, *10*, 218–231. [CrossRef]
11. Doberstein, B.; Stager, H. Towards Guidelines for Post-Disaster Vulnerability Reduction in Informal Settlements. *Disasters* **2013**, *37*, 28–47. [CrossRef]
12. Usamah, M.; Handmer, J.; Mitchell, D.; Ahmed, I. Can the Vulnerable Be Resilient? Co-Existence of Vulnerability and Disaster Resilience: Informal Settlements in the Philippines. *Int. J. Disaster Risk Reduct.* **2014**, *10*, 178–189. [CrossRef]
13. Dangol, N.; Carrasco, S. Residents' Self-Initiatives for Flood Adaptation in Informal Riverbank Settlements of Kathmandu. *Int. J. Disaster Risk Reduct.* **2019**, *40*, 101156. [CrossRef]
14. Marques, E.; Saraiva, C. Urban Integration or Reconfigured Inequalitie? Analyzing Housing Precarity in São Paulo, Brazil. *Habitat Int.* **2017**, *69*, 18–26. [CrossRef]
15. Nielsen, M. Into Architecture: House-Building and Acentred Personhood in Maputo, Mozambique. In *Elements of Architecture: Assembling Archaeology, Atmosphere and the Performance of Building Spaces*; Bille, M., Sorensen, T.F., Eds.; Taylor & Francis Group: London, UK, 2016; pp. 273–286.
16. Cronin, V.; Guthrie, P. Alternative Approaches to Slum Upgrading in Kibera, Nairobi. *Proc. Inst. Civ. Eng. Urban Des. Plan.* **2010**, *164*, 129–139. [CrossRef]
17. Celentano, G.; Habert, G. Beyond Materials: The Construction Process in Space, Time and Culture in the Informal Settlement of Mathare, Nairobi. *Dev. Eng.* **2021**, *6*, 20. [CrossRef]
18. Rodgers, J.P.E. Why Schools Are Vulnerable to Earthquakes. In Proceedings of the 15th world conference on Earthquake Engineering, Lisbon, Portugal, 24–28 September 2012.
19. Feliciano, D.; Arroyo, O.; Liel, A.B.; Carrillo, J. A Framework to Assess the Seismic Vulnerability of Informally Constructed Houses: A Case Study in Villavicencio, Colombia. In Proceedings of the 12th National Conference on Earthquake Engineering, Earthquake Engineering Research Institute, Salt Lake City, UT, USA, 27 June–1 July 2022.
20. UN-Habitat. *Housing for All: The Challenges of Affordability, Accessibility and Sustainability*; UN-Habitat: Nairobi, Kenya, 2008.
21. Kowaltowski, D.C.C.K.; Mikami, S.A.; Pina, G.; Ruschel, R.C.; Labaki, L.C.; Bertolli, S.R.; Filho, F.B.; Fávero, E. A House Design Assistance Program for the Self-Building Process of the Region of Campinas, Brazil: Evaluation through a Case Study. *Habitat Int.* **2005**, *29*, 95–111. [CrossRef]
22. Goethert, R. Monday Developments. 2010, pp. 23–25. Available online: https://sigus-r1.mit.edu/sites/default/files/documents/PagesMondayMag.pdf (accessed on 19 December 2023).
23. Mota, N. Incremental Housing. In *The New Urban Condition*; Routledge: London, UK, 2021; pp. 160–182.
24. Turner, J.F. Housing As a Verb. In *Freedom To Build: Dweller Control of the Housing Process*; Turner, J.F., Fichter, R., Eds.; Macmillan: New York, NY, USA, 1972; pp. 148–175.
25. Till, J. *Architecture Depends*; MIT Press: Cambridge, MA, USA, 2009.
26. Vitruvius, M.P. *Ten Books on Architecture*; Rowland, I.D., Noble Howe, T., Eds.; Cambridge University Press: Cambridge, UK, 1999; ISBN 9780511840951.
27. Guyer, P. *A Philosopher Looks at Architecture*; Cambridge University Press: Cambridge, UK, 2021; ISBN 9780511712258.
28. Lombard, M. Struggling, Suffering, Hoping, Waiting: Perceptions of Temporality in Two Informal Neighbourhoods in Mexico. *Environ. Plan. D Soc. Space* **2013**, *31*, 813–829. [CrossRef]
29. Moatasim, F. Informality Materialised: Long-Term Temporariness as a Mode of Informal Urbanism. *Antipode* **2019**, *51*, 271–294. [CrossRef]
30. Till, K.E. Wounded Cities: Memory-Work and a Place-Based Ethics of Care. *Polit. Geogr.* **2012**, *31*, 3–14. [CrossRef]
31. Till, J. Architecture and Contingency. *Field Free J. Archit.* **2007**, *1*, 120–135.
32. Bhan, G. From the Basti to the 'House': Socio-Spatial Readings of Housing Policy in India. *Curr. Sociol.* **2017**, *65*, 587–602. [CrossRef]
33. Mitlin, D. Lessons from the Urban Poor. Collective Action and Rethinking of Development. In *Climate Change and the Crisis of Capitalism*; Routledge: London, UK, 2011.
34. Archer, D. Building Urban Climate Resilience through Community-Driven Approaches to Development: Experiences from Asia. *Int. J. Clim. Chang. Strateg. Manag.* **2016**, *8*, 654–669. [CrossRef]
35. Twigg, J. The Evolution of Shelter 'Self-Recovery': Adapting Thinking and Practice for Post-Disaster Resilience. *J. Br. Acad.* **2021**, *9*, 5–22. [CrossRef]
36. De Bruijn, K.M. Resilience and Flood Risk Management. A Systems Approach Applied to Lowland Rivers. *Water Policy* **2005**, *6*, 53–66. [CrossRef]
37. Elkharboutly, M.; Wilkinson, S. International Journal of Disaster Risk Reduction Cyclone Resistant Housing in Fiji: The Forgotten Features of Traditional Housing. *Int. J. Disaster Risk Reduct.* **2022**, *82*, 103301. [CrossRef]
38. Barenstein, J.D. Housing Reconstruction in Post-Earthquake Gujarat. *Humanit. Pract. Netw. Netw. Pap.* **2006**, *44*, 44.

39. Barakat, S. Housing Reconstruction after Conflict and Disaster. 2003. Available online: https://pure.york.ac.uk/portal/en/publications/housing-reconstruction-after-conflict-and-disaster (accessed on 19 December 2023).
40. van Leersum, A.; Arora, S. Implementing Seismic-Resistant Technologies in Post-Earthquake Pakistan: A Process Analysis of Owner Driven Reconstruction. *Habitat Int.* **2011**, *35*, 254–264. [CrossRef]
41. Marinovic, G.I. The Guidelinie for Customising Incremental Houing Based on Two Chilean Case Studies. *J. Archit. Urban.* **2020**, *44*, 166–175. [CrossRef]
42. Napier, M. Core Housing and Subsidies in South Africa: Addressing the Unintended Outcomes. *World Congr. Hous. Transform. Hous. Environ. Through Des.* **2005**. Available online: http://hdl.handle.net/2263/10322 (accessed on 19 December 2023).
43. Kamalipour, H.; Dovey, K. Incremental Production of Urban Space: A Typology of Informal Design. *Habitat Int.* **2020**, *98*, 102133. [CrossRef]
44. Wainer, L.S.; Ndengeingoma, B.; Murray, S. Incremental Housing, and Other Design Principals for Low Cost Housing. 2016, p. 34. Available online: https://www.theigc.org/sites/default/files/2016/11/Wainer-et-al-2016-final-report.pdf (accessed on 19 December 2023).
45. Delgado, L.; Antipova, X. A Debate on Incremental Housing: Can an Old Answer Be the New Solution for How to Best Rebuild Haiti? 2010, pp. 1–15. Available online: https://web.mit.edu/incrementalhousing/WUF-Rio/pdfs/SE-4-SUMMARY-DelgadoXenia.pdf (accessed on 19 December 2023).
46. Carrasco, S.; Brien, D.O. Incremental Pathways of Post-Disaster Housing Self-Recovery in Villa Verde, Chile. *Architecture* **2022**, *2*, 544–561. [CrossRef]
47. O'Brien, D.; Carrasco, S. *Incremental Housing in Villa Verde, Chile: A View through the Sendai Framework Lens*; Elsevier Inc.: Amsterdam, The Netherlands, 2021; ISBN 9780128190784.
48. Askar, R.; Rodrigues, A.L.; Bragança, L.; Pinheiro, D. From Temporary to Permanent; A Circular Approach for Post-Disaster Housing Reconstruction. *IOP Conf. Ser. Earth Environ. Sci.* **2019**, *225*, 012032. [CrossRef]
49. Kowaltowski, D.C.C.K. Aesthetics and Self-Built Houses: An Analysis of a Brazilian Setting. *Habitat Int.* **1998**, *22*, 5–8. [CrossRef]
50. Brand, S. *How Buildings Learn. What Happens after They're Built*; Penguin: London, UK, 1995; Volume 6, ISBN 9786021018187.
51. Singh, K. *Quantitative Social Research Methods*; SAGE Publications: New Delhi, India, 2007.
52. Whitehead, T.L. Basic Classical Ethnographic Research Methods. *Ethnogr. Inf. Community Cult. Assess. Res. Syst. Work. Pap. Ser.* **2005**, *1*, 1–28.
53. Hofman, C.L.; Stancioff, C.E.; Richards, A.; Auguiste, I.N.; Sutherland, A.; Hoogland, M.L.P. Resilient Caribbean Communities: A Long-Term Perspective on Social Adaptability to Natural Hazards, and Sustainability in the Lesser Antilles. *Sustainability* **2021**, *13*, 9807. [CrossRef]
54. Mycoo, M.A. Beyond 1.5 °C: Vulnerabilities and Adaptation Strategies for Caribbean Small Island Developing States. *Reg. Environ. Chang.* **2018**, *18*, 2341–2353. [CrossRef]
55. Caribbean Community Climate Change Centre (CCCCC) Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change (2009–2015) 2009. Available online: https://www.widecast.org/Resources/Docs/CCCCC_2009_Climate_Change_and_the_Caribbean_2009-2015.pdf (accessed on 19 December 2023).
56. Douglass, K.; Cooper, J. Archaeology, Environmental Justice, and Climate Change on Islands of the Caribbean and Southwestern Indian Ocean. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 8254–8262. [CrossRef] [PubMed]
57. UN Habitat. *Affordable Land and Housing in Latin America and the Caribbean*; Publishing Services Section: Nairobi, Kenya, 2011; ISBN 9789211319385.
58. World Bank. *Rapid Housing Sector Assessment: Sint Maarten*; World Bank: Washington, DC, USA, 2020; pp. 1–94.
59. Collodi, J.; Pelling, M.; Fraser, A.; Borie, M.; Di Vicenz, S. How Do You Build Back Better so No One Is Left behind? Lessons from Sint Maarten, Dutch Caribbean, Following Hurricane Irma. *Disasters* **2021**, *45*, 202–223. [CrossRef]
60. Medina, N.; Abebe, Y.A.; Sanchez, A.; Vojinovic, Z.; Nikolic, I. Surveying After a Disaster: Capturing Elements of Vulnerability, Risk and Lessons Learned from a Household Survey in the Case Study of Hurricane Irma in Sint Maarten. *J. Extrem. Events* **2019**, *06*, 1950001. [CrossRef]
61. Free Vector Maps Vector Flag of Caribbean Islands with Countries. Available online: https://freevectormaps.com/world-maps/caribbean/WRLD-CI-02-0001?ref=atr (accessed on 17 January 2024).
62. Muhs, D.R.; Schweig, E.S.; Simmons, K.R.; Halley, R.B. Late Quaternary Uplift along the North America-Caribbean Plate Boundary: Evidence from the Sea Level Record of Guantanamo Bay, Cuba. *Quat. Sci. Rev.* **2017**, *178*, 54–76. [CrossRef]
63. National Hurricane Center and Central Pacific Hurricane Center IRMA Graphics Archive: 5-Day Forecast Track, Initial Wind Field and Watch/Warning Graphic. Available online: https://www.nhc.noaa.gov/archive/2017/IRMA_graphics.php?product=5day_cone_with_line_and_wind (accessed on 17 January 2024).
64. National Hurricane Center and Central Pacific Hurricane Center MARIA Graphics Archive: 5-Day Forecast Track, Initial Wind Field and Watch/Warning Graphic. Available online: https://www.nhc.noaa.gov/archive/2017/MARIA_graphics.php?product=5day_cone_with_line_and_wind (accessed on 17 January 2024).
65. Open Street Map Relation: Sint Maarten (1231790). Available online: https://osm.org/go/Y0tNLA_?relation=1231790 (accessed on 17 January 2024).

66. STAT. Department of Statistics. Government of Sint Maarten. Population Estimates and Vital Statistics 2022 and 2023. 2023, pp. 1–2. Available online: http://stats.sintmaartengov.org/press_release/Population/2023/Press_release_est_Population_2023.pdf (accessed on 19 December 2023).
67. Twigg, J.; Lovell, E.; Schofield, H.; Morel, L.M.; Flinn, B.; Sargeant, S.; Dijkstra, T.; Stephenson, V.; Albuerne, A.; Rossetto, T.; et al. Self-Recovery from Disasters An Interdisciplinary Perspective. 2017. Available online: https://discovery.ucl.ac.uk/id/eprint/10033812/ (accessed on 19 December 2023).
68. Estaji, H. A Review of Flexibility and Adaptability in Housing Design. *Int. J. Contemp. Archit. New ARCH* **2017**, *4*, 37–49. [CrossRef]
69. Duffy, F. Measuring Building Performance. *Facilities* **1990**, *8*, 149. [CrossRef]
70. Askar, R.; Bragança, L.; Gervásio, H. Adaptability of Buildings: A Critical Review on the Concept Evolution. *Appl. Sci.* **2021**, *11*, 4483. [CrossRef]
71. Bredenoord, J.; Van Lindert, P.; Smets, P. *Affordable Housing in the Urban Global South: Seeking Sustainable Solutions*; Routledge: London, UK, 2014.
72. Maynard, V.; Parker, E.; Twigg, J. *The Effectiveness and Efficiency of Interventions Supporting Shelter Self-Recovery Following Humanitarian Crises: An Evidence Synthesis*; Oxfam: Oxford, UK, 2017; Volume 95.
73. Greene, M.; Rojas, E. Incremental Construction: A Strategy to Facilitate Access to Housing. *Environ. Urban.* **2008**, *20*, 89–108. [CrossRef]
74. Parrack, C.; Flinn, B.; Passey, M. Getting the Message across for Safer Self-Recovery in Post-Disaster Shelter. *Open House Int.* **2014**, *39*, 47–58. [CrossRef]
75. Gibbs, T. Hurricanes and Their Effects on Buildings and Structures in the Caribbean. *Disaster Manag.-Redhill* **1994**, *6*, 183.
76. Indrianingrum, L.; Azman, M.N.A.; Downing, K.J. Layout Tambaklorok Fisherman Village of Low-Income Housing: A Case Study of the Central Java, Indonesia. *Int. J. Innov. Creat. Chang.* **2019**, *7*, 162–178.
77. Murray, P.B.; Eeri, M.; Feliciano, D.; Briar, H.; Liel, A.B.; Eeri, M.; Eeri, M.; Javernick-will, A. Seismic Safety of Informally Constructed Reinforced Concrete Houses in Puerto Rico. *Earthq. Spectra* **2023**, *39*, 5–33. [CrossRef]
78. Harriss, L.; Researcher, V.; Practice, E.; Kingdom, U.; Parrack, C.; Lecturer, S.; Practice, E.; Kingdom, U.; Jordan, Z.; Practice, E.; et al. Building Safety in Humanitarian Programmes That Support Post- Disaster Shelter Self-Recovery: An Evidence Review. *Disasters* **2020**, *44*, 307–335. [CrossRef] [PubMed]
79. Lochhead, M.; Murray, P.B.; Goldwyn, B.; Liel, A.B. Multi-Hazard Performance of Informally-Constructed Puerto Rican Houses. In Proceedings of the 12th National Conference on Earthquake Engineering, Salt Lake City, UT, USA, 27 June–1 July 2022.
80. Prevatt, D.O. Improving the Cyclone-Resistance of Traditional Caribbean House Construction through Rational Structural Design Criteria. *J. Wind. Eng. Ind. Aerodyn.* **1994**, *52*, 305–319. [CrossRef]
81. Osborne, R.W.A.; Prevatt, D.O.; Imbert, I.D.C. Cyclone Resistance of Residential Buildings in the Caribbean. In Proceedings of the IABSE Congress Report = Rapport du congrès AIPC = IVBH Kongressbericht; 1992. Available online: https://www.e-periodica.ch/cntmng?pid=bse-cr-002:1992:14::13 (accessed on 19 December 2023).
82. Goldwyn, B.; Javernick-Will, A.; Liel, A.B. Multi-Hazard Housing Safety Perceptions of Those Involved with Housing Construction in Puerto Rico. *Sustainability* **2022**, *14*, 3802. [CrossRef]
83. Hendriks, E.; Luyten, L.; Parrack, C. Knowledge Exchange and Adoption to Enable Safer Post-Disaster Self-Recovery. *IDRiM J.* **2018**, *8*, 1–21. [CrossRef]
84. Venable, C.; Javernick-will, A.; Liel, A.B.; Koschmann, M.A. Reduction Revealing (Mis) Alignments between Household Perceptions and Engineering Assessments of Post-Disaster Housing Safety in Typhoons. *Int. J. Disaster Risk Reduct.* **2021**, *53*, 101976. [CrossRef]
85. Prevatt, D.O.; Roueche, D.B.; Aponte-Bermúdez, L.D.; Kijewski-Correa, T.; Li, Y.; Chardon, P.; Cortes, M.; del Puerto, C.L.; Mercado, A.; Muñoz, J.; et al. Performance of Structures Under Successive Hurricanes: Observations from Puerto Rico and the US Virgin Islands after Hurricane Maria. In *Forensic Engineering 2018: Forging Forensic Frontiers*; American Society of Civil Engineers: Reston, VA, USA, 2018.
86. Boudon, P. *Lived-in Architecture: Le Corbusier's Pessac Revisited*; MIT Press: Cambridge, MA, USA, 1979; ISBN 0262520532.
87. Bredenoord, J. Sustainable Housing and Building Materials for Low-Income Households. *J. Arch. Eng. Technol.* **2016**, *5*, 1–9. [CrossRef]
88. Slaughter, E.S. Design Strategies to Increase Building Flexibility. *Build. Res. Inf.* **2001**, *29*, 208–217. [CrossRef]
89. López-Escamilla, Á.; Herrera-Limones, R.; León-Rodríguez, Á.L. Evaluation of Environmental Comfort in a Social Housing Prototype with Bioclimatic Double-Skin in a Tropical Climate. *Build. Environ.* **2022**, *218*, 109119. [CrossRef]
90. Sanoff, H. Community Participation Methods in Design and Planning. *Landsc. Urban Plan.* **2000**, *50*, 270–271. [CrossRef]
91. Potter, R.B. *Low-Income Housing and the State in the Eastern Caribbean*; University of the West Indies Press: Jamaica, WI, USA, 1994.
92. Aponte-Parés, L. What's Yellow and White and Has Land All around It?: Appropriating Place in Puerto Rican Barrios. *Cent. J. Cent. Puerto Rican Stud.* **1995**, *7*, 8–19.
93. Clarke, C.G. Urbanization in the Caribbean. *Geography* **1974**, *59*, 223–232.
94. Bredenoord, J.; van Lindert, P. Pro-Poor Housing Policies: Rethinking the Potential of Assisted Self-Help Housing. *Habitat Int.* **2010**, *34*, 278–287. [CrossRef]

95. Bhan, G. Notes on a Southern Urban Practice. *Environ. Urban.* **2019**, *31*, 639–654. [CrossRef]
96. Vale, L.J.; Shamsuddin, S.; Gray, A.; Bertumen, K. What Affordable Housing Should Afford: Housing for Resilient Cities. *Cityscape A J. Policy Dev. Res.* **2014**, *16*, 21–50.