Designing for a Flow

Co-creative Approach to Adaptable and Resilient Housing

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TOC

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Agnieszka Maria KUŚ

This dissertation has been approved by the promotors.

Composition of the doctoral committee:

Rector Magnificus,	chairperson
Dr. N.J. Amorim Mota	Delft University of Technology, promotor
Prof. dr. E. van Bueren	Delft University of Technology, promotor

Independent members:

Dr.ir. M.G. Elsinga	Delft University of Technology
Prof.dr.ir. M.J. van Dorst	Delft University of Technology
Dr. D. Dodman	Erasmus University Rotterdam
Dr. L. Algoed	Vrije Universiteit Brussel, Belgium
Dr. C.E.L. Newton	Delft University of Technology, reserve member

Dr. A. Carmona Báez, University of St. Martin, Sint Maarten, has contributed greatly to the preparation of this dissertation.

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In loving memory of Dr.ir. Wacław Jachna
a loving grandfather, caring soul, and brilliant mind,
who lit the spark that continues to brighten my world.

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TOC

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TOC

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TOC

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TOC

Foreword

A house is both the one of the most elemental and one of the most complex architectural forms, and housing studies constitute a fundamental part of architectural practice and research. Such studies often draw on insights shared by residents—descriptions of space formation, material choices, and construction activities—that together explain how a house came to exist in the form observed at the moment of study.

Similarly, this research began with conversations with the residents of self-organized housing, who shared detail accounts of their houses, including material sourcing, spatial organization, construction process, and subsequent adaptations and repairs. While these insights enable the tracing and understanding of housing development over time, they are frequently inseparable from personal histories and individual circumstances of each household that have shaped the construction and adaptation of the house.

These connections make housing studies particularly sensitive, as they emphasise the inseparable relationship between the house as a physical object and the home as a lived and meaningful space—a place where daily life unfolds and where identity, culture, memory, and meaning are embedded. In this sense, the insights shared by the residents offer a layered reading of housing, allowing research to capture not only material and spatial adaptations but also the moments through which a house becomes a home, along with the ethical responsibility that accompanies engaging with such narratives.

Although the conversations with residents of St. Martin focused on housing construction and adaptation processes, the insights shared were often closely tied to personal experiences: moments of joy and hardship, significant family events, creativity under constraint, frustration and perseverance, resilience in the face of limited resources, and mutual support confronting environmental risks. These narratives revealed how personal and collective circumstances become inscribed in the material fabric of the house.

Individual household experiences are built into foundations, protected by roofs, and expressed through walls. Changing circumstances materialize through construction and adaptation—additional rooms added as children grow older, secondary kitchens accommodating diverse cooking practices, or patched walls bearing the marks of resistance to hurricanes. These traces are visible through windows, mediated by curtains and doors, and revealed through the act of opening one's home to others. Such gestures—inviting family members, neighbours, or researchers inside—create opportunities to listen, observe, and engage through shared time and conversation, forming the basis for a deeper understanding of self-organized housing as both a material and social process.

I am deeply grateful to the residents of St. Martin who welcomed me into their homes. Their generosity in sharing insights, memories, and reflections shaped not only my understanding of housing and homes, but also challenged and enriched my perspective as both a guest and a researcher.

As a researcher coming from outside the context, I approached these conversations with care, humility, and a genuine willingness to listen and learn. These encounters were not merely sources of empirical knowledge; they were moments of connection and mutual reflection that grounded my research in the lived, situated knowledges of those who so generously opened their homes to me.

Together, we spoke about the homes as:

- Spaces where family stories evolve, traditions are sustained, and memories are formed and carried over time

  […] I was born here. In this house. When I was born, in this house it was just a two room. Two room wood house. And my grandparents had thatched house… … well old people used to call it thatched [made] with theses bushes, and… they had a yard, and they had some… kitchen. That [type of house] they used to make, with the cattle dung and […] the manure, and they used to glue on the wood, And it used to stay strong. […] – Caroline

- Spaces of social resilience, familial care and responsibility

  […] Why did I move from there to here? I had 2 children a girl and a boy, their mother passed away in 2009 and me alone. Me no have no sister, no feminine in St. Maarten. I'm the father and mother for my two children, my daughter when the mother passed away she was only 3 months. Me have to hold it then, that's why I make these 2 rooms for the 2 children to sleep. My boy sleeping here, alright? Me I stayed right there, me buy food, this have light […] It has an A/C, It has water and everything. I shop in the supermarket and buy food for them. […] We have current and water and pipes, everything. This is a complete house self. – Henry

TOC

- Spaces that adapt, reflecting traditions and cultural practices

  […] I built up a kitchen there to fry. My daughter loves to fry stuff. So, I built that up there for her to fry stuff. Instead of frying stuff in the original kitchen inside, I also built another kitchen in the back for me to cook in. […] – Maria

- Spaces shaped by bonds and mutual care in response to environmental risks

  […] Hurricane Luis - everything gone. I lived on the next [other] side [of the island]. At my house it come, and all gone […] That's why I move here. Not for Irma, with Luis, everything gone. Everything. […] This house… The land… I get to people living here [before]. [It was an] Old man, he dead now. [he said,] Now I live here, I know you [name], you is a good guy. I have a house, I'd like for you to make house. He gave me the land. […] – Juan

- Spaces of mutual support and collective making

  […] Long time when people were building you used to get people helping you, this is called jollification […]. This helping, that one helped, the other one helped. It used to be so. We used to help one and other. Whenever they get a time pure chance and they building, you building, I'm helping you, and when you start to build yours now, I help you and so the people used to work. […] – Emanuella

The opportunity to listen to those perspectives and to engage in conversations about the problems, challenges, frustrations, and solutions residents have implemented required effort and openness from all involved, as well as the guidance and support of those who helped plan and carry out this research. I found it immensely enriching to step out of my comfort zone—to visit residents in their homes or neighbourhood gathering places, to share a tea or a beer, and to take the time to get to know one another before moving into more guided conversations around the research themes. While this process was not always easy, it enabled a connection and understanding that solely using more formal research methods would rarely allow.

I also sought to return to these conversations over time, visiting residents again whenever I returned to the island. These moments allowed us to deepen our connections through conversations, speak about daily life, their homes, and about how the research itself was unfolding. Building connection and understanding takes time, and engaging in such practices requires a conscious commitment to allocating that time and the necessary resources.

TOC

I wholeheartedly loved this research, and I believe what kept me so engaged was the privilege of working alongside residents whose knowledge and experience were central to the research itself. The possibility that this work could contribute to more equitable and resilient housing gave this work a sense of purpose that went beyond the academic. I must also acknowledge that this came with its own weight, as translating research into real impact extends far beyond the capacity of an individual researcher or the timeframe of a doctoral study. Nevertheless, I remain optimistic, and I believe that continuing to build on the networks, connections, findings, and tools developed through this research can bring us closer to achieving those goals in the future.

Although throughout this research I sought, to the best of my knowledge and ability, to foreground the experiences and insights of residents, it is ultimately I who document and interpret the houses and receive academic recognition for the work written about the findings we developed together. Even in this foreword, residents' names remain pseudonymized due to ethical considerations. This tension remains unresolved, underscoring the need for continued reflection and effort to develop more inclusive ways of strengthening and foregrounding the perspectives of those who contribute so fundamentally to knowledge production.

This thesis draws inspiration from the depth of the experiences and perspectives shared with me, and from the resilience and pride with which many residents spoke about the homes they built. It also emerged from my own positionality and privilege, including the socio-economic and educational circumstances that enabled me to undertake this research within institutions able to support it. I am deeply grateful to the residents, building professionals, and researchers who generously shared their time, insights, and patience throughout this PhD journey. Their perspectives challenged and expanded my own, shaping a thesis grounded in co-creative practices and in the strength, adaptability, and resilience demonstrated by the residents of St. Martin and their homes.

Contents

List of Figures

Abstract

This research investigates how adaptability and decision-making in the incremental development of self-organized housing can be supported in hazard-prone Caribbean contexts, with a focus on St. Martin. In regions where low-income households face financial, technical, and administrative barriers to formal housing supply, self-organized housing becomes a primary means of access to shelter. While offering flexibility and relative autonomy, such housing is often developed under significant constraints, which may compromise structural safety, climate comfort, and long-term functionality. In hazard-prone environments where risks are intensified by climate change, adaptability and decision-making under constraint emerge as a central challenge.

Design approaches that integrate professional support into resident-driven housing processes, such as assisted self-organized housing, offer a way to improve housing conditions. Yet existing approaches often focus on initial construction and provide limited guidance for long-term adaptation and decision-making throughout incremental development. This research addresses this gap by developing a design approach—Designing for a Flow—a structured guidance that integrates principles, methods, and tools to inform the design and construction of self-organized housing. It does so by integrating circular design principles and co-creative methods to enhance adaptability and resilience in incremental housing processes.

Conceptualizing housing as a dynamic process unfolding over time, the approach facilitates “flows” through three interrelated dimensions: development flow (incremental construction and adaptation), material flow (repairability and replaceability of building elements), and knowledge flow (collaborative decision-making between residents and building professionals).

Methodologically, the study adopts a transdisciplinary Participatory Action Research approach embedded within a single-case study in St. Martin. Through iterative stages of contextual analysis, housing studies, and the development and testing of collaborative tools—including the Housing Flows Cards and the Designing for a Flow co-design tool—the research examines how circular and co-creative strategies can support informed adaptation over time.

The study contributes a design approach that advances assisted self-organized housing by integrating adaptability and collaborative decision-making. While grounded in the Caribbean context, the findings offer transferable insights for supporting incremental, resilient housing development in other climate-affected contexts.

Summary

Housing is widely recognized as a fundamental human right and critical factor in reducing poverty, improving health and well-being. Despite this recognition, access to adequate and affordable housing remains a persistent global challenge, particularly for low-income individuals and households. These groups often face compounded financial, physical, and administrative barriers that limit their ability to access formal housing supply. In hazard-prone regions, these challenges are further intensified by environmental risks, whose impacts disproportionately affect those groups and their housing conditions.

In many such contexts, limited access to formal housing supply leads residents to rely on self-organized housing: dwellings that are constructed gradually, large by residents themselves, in accordance with available resources, needs, and aspirations. While self-organized housing offers relative flexibility and autonomy, it is often developed under significant financial and technical constraints. As a result, construction materials, structural systems, and spatial layouts may be suboptimal, leading to long-term performance and comfort issues and heightened vulnerability to hazards such as hurricanes, floods, and storm surges, which are further intensified by climate change.

Self-organized housing evolves over time through incremental construction, repairs, and adaptations responding to changing household needs, material deterioration, and environmental risks. However, these adaptations can be challenging to implement and do not necessarily lead to improved housing conditions. Decisions regarding construction and adaptation are typically made by residents based on personal experience and limited access to technical knowledge, professional support, or long-term planning tools. Under such constraints, adaptations may inadvertently reduce structural safety, thermal performance, or future adaptability. This highlights adaptability and decision-making under constraint as a central challenges in self-organized housing development.

Assisted self-organized housing approaches—design approaches that integrate professional assistance into self-organized housing processes—offer a promising pathway to address these challenges. By combining gradual, resident-driven development with technical expertise from building professionals, such approaches can improve functionality, comfort, and safety while maintaining residents’ agency and responsiveness to changing circumstances. However, existing self-organized

TOC

housing approaches often focus on supporting initial construction, while offering limited guidance for long-term adaptation and for improving decision-making related to implications of housing adaptations over time.

This thesis argues that adaptability and resilience of self-organized housing can be strengthen by integrating principles of circular design and co-creation into assisted self-organized housing approaches. Circular design, which seeks to keep resources in use for as long as possible, offers strategies for constructing buildings in ways that facilitate repair, replacement, and disassembly of components. Applied to self-organized housing, circular design principles can reduce the effort, cost, and disruption associated with future adaptations. At the same time, co-creation—understood as collaborative processes of knowledge exchange and joint decision-making between residents and building professionals—can enhance the quality of decisions that guide incremental development and adaptation.

Building on these premises, the thesis develops a design approach—understood as a way of thinking that shapes the design process—termed *Designing for a Flow*. The approach conceptualizes housing as a dynamic process unfolding over time, drawing on Stewart Brand's concept that buildings "flow" rather than remain fixed. In this research, flows are operationalized through three interrelated dimensions:

1. **development flow**, referring to the gradual construction and ongoing adaptation of self-organized housing;
2. **material flow**, referring to the ease with which building elements can be repaired, replaced, or removed; and
3. **knowledge flow**, referring to the exchange of knowledge between residents and building professionals that informs decision-making throughout the housing processes.

Together, these concepts inform a design approach—a structure guidance combining principles, methods, and tools—that supports adaptability and resilience in self-organized housing by addressing both incremental development and the decision-making that precedes and shapes them over time.

The study is situated in the hazard-prone Caribbean context, with a particular focus on the island of St. Martin. The research is embedded within a single-case study encompassing multiple self-organized housing cases across several neighbourhoods. St. Martin provides a relevant context for the study, as its limited formal housing supply has led to a high prevalence of self-organized housing, exposure to multiple hazards and environmental risks amplified by climate change, and the importance of post-disaster reconstruction.

TOC

Methodologically, the research is underpinned by a transdisciplinary approach that aims to foster knowledge exchange between various academic and non-academic partners, including residents and local building professionals, to enhance contextual relevance and inclusivity. The study adopts a Participatory Action Research (PAR) approach, involving relevant partners in identifying and understanding challenges related to self-organized housing development, adaptation practices, and environmental risks, and jointly developing and testing initiatives to address them.

Following the principles of PAR, the research is organised into four iterative stages. The first stage develops a contextualized understanding of self-organized housing development processes, adaptation practices, and associated challenges and opportunities, leading to the initial formulation of the "Designing for a Flow" framework. The second stage investigates self-organized housing trajectories in depth by tracing incremental construction, hazard-related repairs, and adaptations across different housing types. The third stage develops and tests a collaborative method and visual tool—the "Housing Flows" cards—designed to facilitate structured conversations and knowledge exchange between residents and building professionals regarding material and design choices. The fourth stage applies and refines the approach and proposes a co-design tool "Designing for a Flow" tested through design sessions, resulting in housing design proposals aimed at improving adaptability and resilience through informed, co-creative decision-making.

Overall, this thesis develops and examines a design approach that integrates assisted self-organized housing approach, circular design principles, and co-creative methods to support adaptability and decision-making in self-organized housing. By conceptualizing housing as a dynamic process unfolding over time, the research addresses a critical gap in existing approaches that largely focus on initial construction and overlook the cumulative effects of incremental adaptations, particularly in hazard-prone contexts. The proposed approach and associated tools offer practical guidance for residents, building professionals, and other stakeholders to collaboratively plan, construct, and adapt housing in ways that enhance resilience, material efficiency, and climate comfort while maintaining residents' agency. While grounded in the case of St. Martin, the approach is intended to be transferable and adaptable to other contexts where self-organized housing is prevalent, and to inform future research, design practice, and policy development concerned with incremental, resilient, and inclusive housing approaches.

Samenvatting

Wonen wordt algemeen erkend als een fundamenteel mensenrecht en als een cruciale factor in het verminderen van armoede en het verbeteren van gezondheid en welzijn. Ondanks deze erkenning blijft toegang tot adequate en betaalbare huisvesting wereldwijd een hardnekkige uitdaging, met name voor mensen en huishoudens met een laag inkomen. Deze groepen worden vaak geconfronteerd met een combinatie van financiële, fysieke en administratieve barrières die hun toegang tot het formele woningaanbod beperken. In gebieden die gevoelig zijn voor natuurrampen worden deze uitdagingen verder versterkt door milieurisico's, waarvan de gevolgen disproportioneel zwaar wegen op deze groepen en hun woonomstandigheden.

In veel van dergelijke contexten leidt de beperkte toegang tot formele huisvesting ertoe dat bewoners afhankelijk worden van zelfgeorganiseerde huisvesting: woningen die geleidelijk worden gebouwd, grotendeels door bewoners zelf, in overeenstemming met beschikbare middelen, behoeften en ambities. Hoewel zelfgeorganiseerde huisvesting relatieve flexibiliteit en autonomie biedt, wordt deze vaak ontwikkeld onder aanzienlijke financiële en technische beperkingen. Daardoor kunnen bouwmaterialen, constructiesystemen en ruimtelijke indelingen suboptimaal zijn, wat leidt tot problemen op het gebied van prestaties en comfort op lange termijn en tot een verhoogde kwetsbaarheid voor gevaren zoals orkanen, overstromingen en stormvloeden, die bovendien worden versterkt door klimaatverandering.

Zelfgeorganiseerde huisvesting ontwikkelt zich in de loop van de tijd door middel van incrementele bouw, reparaties en aanpassingen als reactie op veranderende behoeften van huishoudens, materiaalveroudering en milieurisico's. Deze aanpassingen kunnen echter moeilijk te realiseren zijn en leiden niet noodzakelijk tot verbeterde woonomstandigheden. Beslissingen met betrekking tot bouw en aanpassing worden doorgaans genomen door bewoners op basis van persoonlijke ervaring en met beperkte toegang tot technische kennis, professionele ondersteuning of hulpmiddelen voor langetermijnplanning. Onder dergelijke omstandigheden kunnen aanpassingen onbedoeld de structurele veiligheid, thermische prestaties of toekomstige aanpasbaarheid verminderen. Dit maakt aanpasbaarheid en besluitvorming onder beperkingen tot centrale uitdagingen binnen de ontwikkeling van zelfgeorganiseerde huisvesting.

Benaderingen van ondersteunde zelfgeorganiseerde huisvesting — ontwerpbenaderingen die professionele ondersteuning integreren in processen van zelfgeorganiseerde huisvesting — bieden een veelbelovende mogelijkheid om deze uitdagingen aan te pakken. Door geleidelijke, door bewoners gestuurde ontwikkeling te combineren met technische expertise van bouwprofessionals, kunnen dergelijke benaderingen functionaliteit, comfort en veiligheid verbeteren, terwijl tegelijkertijd de autonomie van bewoners en de flexibiliteit om in te spelen op veranderende omstandigheden behouden blijven. Bestaande benaderingen van zelfgeorganiseerde huisvesting richten zich echter vaak vooral op ondersteuning van de initiële bouwfase en bieden beperkte richtlijnen voor langetermijnaanpassingen en voor het verbeteren van besluitvorming met betrekking tot de implicaties van woningaanpassingen in de tijd.

Deze scriptie betoogt dat de aanpasbaarheid en veerkracht van zelfgeorganiseerde huisvesting kunnen worden versterkt door principes van circulair ontwerp en co-creatie te integreren in benaderingen van ondersteunde zelfgeorganiseerde huisvesting. Circulair ontwerp, dat erop gericht is grondstoffen zo lang mogelijk in gebruik te houden, biedt strategieën om gebouwen zodanig te construeren dat reparatie, vervanging en demontage van componenten worden vergemakkelijkt. Toegepast op zelfgeorganiseerde huisvesting kunnen circulaire ontwerpprincipes de inspanning, kosten en verstoring die gepaard gaan met toekomstige aanpassingen verminderen. Tegelijkertijd kan co-creatie — opgevat als collaboratieve processen van kennisuitwisseling en gezamenlijke besluitvorming tussen bewoners en bouwprofessionals — de kwaliteit verbeteren van de beslissingen die incrementele ontwikkeling en aanpassing sturen.

Voortbouwend op deze uitgangspunten ontwikkelt de scriptie een ontwerpbenadering — opgevat als een manier van denken die het ontwerpproces vormgeeft — genaamd *Designing for a Flow*. Deze benadering conceptualiseert huisvesting als een dynamisch proces dat zich in de tijd ontvouwt, geïnspireerd door Stewart Brands concept dat gebouwen “stromen” in plaats van statisch blijven. In dit onderzoek worden deze “flows” geoperationaliseerd via drie onderling verbonden dimensies:

1. **ontwikkelingsflow**, verwijzend naar de geleidelijke bouw en voortdurende aanpassing van zelfgeorganiseerde huisvesting;
2. **materiaalflow**, verwijzend naar het gemak waarmee bouwelementen kunnen worden gerepareerd, vervangen of verwijderd; en
3. **kennisflow**, verwijzend naar de uitwisseling van kennis tussen bewoners en bouwprofessionals die besluitvorming gedurende het gehele huisvestingsproces ondersteunt.

Samen vormen deze concepten een ontwerpbenadering — een gestructureerde leidraad die principes, methoden en hulpmiddelen combineert — die aanpasbaarheid en veerkracht in zelfgeorganiseerde huisvesting ondersteunt door zowel incrementele ontwikkeling als de besluitvorming die daaraan voorafgaat en deze in de tijd vormgeeft, te adresseren.

De studie situeert zich in de door natuurrampen bedreigde Caribische context, met bijzondere aandacht voor het eiland St. Martin. Het onderzoek is ingebed in een enkelvoudige casestudie die meerdere gevallen van zelfgeorganiseerde huisvesting in verschillende wijken omvat. St. Martin vormt een relevante context voor deze studie, aangezien het beperkte formele woningaanbod heeft geleid tot een hoge prevalentie van zelfgeorganiseerde huisvesting, blootstelling aan meerdere gevaren en milieurisico's die worden versterkt door klimaatverandering, en het belang van wederopbouw na rampen.

Methodologisch is het onderzoek gebaseerd op een transdisciplinaire benadering die kennisuitwisseling tussen diverse academische en niet-academische partners wil bevorderen, waaronder bewoners en lokale bouwprofessionals, om de contextuele relevantie en inclusiviteit te versterken. De studie hanteert een Participatory Action Research (PAR)-benadering, waarbij relevante partners worden betrokken bij het identificeren en begrijpen van uitdagingen met betrekking tot de ontwikkeling van zelfgeorganiseerde huisvesting, aanpassingspraktijken en milieurisico's, evenals bij het gezamenlijk ontwikkelen en testen van initiatieven om deze aan te pakken.

In overeenstemming met de principes van PAR is het onderzoek georganiseerd in vier iteratieve fasen. De eerste fase ontwikkelt een gecontextualiseerd begrip van processen van zelfgeorganiseerde huisvestingsontwikkeling, aanpassingspraktijken en de daarmee samenhangende uitdagingen en kansen, wat leidt tot de eerste formulering van het raamwerk *Designing for a Flow*. De tweede fase onderzoekt trajecten van zelfgeorganiseerde huisvesting diepgaand door incrementele bouw, op gevaren gerichte reparaties en aanpassingen binnen verschillende woningtypen te traceren. De derde fase ontwikkelt en test een collaboratieve methode en een visueel hulpmiddel — de *Housing Flows*-kaarten — ontworpen om gestructureerde gesprekken en kennisuitwisseling tussen bewoners en bouwprofessionals over materiaal- en ontwerpkeuzes te faciliteren. De vierde fase past de benadering toe, verfijnt deze verder en stelt een co-ontwerptool voor genaamd *Designing for a Flow*, getest via ontwerpsessies die resulteerden in woningontwerpen gericht op het verbeteren van aanpasbaarheid en veerkracht door middel van geïnformeerde, co-creatieve besluitvorming.

Over het geheel genomen ontwikkelt en onderzoekt deze scriptie een ontwerpbenadering die ondersteunde zelfgeorganiseerde huisvesting, principes van circulair ontwerp en co-creatieve methoden integreert om aanpasbaarheid en besluitvorming binnen zelfgeorganiseerde huisvesting te ondersteunen. Door huisvesting te conceptualiseren als een dynamisch proces dat zich in de tijd ontvouwt, adresseert het onderzoek een cruciale lacune in bestaande benaderingen, die zich grotendeels richten op de initiële bouwfase en de cumulatieve effecten van incrementele aanpassingen negeren, met name in contexten die gevoelig zijn voor natuurrampen. De voorgestelde benadering en bijbehorende hulpmiddelen bieden praktische richtlijnen voor bewoners, bouwprofessionals en andere betrokkenen om gezamenlijk woningen te plannen, bouwen en aanpassen op manieren die veerkracht, materiaalefficiëntie en klimaatcomfort versterken, terwijl de autonomie van bewoners behouden blijft. Hoewel de benadering is gebaseerd op de casus van St. Martin, is zij bedoeld om overdraagbaar en aanpasbaar te zijn naar andere contexten waar zelfgeorganiseerde huisvesting veel voorkomt, en om toekomstig onderzoek, ontwerppraktijk en beleidsontwikkeling rond incrementele, veerkrachtige en inclusieve huisvestingsbenaderingen te informeren.

1 Introduction

1.1 Self-Organized Housing as a Response to Housing Challenges

Housing is widely recognized as both a fundamental human right and a key determinant of poverty reduction, health, and well-being (Akinsulire et al., 2024; Beall & Fox, 2009; Smets et al., 2014). Yet, **access to affordable and adequate housing** is becoming increasingly challenging worldwide (Mazzucato & Doyle, 2020; UN Habitat, 2015). As of 2024, the UN estimates that 2.8 billion people—approximately one-third of the global population—experience some form of **housing inadequacy** (UN Habitat, 2024a). Deficits in affordable housing persist across diverse contexts, particularly in areas with high population density and densifying regions across continents, including Europe (Eurostat, 2024) and Latin America and the Caribbean (Inter-American Development Bank, 2022).

Housing is linked to environmental, political and financial systems, which directly influence its affordability and accessibility. The financialization of land and housing—where they are used primarily for investment rather than residence—drives up prices and increases pressures on urban land use and ecosystems (Gallent, 2022; Özdemir & Eraydin, 2017). At the same time, **climate change**, to which building sector contributes by accounting for nearly 40% of global energy-related **CO_2 emissions** and by consuming large quantities of land, minerals, and materials challenges housing accessibility (United Nations Environment Programme, 2025). Additionally, limited land availability, insufficient formal affordable housing supply, and unequal access to resources and opportunities make housing increasingly inaccessible (Czischke, 2019; Stacy et al., 2023).

The consequences of these economic and environmental pressures manifest unevenly and **disproportionately affect some groups**. Low-income households, young people, women-headed households, migrants, older adults, people with disabilities, and marginalized racial or ethnic groups, are among those most severely impacted (Gallent, 2022; Ghaedrahmati & Shahsavari, 2019; Haycox et al., 2024; King et al., 2017; Mehdipanah et al., 2021; Menghoung et al., 2025; Valderrama-Ulloa et al., 2023; Vijimala, 2024; Zewde et al., 2024). Although contributing the least to global emissions, these groups often face the most severe consequences of **climate-amplified weather events**, which negatively affect both housing access and the quality and stability of the homes, as well as overall livelihoods (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2022; UN Habitat, 2024b; Usamah et al., 2014). Housing access is further constrained for those affected by income insecurity, precarious labour conditions, and legal restrictions on mobility or tenure.

Governments and international agencies have long attempted to address the challenges of housing accessibility. From the mid-20th century onward, **large-scale social housing programs** were introduced in response to rapid urbanization and industrialization, as well as rising concerns about poverty, public health risks, and social unrest (Gilbert, 2004; Harris, 1991; Stoloff, 2004). These programs of formal **affordable housing supply**—typically providing **fully constructed housing units** —were designed to offer dwelling for low- and middle-income working households excluded from private housing market (Amirjani, 2020; Salama & Sengupta, 2011; Stoloff, 2004). However, scholars dispute their effectiveness: while some argue these programs expanded housing access, others contend they failed to meet the diverse needs of individual households, reinforced existing social inequalities, and fostered long-term dependence on state support (Horgan, 2020; Iftekhar, 2007; Smets & Kusenbach, 2020; Wainer et al., 2016a).

Despite substantial construction output, these programs do not keep pace with the rising demand for affordable housing and leave significant gaps in provision (Beall & Fox, 2009; Greene & Rojas, 2008a). Consequently, a substantial proportion of housing continues to be produced through **individual initiatives**, most notably **"self-organized housing,"** introduced here as an umbrella term that includes **"self-help," "incremental," and "self-built"** housing approaches. Such housing evolve gradually, in line with **households' financial capacity and changing needs**, provided a way for families with informal or irregular incomes to gradually develop homes and in many combining dwellings with income-generating possibilities by including small-scale economic activities or opportunities for renting parts of the houses (Greene & Rojas, 2008a; Mota, 2021a; Wakely & Riley, 2011a).

Expanding globally (McTarnaghan et al., 2016a; Sánchez, 2024; UN Habitat, 2015), these types of dwellings represent households' strategies to address the shortcomings of formal affordable housing supply programs by constructing their own homes (Goethert, 2010a; Smets et al., 2014). Although often associated in policy and design discourse with negative connotations such as precariousness or informality, self-organized housing spans a wide spectrum—from temporary shelters to fully developed permanent dwellings (Wakely & Riley, 2011a).

In self-organized housing, the gradual development and adaptation are evident in **incremental construction,** modification, and the reuse, repair and repurposing of materials as households respond to changing family structures, resource availability, and environmental risks (Kamalipour & Dovey, 2020; Lizarralde, 2011a; Mukhija, 2014a; Twigg et al., 2017). Such practices help **reduce initial construction costs and labour** and aim to **extend the longevity of houses and building elements** (Carenzo et al., 2022; Gall et al., 2020; Hobson, 2020; Korsunova et al., 2022).

Since the 1940s—and more visibly from the 1960s—international agencies and scholars, including Crane, Abrams, Mangin, and Turner, emphasized the potential of **assisted self-organized housing approaches** to address housing inaccessibility (Abrams, 1964a; Crane & Paxton, 1951; Harris, 2003a; Mangin, 1967a; J. F. Turner, 1972a; J. F. C. Turner, 1976a). This design approach, understood as a set of principles and methods guiding designing processes and decisions, reframed self-organized housing not as a problem to be eradicated but as a viable affordable housing strategy. By drawing on incremental construction processes combining residents' agency with the support of building professionals, it emphasized an understanding of **housing as an ongoing process** rather than a finished product (J. F. C. Turner, 1976a). Promoted for its relative affordability, scalability, and adaptability, assisted self-organized housing approaches contrast with earlier reliance on the delivery of complete housing units (Harris, 1998; Rybczynski & Bhatt, 2004).

Importantly, beyond affordability and adaptability, assisted self-organized housing approaches emphasized the **involvement of both residents and building professionals i**n design and construction, underlining the potential of connecting affordable housing development with participatory design approaches (Indris, 2023; Lizarralde, 2011b; Smets et al., 2014). Such design approaches, involving various levels of **resident participation**, allowed dwellings to reflect household priorities more closely (Kowaltowski, 1998), aimed at strengthening social networks, and enhancing attachment to place—factors linked to residents' well-being and long-term housing functionality (Furtado & Renski, 2021; Gilbert, 1999; Twigg et al., 2017). At the same time, building professionals contributed to improved planning, design, and construction quality. The joint design and construction efforts also aimed at enhancing technical construction knowledge of the residents involved in the process, which is particularly critical in **hazard-prone settings** (Carrasco & Brien, 2022; Furtado & Renski, 2021; Twigg et al., 2017). For these reasons, assisted self-organized housing approaches have been widely promoted in many regions, including in new housing development and post-disaster reconstruction in hazard-prone contexts (L. Harriss, Researcher, et al., 2020; Hendriks et al., 2016, 2018; Lyons et al., 2010a; Maynard et al., 2017a; Parrack et al., 2014; Schilderman & Lyons, 2011a; Twigg, 2002).

Nevertheless, **assisted self-organized housing approaches** have significant **limitations** that stem from the inherent challenges of self-organized housing itself (Burgess, 1988; Mathéy Kosta, 1992; Ward, 1982). Self-organized housing often emerges from necessity due to insufficient formal housing supply and are not suitable for everyone. Such approaches demand **significant effort** in construction and maintenance, particularly in the context of increasing climate-amplified weather events and associated challenges. They also require **complex logistics and time, and involve coordination among multiple partners** (Gilbert, 1999; Huisman & Czischke, 2023). Moreover, promoting assisted self-organized housing can be interpreted as shifting responsibility for housing provision away from governments and institutions (Bryant & Aggleton, 2025; Davoudi, 2012; Lam & Kuipers, 2019). Despite these challenges, self-organized housing remains an **important means of meeting the housing needs** particularly for those excluded from formal affordable housing supply programs delivering fully developed units (Bredenoord et al., 2010; Bredenoord & van Lindert, 2010; Mukhija, 2014a; Van Noorloos et al., 2020).

1.2 Housing Challenges in the Caribbean and the Case of St. Martin

The challenges of housing accessibility and adequacy are particularly visible in hazard-prone contexts such as the **Caribbean**, including **the island of St. Martin**, which forms the focus of this research. The region's natural beauty drives international investment which inflates land values and accelerates the pace and scale of development catering mainly to high-income investors, thereby exacerbating housing inaccessibility and contributing to environmental degradation—such as soil erosion, waste accumulation, and over-excavation (Wilby, 2007; Zięba et al., 2020). Alongside long-standing housing inequalities, insecure land tenure, and the lasting effects of colonial and post-colonial exploitation, Caribbean residents are affected by the implications of living in one of the most **climate-affected regions** globally, including rising sea levels, intensified hurricanes, and extreme heat (Collodi et al., 2021; Kelder et al., 2025a; McHardy & Donovan, 2016; M. Mycoo, 2020a; Sandoval & Sarmiento, 2020; United Nations Office for Disaster Risk Reduction (UNDRR), 2023). Those pressures directly affect housing accessibility and adequacy, particularly for low-income residents.

Due to **limited availability of affordable and accessible formal housing supply**, many residents in the Caribbean, including St. Martin, construct **self-organized housing** (Collodi et al., 2021; Potter, 1994; Potter & Conway, 1997; Sandoval & Sarmiento, 2020). Many households are multigenerational, and construction typically relies on the joint efforts of family, friends, and local builders (M. Mycoo, 2020b; WWDIA, 2016). Shaped by necessity, and the effort and creativity of those involved, those houses reflect cultural practices and household priorities to a greater extent than fully developed affordable housing units (Benson & Hamiduddin, 2017b; Bredenoord & van Lindert, 2010; Gattoni, 2009).

Self-organized houses on the island face multiple challenges, particularly related to financial, logistical, legal, and technical constraints. They are frequently constructed with limited financial resources, restricted access to durable building materials, and limited technical expertise (Mehdizadeh et al., 2023; M. Mycoo, 2020b; M. A. Mycoo, 2018). Such dwellings are typically developed incrementally and adapted over time, resulting in **wide variation in form, size, and materials**. Some are initially built as small units using temporary materials, such as wooden boards and corrugated iron; others begin by repurposing shipping containers or refurbishing existing structures; still others are constructed from the outset using more durable materials, such as concrete blocks (Lang & Marshall, 2011; Prevatt et al., 2010). Houses are **often extended and adapted over time** through replacement of temporary materials with more durable ones, the addition of new rooms, or the modification of existing spaces. Materials and building elements are usually gradually repaired or replaced as they wear out or are damaged. These material and structural differences across self-organized housing influence maintenance requirements, **levels of exposure to environmental risks, and vulnerability to hazards**.

Climate-amplified weather events pose additional challenges, further complicating housing adequacy. Houses constructed with low-cost materials or structural systems that are insufficient to withstand environmental risks are particularly vulnerable to storm surges, heavy rainfall, and hurricane-force winds (Goldwyn et al., 2021, 2022a; Lang & Marshall, 2011; Lochhead, Murray, et al., 2022; Marshall et al., 2011; Valdivieso et al., 2024). This vulnerability was starkly exposed during Hurricanes Irma and Maria in 2017, which damaged an estimated 70–85% of the housing stock in St. Martin, with self-organized houses among the most severely affected (Der Sarkissian et al., 2021; World Bank, 2017, 2019, 2020). Many self-organized houses lack insurance coverage and often do not qualify for limited—and frequently prolonged—post-disaster rebuilding programs, leaving residents largely responsible for repairs and reconstruction, much of which remains incomplete to this day (Collodi et al., 2021).

Beyond climate-amplified weather events, self-organized housing on the island is also increasingly affected by **climate-related challenges** such as heat stress. Overheating is a common issue due to high building density, inadequate ventilation, and the widespread use of heat-absorbing materials such as concrete (Bonaccorso & da Graça, 2022; Lochhead, Murray, et al., 2022; Murray et al., 2023a). These conditions pose heightened health risks, particularly for elderly residents and children. As climate-related challenges and environmental risks **intensify with rising global temperatures** and increasing unstable climate systems, the need for coordinated political and regulatory action becomes more urgent (IPCC, 2001, 2022; Kelder et al., 2025a; UN Habitat, 2024b). At the same time, these pressures underline the importance of housing design approaches that can support self-organized housing in withstanding environmental risk and address climate-related challenges particularly in contexts where formal housing supply remains limited.

In such contexts, **adaptation** is an important process allowing to respond to intensifying climate-related challenges, for example through measures that improve ventilation or reduce overheating (Brunoro, 2013; Kinnane et al., 2017). In self-organized housing, adaptation is expressed through incremental construction, modification, and repairs as households respond to changes in family structures, available resources, and environmental risks (Kamalipour & Dovey, 2020; Lizarralde, 2011a; Mukhija, 2014a; Twigg et al., 2017). **Adaptability** —the ability to **change over time in response to shifting conditions and circumstances**—is therefore a key aspect contributing to housing adequacy also referring to integration of new materials, technologies, and knowledge into existing building (Itma, 2019; Moffatt & Russell, 2001; Schmidt et al., 2009).

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1.3 Supporting Housing Adaptability through Design and Decision-Making

One of the ways to improve adaptability is through design approaches that facilitate constructing buildings in a way that allows for **modifications over time**. One of such approaches is **circular economy**, which seeks to keep resources in use for as long as possible by extending the lifespan of materials, reducing waste, and enabling continuous resource cycles (Blomsma & Brennan, 2017; Kirchherr et al., 2017). Circular design operationalizes those principles by encouraging design that enables **reuse, repair, disassembly, and ease of maintenance,** allowing individual components to be updated or replaced without major disruptions to the wider building system (Cruz Rios & Grau, 2020; Dokter, 2021; Moreno et al., 2016). By adopting these principles, design approaches can enhance adaptability by facilitating repairs, modifications, and incremental alterations in response to evolving household needs and challenges (Gomide et al., 2024; Marchesi et al., 2020; Marchesi & Tweed, 2021; Schröder et al., 2020). In this sense, adaptability also contributes to resilience —the ability of housing to **adjust to environmental risks, withstand hazards, and recover** from them—by enabling structural improvements, maintenance, and repair (Bryant & Aggleton, 2025; Mulligan et al., 2016; Schilderman & Lyons, 2011a; Usamah et al., 2014).

Although adaptability is a crucial characteristic for self-organized housing, particularly in hazard-prone contexts, where dwellings should be able to evolve in response to changing risks, resources, and household needs, adaptations can be difficult to implement and sometimes do not lead to improvements in housing conditions (Antwi-Agyei et al., 2018; Barnett & O'Neill, 2010; Schipper, 2020). **Adaptations demand additional effort, skills, and financial resources**, and can affect other parts of the house depending on the scale and type of modification, the materials involved, and their connections within the existing structure, as decisions regarding construction and adaptation are typically made by residents based on personal experience and limited access to technical knowledge, professional support, or long-term planning tools (Benson & Hamiduddin, 2017a; Charles & Chang-Richards, 2023; Kamalipour & Dovey, 2020; Moatty & Vinet, 2016). Under such circumstances, adaptations may inadvertently **reduce structural safety, thermal performance, or future adaptability**. This highlights the need to also address the **decision-making leading to adaptions** in self-organized housing.

Strengthening informed decision-making processes is crucial to ensure that adaptations effectively respond to existing and emerging challenges. Informed decision-making relies on the **planning capacity, technical knowledge, and practical skills of those involved in building practices** (Capell & Ahmed, 2021; Flinn et al., 2017; Lam & Kuipers, 2019; Lyons et al., 2010a; Twigg, 2021). These capacities can be enhanced through **collaboration between residents and building professionals** that emphasizes joint decision-making and knowledge exchange, combining local experience with technical expertise (Bridi et al., 2024a; Nguyen et al., 2024; Sanders et al., 2008).

Such collaboration can support the consideration of the long-term implications of planning and design decisions—for example, how material choices affect ventilation, thermal comfort, and hazard resistance. It can also encourage improving and **balancing various housing considerations**, including safety, comfort, and functionality of spatial layouts, as well as aesthetics. By anticipating possible future changes, collaborative processes can help guide informed design decisions that **enable adaptation over time** (Fromm, 2012; Hamid, 2012; Lam & Kuipers, 2019). Within a range of collaborative approaches that employ co-creative methods and tools, co-design offers a way to jointly design housing (Govender & Loggia, 2023; Steen, 2013; Stenberg et al., 2022).

Access to affordable and adequate housing remains a crucial issue, and **self-organized housing remains one of the primary ways** in which many low-income individuals and households secure a place to live, including in the Caribbean. While it offers benefits such as the possibility of gradually developing a house, it also faces significant challenges, including vulnerability to climate impacts. Assisted self-organized housing provides an opportunity to improve both accessibility and adequacy, yet these houses still encounter challenges that require careful consideration of how they are developed, adapted, and maintained, as well as how decisions about these processes are made.

Assisted self-organized housing informed by design approaches that enhance adaptability—including those drawing on circular design—can help address these challenges by **enabling houses to be more easily developed, adapted, or redeveloped over time**. Furthermore, collaboration between residents and building professionals can strengthen informed decision-making, ensuring that adaptations effectively respond to existing conditions and emerging risks.

1.4 Problem formulation

1.4.1 Research gap

Existing scholarship and observable realities highlight the persistent global challenge of accessing **affordable and adequate housing**, particularly among **low-income households**. Research further underscores the importance of self-organized housing as means of accessing shelter (Bredenoord et al., 2010, 2014a; Goethert, 2010a; Harris, 1991; Smets et al., 2014). Although such housing continues to accommodate large groups of people excluded from formal housing supply programs, they are frequently developed under significant financial, technical, and administrative constraints. These constraints, combined with increasing environmental risks, affect housing quality and long-term performance and often result in suboptimal material choices, structural systems, and spatial layouts, leading to reduced comfort and heightened vulnerability to hazards.

These challenges are exacerbated in hazard-prone regions, where **climate change** is **intensifying environmental risks** and increasing the frequency and severity of hurricanes, storms, and prolonged heatwaves (Goldwyn et al., 2021, 2022a; Lochhead, Murray, et al., 2022; UN Habitat, 2024b). While housing research in Latin America has expanded in recent decades, the Caribbean—despite facing complex climate challenges and housing vulnerabilities—remains underrepresented, with relatively few targeted studies (McTarnaghan et al., 2016b; UN Habitat, 2011). Existing research documents the impacts of hurricanes, earthquakes, sea-level rise, and rising land costs on self-organized housing in islands such as Puerto Rico, Haiti, and Curaçao (Bulbaai & Halman, 2021; Caldieron, 2011; Curet, 1992; Delgado & Antipova, 2010; Goldwyn et al., 2022a; Hinojosa & Meléndez, 2018; Lang & Marshall, 2011; Lochhead, Goldwyn, et al., 2022; Lochhead, Murray, et al., 2022; Marshall et al., 2011; Mix et al., 2011; Murray et al., 2023a; Osborne et al., 1992; Ou-yang et al., 2013; Prevatt, 1994; Prevatt et al., 2010, 2018; Sanderson et al., 2014; Talbot et al., 2019, 2020). These studies primarily focus on impacts and vulnerabilities, with limited attention to residents' incremental building, adaptation, and repair practices, the influence of constrained technical and financial support, and the roles of decision-making and multiple partners in shaping housing development.

In response to these challenges, **assisted self-organized housing** has been promoted in hazard-prone regions, including Caribbean, for both new construction and post-disaster reconstruction (Flinn et al., 2017; Hendriks et al., 2016; Potter, 1994; Potter & Conway, 1997; Twigg et al., 2017). Although these approaches aim to improve housing conditions through collaboration between the residents and building professionals, scholars have noted several limitations, including short-term forms of support and restricted capacity to accompany ongoing **incremental housing development** (Carrasco & O'Brien, 2021; Marinovic, 2020; O'Brien et al., 2020a; Schipper, 2020). Consequently, there remain limited studies on how assisted approaches support decision-making and long-term adaptation, particularly in under-studied, **hazard-prone contexts such as the Caribbean**.

At the same time, emerging literature points to the potential of **circular design** and **co-creative approaches**. Circular design principles offer opportunities to enhance adaptability, repairability, and material efficiency (Askar et al., 2019; Gomide et al., 2024; Marchesi & Tweed, 2021; Schröder et al., 2020), while co-creative approaches are increasingly recognized for strengthening collaboration between residents and professionals throughout the duration of the projects and for supporting shared decision-making (Brandsen et al., 2018; Nguyen et al., 2024; Sanders et al., 2008). However, both approaches remain limited in how they can be effectively adapted to the realities of self-organized housing. In particular, there is limited guidance on facilitating dialogue around material and design choices and their implications throughout the incremental development process, supporting collaboration, and embedding these approaches into housing processes in hazard-prone contexts.

Taken together, the literature reveals limited research connecting residents' **incremental housing practices** and **decision-making processes** with assisted self-organized housing and design approaches grounded in circular principles and co-creative practices in hazard-prone Caribbean contexts. Addressing this gap is essential for developing more resilient and adaptable housing design approaches in climate-affected contexts.

1.4.2 Research aim

This research aims to address the limited integration of decision-making support and design approaches in the incremental development of self-organized housing in hazard-prone Caribbean contexts. It focuses on understanding how low-income households gradually construct and adapt their homes in response to multiple challenges, and how these processes are shaped by residents' decision-making and collaboration with building professionals. Specifically, the research investigates how a design approach grounded in circular principles and co-creative practices can support adaptability and decision-making in assisted self-organized housing.

1.4.3 Research objectives

Main research objective

- Investigate the potential of a design approach to support decision-making and enhance the adaptability of self-organized housing in hazard-prone Caribbean contexts.

Sub-research objectives

- Analyse the challenges encountered in the development and adaptation of self-organized housing in St. Martin, and to examine how circular design principles can support adaptability in response to these challenges.
- Document and analyse how residents in St. Martin incrementally develop and adapt their housing in response to diverse challenges, including climate-related risks, and how these processes relate to material and design choices.
- Investigate decision-making processes and the roles of multiple partners, including residents and building professionals, in shaping incremental housing development.
- Develop and apply a design approach integrating circular design principles and co-creative practices to support housing development and adaptation.
- Develop, test, and evaluate co-creative methods and tools aligned with the design approach, and to assess their potential to support decision-making and enhance housing adaptability.

TOC

1.4.4 Research questions

Main research question

- How can a design approach support decision-making in the development and adaptation of self-organized housing in Caribbean contexts to enhance housing adaptability to diverse challenges?

Sub-research questions

- How do residents of self-organized housing in St. Martin incrementally develop and adapt their homes in response to diverse challenges?
- How can circular design principles support the development and adaptation of self-organized housing and inform a design approach that enhances housing adaptability, including to climate-related challenges?
- How can collaboration between residents and building professionals be supported through a design approach for self-organized housing?
- How can co-creative methods and tools enhance this collaboration and support decision-making during incremental housing development and adaptation?

1.5 Conceptual foundation

This research builds on concepts related to self-organized housing, including housing development, adaptation, and forms of assistance that engage with incremental building processes aimed at enhancing adaptability and resilience. Many approaches to **incremental and assisted self-organized housing** understand dwellings through a temporal lens, linking spatial practices to change over time (Goethert, 2010a; Greene & Rojas, 2008a; Kamalipour & Dovey, 2020; Mota, 2021a; Mukhija, 2014a; Wainer et al., 2016a; Wakely & Riley, 2011a). While incremental development and assisted self-organized housing are discussed in the background section, the specific understanding of temporalities adopted in this research requires further clarification.

In architectural research, **temporalities** emphasize the inseparable relationship between architecture and time, highlighting how spatial practices are shaped by uncertainty, change, and external influences (Banerjee, 2022; Hudson, 2015a; Lall, 2022a; Till, 2009). This often relates to contingency, whereby buildings are affected by unpredictable events and evolving conditions (Bhan, 2017; Lombard, 2013a; Moatasim, 2019; Till, 2009). Temporalities thus frame architecture as an ongoing process rather than a static product. Self-organized housing, like all forms of building, is shaped by these temporalities and continuously evolves through adaptations addressing various considerations.

This research foregrounds architectural temporalities through the concept of **Flows.** Drawing on Stewart Brand's discussion of the temporal dimension of buildings—and his citation of Rina Swentzell's notion of "flow, continual flow, continual change, continual transformation"(Brand, 1995)—the concept recognizes buildings as entities that evolve over time and must accommodate change. Brand argues that all buildings "flow" through time and therefore must be designed to accommodate change.

Here, **Flow** is used as a conceptual metaphor for gradual processes unfolding over time that shape housing development, material transformations, and knowledge exchange. It is articulated across three interconnected dimensions:

1. **Developmental Flows**, referring to the incremental evolution of self-organized housing through building practices and decisions over time.
2. **Material Flows**, referring to the adaptation, repair, replacement, and modification of materials and elements.
3. **Knowledge Flows**, referring to the exchange of knowledge, skills, and experiences that affect decision-making among the various partners involved in housing development and adaptation.

Building on these concepts, the **Designing for a Flow** approach is introduced and developed in this research to explore the potential of such a design approach to support interconnected developmental, material, and knowledge flows.

1.6 Research approach

1.6.1 Researcher Positionality

As a researcher engaging with self-organized housing practices in low-income and hazard-prone contexts, I recognize that my perspective is shaped by my academic training, personal background, and socio-spatial position. This research requires an ongoing awareness of the power dynamics, assumptions, and values I bring into both the field and the interpretation of data.

My participation in this project was shaped by my involvement in the NWO-supported project ***Islanders at the Helm***, which brought together researchers from across the Kingdom of the Netherlands to investigate and co-create sustainable and inclusive solutions for social adaptation to climate challenges in the (Dutch) Caribbean. The project fostered collaboration between societal partners and researchers from a multidisciplinary perspective, emphasizing locally grounded and participatory approaches.

I approach this work as someone trained in Architecture, with a particular interest in the relationship between built form and everyday life. My academic path—shaped by experiences at Wrocław University of Science and Technology, Polytechnic of Turin, and Delft University of Technology—has equipped me with tools to analyse housing from both technical and socio-cultural perspectives. However, I acknowledge that these tools are embedded within institutional and Eurocentric knowledge systems, which may not always resonate with, or fully account for, contextual knowledge systems.

I do not live in the context I study, and my social, economic, and educational privileges differ significantly from those of the residents whose housing I aim to understand. This distance introduces both opportunities and limitations: while I may offer an analytical lens that connects local practices to broader theoretical, design, and policy frameworks, I also risk missing the subtle, embodied dimensions of lived experience. I have made a conscious effort to mitigate this distance by listening attentively, prioritizing resident narratives, building relationships based on trust and mutual respect, and remaining open to critique and learning.

Throughout the research, I also attempted to collaborate with various partners from St. Martin and other Caribbean contexts to the fullest extent that the research timeline and resources allowed, by participating in various research-oriented and cultural activities to deepen my contextual understanding. I actively collaborated with researchers and students from the University of St. Martin, who strongly influenced my research approach and methodological choices towards more collaborative approaches. Moreover, I worked with research assistants who further supported my contextual understanding and assisted during research activities conducted in Spanish. As explained in the foreword, I approached conversations with residents with care, humility, and a genuine willingness to listen and learn from diverse experiences, combining them with my theoretical knowledge.

My interest in self-organized housing stems from personal experience, albeit in a different context from the one I study, shaped by different needs and circumstances. Specifically, I grew up observing a house in Poland that my father and grandfather built incrementally with the help of family and local builders. Watching them construct, repair, and improve the house over time—and seeing the satisfaction and connection it brought—shaped my passion for architecture and my interest in the processes and dynamics of self-constructed homes.

Therefore, this research is motivated by personal interests, and by a desire to view self-organized houses not as a temporary solution but as a legitimate, adaptable, and resilient mode of spatial production, and to understand the processes that unfold during such incremental practices. My positionality has prompted me to advocate for approaches that recognize and value incremental building practices, collaboration, and the relationships built through such approaches.

Throughout the research process, I have engaged in continuous reflexivity—interrogating how my positionality, methods, and representational choices influence the knowledge being produced. I recognize that this thesis is not a neutral account, but rather a situated interpretation shaped by my particular epistemological and personal standpoint.

1.6.2 Research methodology

This research is grounded in a constructivist and advocacy/participatory research paradigm. It draws on constructivism to emphasize that knowledge about self-organized housing is situated, context-dependent, and emergent—arising from residents' experiences and practices—and on the advocacy/participatory paradigm, which emphasizes that the research can benefit from **collaboration**, and use of **methods and tools** that position residents and building professionals as contributors or partners in both the creation of the design approach and the generation of knowledge on adaptable housing solutions (Bereiter, 1994; Creswell, 2009; Guba & Lincoln, 1994; Olusegun, 2015). In this study, the term **"partners"** specifically refers to residents of self-organized housing and building professionals. This combined paradigm influences how the study is framed, determines which approaches and methods are selected, and guides how data are collected, analysed, and interpreted.

The choice of these paradigms also responds to longstanding critiques of research approaches for their limited integration of local contexts and residents into research processes (Abenia, 2024; H. Harriss et al., 2023; Igwe et al., 2022a; Kouritzin & Nakagawa, 2018). Such approaches in architectural research have often failed to recognize the complexity and political context of architectural objects, frequently moving between sites without sustained commitment, prioritizing European discourses and systems of knowledge, and neglecting to credit or compensate people involved in the research (Chami & Ebrahimi, 2025; Reisinger, 2022; Tomer, 2020). Scholars have also pointed to the paradox of intensively studying underrepresented groups while providing limited or no tangible benefit to them (Coelho et al., 2025a; Tuhiwai Smith, 1999). Research approaches and methods that either exclude or, conversely, romanticize or idealize underrepresented groups without acknowledging their real challenges and hardships, are increasingly criticized as extractive—both in the sense of excluding residents and in terms of negative environmental impact (Grima, 2021; Igwe et al., 2022b; Yaneva, 2018) or even reproducing colonial dynamics (Coelho et al., 2025b; Gomez-Barris, 2016; Igwe et al., 2022a; Kouritzin & Nakagawa, 2018)—especially when they produce outcomes that are inaccessible, intangible, or irrelevant to the very groups they claim to serve.

This research aims to mitigate these concerns by employing co-creative and participatory methods that actively involve residents throughout the study, integrate local and contextual knowledge (including materials, practices, and environmental realities relevant to Caribbean self-organized housing), foster sustained community engagement, produce tangible outputs such as a design approach, methods, and tools to directly benefit residents, and explicitly reflect on power dynamics, ethical responsibilities, and potential environmental impacts to reduce extractive practices.

Building on this, the study addresses the challenge of **access to affordable housing** by developing, testing, and assessing **a design approach** that supports incremental development of self-organized housing in hazard-prone Caribbean contexts. Residents have long undertaken incremental construction, adaptations, and repairs themselves, often with limited institutional support. This study builds on these incremental practices and engages key partners to jointly develop and implement a design approach aimed at strengthening the resilience and adaptability of self-organized dwellings. Accordingly, the research sits at the intersection of three key fields:

- **housing studies**, focusing on self-organized housing and incremental construction;
- **adaptable and resilient design**, particularly focusing on the application of circular design principles to improve modification, repairability, and material reuse; and
- **co-creation**, including collaboration between residents and building professionals through co-creative methods and tools, and co-design.

Housing studies provides the foundational lens through which this research examines self-organized housing and incremental construction. Often defined as an interdisciplinary field, housing studies draws on sociology, economics, urban planning, and architecture to understand how housing is produced, accessed, and inhabited across different social and spatial contexts (du Toit et al., 2022; Matthews, 2016; Powell & Simone, 2022). Within this field, a substantial body of scholarship has focused on **self-organized and informal housing** as a primary mode of shelter for low-income residents (Goethert, 2010; Smets et al., 2014; Wakely & Riley, 2011), as discussed in the introduction, with particular relevance to Caribbean contexts where incremental construction has long been shaped by limited institutional support and recurring exposure to natural hazards. This research builds on these insights to understand the existing practices and challenges of residents in the Caribbean, and to develop a design approach grounded in and responsive to those realities.

The study adopts an **interdisciplinary approach**, as a mode of knowledge production, integrating knowledge, concepts, and methods from these three fields to generate new insights (Abevsekera, 2021; Gunawardena et al., 2010). At the same time, it seeks to incorporate **transdisciplinarity** by involving partners from practice as contributors, with the aim of producing academic contributions and bringing science closer to society, reducing implementation gaps (Kim et al., 2022; Regeer et al., 2024). This approach aims to facilitate knowledge exchange on design and construction choices and support the co-development of solutions to climate-related challenges in self-organized housing, aligning with principles of transdisciplinary research (Butt, 2022; Ciesielski et al., 2016; Kim et al., 2022; Thompson Klein et al., 2001). Through this process, it seeks to deliver practical outcomes within the project itself, including increasing design knowledge among partners involved, and contributing to improvements toward more resilient housing development.

From the initial stages of this research, the experiential and situated knowledge of residents was integrated into the process by selecting research methods that facilitate the participation of actors outside academia in knowledge production. This integration of diverse knowledge types is woven throughout the thesis, with particular importance given to the early stages of the research, which influenced the formulation of research problems and objectives, ensuring their grounding in needs identified through engagement with various stakeholders. The institutional framework of this research, including the collaboration with the University of St. Martin, served as an important bridge, connecting the research more closely to the site and its context.

In the initial stages, this was addressed through stakeholder mapping and dialogues regarding housing, building systems, disaster recovery, regulatory frameworks, and climate-related challenges in the built environment. These stakeholders included NGOs active in the aftermath of Hurricane Irma in 2017, architects and built environment experts, public servants, and residents. These conversations were documented through annotated notes and served as an important step in grounding the contextual knowledge of the research. At later stages, the integration of diverse knowledge types was achieved through the collaborative research methods described in the following sections. Through these processes, the research seeks to deliver practical outcomes within the project itself, including increasing design knowledge among partners involved and contributing to improvements toward more resilient housing development.

The research follows the principles of **participatory action research (PAR)**, involving relevant partners in understanding problems they experience and jointly developing actions to address them (Kindon et al., 2007; Wadsworth, 1998). PAR also explicitly addresses power relations by promoting shared decision-making between partners and researchers so that partners become co-researchers, influencing the choice of topics, methods, data collection, and analysis (Baum et al., 2006). Such an approach opposes extractive research that tends to remove data from their context and instead advocates sustained involvement of partners—in this case, residents of self-organized housing—within the context throughout the research process (Baum et al., 2006; Kindon et al., 2007). PAR shares some of its core principles with transdisciplinary research, particularly regarding the involvement of local partners (Regeer et al., 2024; Thompson Klein et al., 2001).

In this study, PAR is implemented through iterative cycles of **planning, action, observation, and reflection** (Figure 1.1) (Orlowski, 2019; Reason & Brandbury, 2008; Wadsworth, 1998). Each cycle involves first understanding the current situation, then planning an action to address it, implementing the action,

TOC

observing its effects, and reflecting on the outcomes before planning the next step. The actions are designed to address specific problems—in this case, supporting incremental housing development—by reflecting on reflect on “what is” and envision “what could be,” and are carried out in close collaboration with the people directly affected (Kemmis, 2006; Wadsworth, 1998).

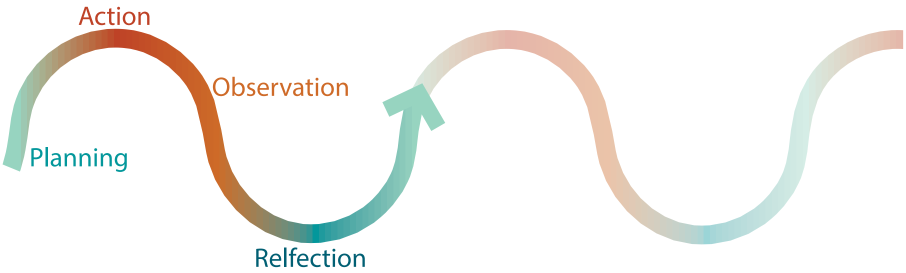

FIG. 1.1 Conceptual diagram of cycles included in Participatory Action Research.

This cyclical approach is intended to enable continuous learning, deepen understanding of the context and self-organized housing challenges, and assess the effects of each action against the study’s objectives, informing subsequent steps. In this research, **“actions”** refer to specific activities undertaken jointly with partners—such as residents and building professionals—in Saint Martin. These activities include workshops, co-design sessions, and other participatory exercises. It is important to note that these actions were conducted in the conceptual stage of developing and testing a design approach; they did not involve real-life design, construction, or adaptation of self-organized housing.

This research implements **participatory methods**. Participatory research and participatory design approaches involve partners throughout the research process—including problem understanding, problem identification, development of research questions, and dissemination of results (Duea et al., 2022; Vaughn & Jacquez, 2020). The extent of involvement in these stages can vary from more passive approaches, such as providing feedback on outcomes, active collaboration in certain phases of research, to community driven initiatives (Almeida & Serra, 2016; Arnstein, 2019; Sanoff, 2000). **Collaborative methods** are a subset of participatory methods that involve a greater depth of engagement. These methods aim to facilitate collaboration with relevant groups or individuals as full partners, building relationships of respect and trust regardless of individual experience or training in science or research (Duea et al., 2022; Woolf et al., 2016). They are grounded in the belief that individual creativity brings meaningful contributions in diverse ways to research (Sanders et al., 2008).

Collaborative methods encompass various practices, including **co-creation**, **co-production**, and **co-design**, which focus on different activities or phases of a project (Brandsen et al., 2018; Dudau et al., 2019; Grindell et al., 2022; Lee, 2008; Sanders et al., 2008). Although these terms are used in diverse ways in the literature (Vargas et al., 2022; Williams et al., 2020), a review by Nguyen et al. (2024) distinguish them as follows: co-creation is an overarching concept that includes both co-production and co-design, focusing on equal cooperation with partners throughout the project; co-production emphasizes involving partners to understand the problem and their perspectives, reflecting diverse needs, whereas co-design involves partners in jointly identifying the problem and participating in designing direct solutions (Nguyen et al., 2024). Therefore, **co-production** produces a shared understanding and knowledge; **co-design** facilitates the development of innovative outcomes that meet the contextual needs of partners; and **co-creation** combines both aspects, producing outcomes of value for the partners that were not known in advance. Given the aim of this research to both understand incremental housing processes and collaboratively develop context-specific solutions, a co-creative approach is particularly appropriate.

In line with this understanding, this research adopts a **co-creative approach**, combining multiple collaborative methods to involve partners throughout the research process. It is structured into **four stages**, each informed by cycles of planning, action through fieldwork activities, observation, and reflection (Figure 1.2). The first stage involved collaborating with partners to analyze challenges related to self-organized housing and formulate an initial framework. The second stage focused on investigating incremental development and adaptation challenges in self-organized houses in St. Martin. The third stage centered on facilitating knowledge exchange and collaborative decision-making on material and design choices. The fourth stage involved co-designing potential housing solutions to enhance the adaptability and resilience of self-organized housing, including the development and testing of a co-design method and tool.

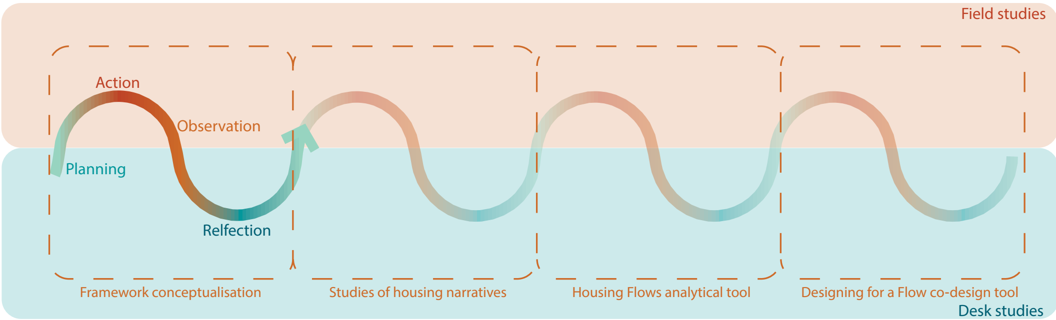

FIG. 1.2 Diagram depicting conceptual approach and consecutive research stages.

1.6.3 Case study: scope and selection

This study uses a participatory action research approach embedded within a **single-case study** of self-organized housing in St. Martin **(Sint Maarten/Saint Martin)**, focusing on several neighbourhoods and diverse groups of residents. Basing the research on a case study enables an in-depth focus in order to understand its complexity and context (Heale & Twycross, 2018; Yin, 2018). In this study, this approach supports an in-depth examination of incremental building practices in hazard-prone Caribbean contexts and supports the co-development and testing of a design approach with residents and professionals.

Such an approach is intended to contribute to the production of context-specific knowledge by focusing on St. Martin Island in the **Caribbean**—an understudied region, particularly in relation to self-organized housing—thus making the literature more inclusive of such contexts. Moreover, the study focuses on residents who are often underrepresented in research, policy discourse, and the design of affordable housing globally and on the island—such as low-income residents (including elderly people, single-parent households, and migrants). This approach also seeks to align with non-extractive research practices by generating knowledge through learning from the housing practices and strategies that people implement both individually and collectively, rather than merely learning about them (H. Harriss et al., 2023; Igwe et al., 2022a; Kouritzin & Nakagawa, 2018), and by taking action to address identified problems together by implementing principles of participatory action research. In addition, it aims to document design knowledge, incremental building practices, and ways to address the challenges related to those aspects, which are context-specific yet may offer potential for adaptation elsewhere.

The choice of St. Martin as the study site has strong practical importance. The island lies within the **Atlantic hurricane belt**, is **seismically active**, and is at risk of intensifying tropical storms and hurricanes, floods, risks of sea-level rises, and heatwaves due to climate change (Abayneh et al., 2019; Kelder et al., 2025a; Medina et al., 2019a; M. A. Mycoo, 2018). Reconstruction efforts after the landfall of Hurricanes Irma and Maria (2017) remain incomplete (Collodi et al., 2021; Der Sarkissian et al., 2021; Jouannic et al., 2020; Mehdizadeh et al., 2023; M. Mycoo, 2020b). Affordable housing programs face challenges both in creating new units for low-income groups and in assisting those groups with rebuilding efforts (M. Mycoo, 2020b; World Bank, 2020). St. Martin also contains a large and diverse stock of self-organized housing located across different neighbourhoods, built incrementally and often through collaborative efforts with local builders, friends, and neighbours—sometimes through a reciprocal process known as “jollification” (Hale, 2015; Lake, 2012; World Bank, 2017). Additionally, English is widely used, as it is one of the official languages in Sint Maarten, which facilitates communication, potential collaborations, and discussions on research outputs between the residents, building professionals, and researchers.

The case study encompasses the island of St. Martin, a small island of 88 km^2 located in northeastern Caribbean (Figure 1.3) (Angell, 2025). The island is divided into northern Collectivité de Saint-Martin, an overseas collectivity of France, and southern Sint Maartin a constituent country of the Kingdom of the Netherlands. St. Martin has a wet-dry tropical climate (Beck et al., 2023), with a dry-warm season from January to April and wet-hot season from August to December, during which hurricanes frequently occur between late June and mid-October (Der Sarkissian et al., 2021; WorldData.info, 2025) (Figure 1.4). The long-lasting effects of Hurricanes Irma and Maria highlight the urgent need for more resilient housing approaches. The island also faces pressing socio-economic challenges, including informal settlements, legal uncertainty in relation to land tenure, and limited access to affordable and safe housing, particularly for low-income households (M. Mycoo, 2020b; World Bank, 2020).

TOC

FIG. 1.3 Map showing St. Martin's location within the Caribbean.

This study focuses on self-organized houses and affordable dwellings located in **various neighbourhoods** across the island. Although the research includes both the northern and southern sides (as self-organized housing practices are similar across the island), the majority of data and organized actions were collected and conducted on the southern side due to the project specific concentration on the Dutch Caribbean, and collaboration with the University of St. Martin, located on Pond Island, Sint Maarten. The study included houses located in neighbourhoods where affordable or self-organized housing is commonly found, such as Belvedere, French Quarter, Dutch Quarter, Middle Region, Pond Island, Cole Bay, Mary's Fancy, Sucker Garden, Hope Estate, Philipsburg, Union Farm, and Concordia.

Fernand: August 20-28, 2025

Wind speed:	max. 52 km/h	Most Affected Cities:
on land:	max. 46 km/h	Marigot
Diameter:	max. 611 km	
Air pressure:	below 1000 mbar	
Saffir-Simpson scale:	tropical depression	

Erin: August 8-23, 2025

Wind speed:	max. 259 km/h	Most Affected Cities:
on land:	max. 519 km	Marigot
Eye:	max. 30 km	
Air pressure:	below 915 mbar	
Saffir-Simpson scale:	category 5	

Ernesto: August 9-20, 2024

Region:	Caribbean Sea	Most Affected Cities:
Wind speed:	max. 120 km/h	Marigot
on land:	max. 102 km/h	
Diameter:	max. 419 km	
Air pressure:	below 967 mbar	
Saffir-Simpson scale:	category 1	

Beryl: June 26 to July 11, 2024

Region:	Caribbean Sea	The hurricane did not make direct landfall in Saint Martin. On July 1st, 2024 at 11:00 pm it had the shortest distance at about 346 km southwest of Marigot. Instead, the first landfall occurred near Gouyave in Grenada on July 1st at 5:00 pm.
Wind speed:	max. 269 km/h	
Diameter:	max. 382 km	
Eye:	max. 30 km	
Air pressure:	below 934 mbar	
Saffir-Simpson scale:	category 5	

Tammy: October 20-31, 2023

Region:	Caribbean Sea	Most Affected Cities
Wind speed:	max. 148 km/h	Marigot
Diameter:	max. 315 km	
Air pressure:	below 965 mbar	
Saffir-Simpson scale:	category 1	

Tammy: October 10-29, 2023

Region:	Caribbean Sea	Most Affected Cities
Wind speed:	max. 139 km/h	Marigot
Diameter:	max. 482 km	
Air pressure:	below 965 mbar	
Saffir-Simpson scale:	category 1	

Philippe: September 20 to October 6, 2023

Region:	Caribbean Sea	Most Affected Cities
Wind speed:	max. 83 km/h	Marigot
Diameter:	max. 667 km	
Air pressure:	below 998 mbar	
Saffir-Simpson scale:	tropical storm	

Lee: September 5-18, 2023

Wind speed:	max. 194 km/h	The hurricane did not make direct landfall in Saint Martin. On September 10th, 2023 at 2:00 pm it had the shortest distance at about 216 km north of Marigot.
Diameter:	max. 530 km	
Air pressure:	below 926 mbar	
Saffir-Simpson scale:	category 3	

Lee: September 1-17, 2023

Wind speed:	max. 194 km/h	The hurricane did not make direct landfall in Saint Martin. On September 10th, 2023 at 2:00 pm it had the shortest distance at about 216 km north of Marigot.
Diameter:	max. 530 km	
Air pressure:	below 926 mbar	
Saffir-Simpson scale:	category 3	

Franklin: August 19-29, 2023

Region:	Caribbean Sea	The hurricane did not make direct landfall in Saint Martin. On August 20th, 2023 at 5:00 am it had the shortest distance at about 213 km south of Marigot. Instead, the first landfall occurred near Güiria in Venezuela on August 19th at 8:00 pm.
Wind speed:	max. 111 km/h	
Diameter:	max. 593 km	
Air pressure:	below 926 mbar	
Saffir-Simpson scale:	tropical storm	

Franklin: August 18 to September 1, 2023

Region:	Caribbean Sea	The hurricane did not make direct landfall in Saint Martin. On August 20th, 2023 at 8:00 am it had the shortest distance at about 186 km southwest of Marigot. Instead, the first landfall occurred near Scarborough in Trinidad and Tobago on August 19th at 8:00 pm.
Wind speed:	max. 111 km/h	
Diameter:	max. 630 km	
Air pressure:	below 926 mbar	
Saffir-Simpson scale:	tropical storm	

FIG. 1.4 Hurricanes, tropical storms, and tropical depressions that impacted St. Martin between August 2023 and August 2025. [Information retracted from (WorldData.info, 2025).]

TOC

Limited housing accessibility on St. Martin results from a combination of geographical, political, legal, socio-economic, and climate-related factors (World Bank, 2020). As a small island, access to construction materials is limited, and their cost is high due to import fees—further driving up development expenses. Much of the new construction, especially in coastal areas, is geared toward tourism, including hotels and luxury villas intended for high-income buyers (Abayneh et al., 2019; Der Sarkissian et al., 2021). At the same time, **access to social or affordable housing remains limited and insufficient**, leaving many low- and middle-income residents without viable housing options.

The island's hilly topography makes flat, buildable land scarce, often concentrated near the coast (Figure 1.5). Building on slopes is more expensive due to the need for excavation and stabilization. At the same time, the legacy of colonialism continues to shape land governance (Roitman & Veenendaal, 2016). Large portions of land remain under the ownership of a few families, and unresolved land issues limit access to mortgages, loans, and insurance for many residents.

FIG. 1.5 View of St. Martin illustrating the island's topography and patterns of housing concentration, particularly along coastal and low-lying areas.

TOC

Rising real-estate prices, driven by tourism and foreign investment, are increasing land and housing costs and placing homeownership out of reach for many residents. Despite relatively modest wages, the island's reputation for economic opportunity and safety continues to attract migrants from neighbouring islands (Collodi et al., 2021), with a report indicating that around 70% of the population on the southern side consists of migrants (Van Vuuren et al., 2022). Many people work in the informal economy due to legal and administrative restrictions that limit opportunities for formal employment or access to affordable housing programmes, which often exposes them to exploitative working conditions. Moreover, many of the residents **receive limited income**—in the southern part of the island, approximately 25% of households report incomes below 80% of the minimum wage (Nationale Ombudsman, 2020).

Although information on luxury real-estate and investment opportunities is widely available online, reliable, up-to-date data on housing provision for low- and middle-income families and on reconstruction progress is scarce or difficult to access. One of the few available reports for the southern side estimated a need for 7,000 additional houses between 2012 and 2020—more than 500 units per year for low- and middle-income residents (Royal Haskoning DHV, 2016). The **large-scale devastation of Hurricane Irma** (2017) halted many housing projects and further increased housing needs, which is reflected in the sharp rise in social-housing applications from 1,500 to 9,000 in 2017 (World Bank, 2017, 2019, 2020).

During Hurricane Irma, an estimated 70–85% of the southern side's approximately 19,400 homes sustained damage, and insurers received about 6,100 claims (World Bank, 2020). The majority of homes were uninsured owing to legal tenure issues, unresolved land disputes, unaffordable premiums, or homeowners' choices. Even under an optimistic scenario in which all accepted claims are repaired, an estimated 7,500 houses would remain to be repaired—nearly 40% of the housing stock.

Emergency and recovery support came from organisations such as the Red Cross, White and Yellow Cross Car Foundation, Salvation Army, other international agencies (Collodi et al., 2021), and the National Recovery Project Bureau (NRPB) which was established on the island to facilitate post-hurricane recovery. Nevertheless, updates on rebuilding efforts remain limited. According to available NRPB data, by 2022—five years after the hurricane—445 houses out of more than 510 dwellings targeted by the program had been rebuilt (Sint Maarten Trust Fund Secretariat Caribbean Country Management Unit Latin America and Caribbean Region World Bank, 2022). Even when including contributions from other agencies, a substantial gap still persists between housing needs and completed repairs. Consequently, many residents have had to seek alternative accommodation or undertake reconstruction themselves. (Further information on affordable housing is provided in Chapter 2, Section 4.)

In this complex context, affordable housing developments are scarce, the available units frequently fail to meet the needs of residents, and formal rebuilding efforts often fail to meet demand. In response, many residents rely on self-organized housing constructed through incremental building practices and adapted and repaired over time though joint efforts involving friends, family, and local builders (Figure 1.6). These housing approaches emerge due to necessity and under considerable constraints, reflecting both the systemic challenges and the ingenuity of residents navigating limited resources, insecure tenure, and environmental risks. Taken together, these conditions underscore the urgent need to enhance the adaptability and resilience of self-organized housing in St. Martin.

FIG. 1.6 Photograph showing housing developments in a lower-income neighbourhood near Illidge Road, St. Martin.

1.6.4 Research design and methods

This research adopts a qualitative approach. Data are collected in the settings of the research partners using approaches such as ethnographic study, interviews, and co-design sessions. The research is conducted in close collaboration with partners, including residents of self-organized housing and building professionals. Researchers from the University of St. Martin support the project by helping to identify and connect with further participants. At every stage, the research seeks to enhance collaboration through designed activities. Participants are recruited through diverse networks and community connections to ensure representation across neighbourhoods and under-represented groups such as low-income households, elderly residents, single-parent households, and migrants.

The study is structured into four iterative cycles, each building on and informing the next.

Stage 1 – Analysing challenges and formulating a design framework

The first stage focuses on analysing challenges related to self-organized housing. It includes a review of literature on affordable and self-organized housing, incremental building practices, and resilient and circular design principles. This is combined with ethnographic fieldwork in St. Martin to identify and document self-organized housing practices through observation, photography, field notes, and conversations with residents and building professionals guiding identification and prioritization of the problem and possible solution. The findings are reflected to plan the next stage.

Stage 2 – Investigating self-organized housing practices

The second stage concentrates on investigating resilience and adaptation practices in self-organized houses. Literature on housing in climate-vulnerable regions informs this stage. Data is collected through ethnographic studies, semi-structured interviews, and photographic documentation. Around 30 interviews with residents of both the northern and southern sides of St. Martin are conducted to jointly document and discuss existing solutions. This stage also develops a classification of housing types based on main construction materials, documenting the trajectory of houses from initial construction to current state, planned modifications, and hazard-related repairs.

TOC

Stage 3 – Developing and testing a collaborative method and tool

The third stage develops and tests a collaborative method and tool, building upon the design approach. Literature on collaborative methods and tools informs the design of a cards meant to facilitate knowledge exchange between residents and building professionals. Data is collected through co-creative sessions with residents in their housing contexts and group workshops with building professionals. These sessions document choices regarding materials and design, as well as participants' reflections on those choices. Feedback from these sessions is used to refine the tool and inform the next cycle.

Stage 4 – Co-designing housing solutions

The fourth stage focuses on co-designing possible future housing solutions. Preparation includes a literature review on co-design and collaborative housing practices, and development of a tool based on the design approach. Co-design sessions with residents and professionals guide participants through a collaborative process to develop and reflect upon possible future housing solutions and to test and refine the tool and its potential to improve adaptability and resilience. Data is collected on design and material choices, as well as the results of the design sessions, and reflections about the process. Outcomes from this stage feed back into the tool, method, and design approach.

Together, these four stages are designed to engage with both theoretical and practical dimensions, producing tools and insights intended to develop a design approach that integrates residents' incremental practices, circular design principles, and co-creative methods to strengthen the resilience and adaptability of self-organized housing in hazard-prone Caribbean contexts, building on the case study of St. Martin.

1.6.5 Contributions

This thesis develops and applies the **Designing for a Flow** approach, which integrates residents' incremental building practices with circular design principles through co-creative approaches. The approach conceptualizes self-organized homes as a dynamic process shaped by **flows of development, materials, and knowledge over time**. It aims to offer structured guidance that brings together principles, methods, and tools to support the design of self-organized housing.

Through the process of development of the design approach, the research opts to generate several contributions. Empirically, it aims to provide new evidence on how residents in hazard-prone Caribbean contexts, such as St. Martin, incrementally build, adapt, and maintain their dwellings to cope with hazards, and to document under-researched practices at the intersection of self-organized housing, climate risks, and circular design principles. Conceptually, it proposes an approach to operationalize resilience and adaptability within self-organized housing in St. Martin. It also advances housing theory by linking incremental building practices with **circular design principles** and **co-creative methods**, extending existing approaches to participatory housing design and assisted self-organized housing.

Methodologically, the research aims to demonstrate how **collaborative approaches**—through co-creative sessions, co-design workshops, and collaborative tools—can be adapted to low-income, hazard-prone contexts. It opts to offer a replicable research process for integrating resident knowledge with professional expertise in the co-development of housing design. Practically, the research aims to produce actionable tools and guidelines, that local governments, NGOs, and practitioners can use to support self-organized housing design in hazard-prone regions, and to inform policy discussions on upgrading, climate adaptation, and resilience in the Caribbean and other similar contexts.

Together, these contributions position self-organized housing not as a finished product but as an ongoing process and aim to demonstrate how collaborative approaches and circular design principles can strengthen the resilience and adaptability of housing in hazard-prone contexts.

1.6.6 Limitations, declarations, and funding

This thesis has several limitations, shaped by the specificities of its context, scope, and methodological approach.

First, the findings are situated within the particular socio-political and environmental context of St. Martin—a small island with a complex colonial legacy, dual governance structures, distinctive housing systems, and acute climate-related vulnerabilities. These conditions have significantly influenced the research, shaping access to data and participants as well as the feasibility of sustained collaboration. While the design approach, methods, and tools developed through this research offer transferable principles for other hazard-prone and resource-constrained contexts, the specific housing practices, economic situation, and socio-cultural dynamic limit their direct generalizability, particularly in terms of specific design and building materials choices which are context-dependent. The study therefore provides context-specific insights and a replicable process rather than universally applicable prescriptions.

Second, the scale and scope of the study imposed constraints on representativeness. Conducted within a defined period and focused on selected neighbourhoods, the research engaged a limited number of participants. While the process aimed for inclusivity, certain groups—such as undocumented individuals, or temporary residents, —were underrepresented in some of the participatory activities. This was both due to preference of individuals and deliberate efforts to minimize risk for those most vulnerable. Nevertheless, their limited presence inevitably shaped the perspectives reflected in the co-creation process and may affect the inclusivity of the findings.

The multi- and transdisciplinary approach of the project created valuable opportunities for integrating academic, professional, and situated knowledge. However, it also presented institutional and logistical challenges. Building trust and fostering collaboration across disciplines and sectors required time and proactive efforts over time—both of which sometimes exceeded the scope of this research. Although the context and the collaboration with partners were a crucial aspect of this study, in line with PAR principles, the research could have included additional stage of collaboration, such as involving partners to a greater extend in commenting on the academic outcomes of each stage and on the products of those initiatives. This proved difficult in practice due to physical and logistical constrains. Institutional constraints such as funding cycles, ethics protocols, and academic timelines sometimes conflicted with the pace and rhythms of local collaboration, limiting continuity and deeper engagement.

Likewise, the use of participatory and co-creative methods—while central to this research—was shaped by practical limitations. Language barriers, differing levels of familiarity with design tools, time constraints, and existing power dynamics all influenced the depth of engagement. For instance, formal stakeholders at times expressed reluctance to participate in activities alongside students or residents, revealing underlying hierarchies that reflect broader social dynamics on the island. These challenges emphasize the need to interpret co-designed outputs as contextual and situated, rather than definitive or universally transferable.

Finally, these limitations are inseparable from the positionality of the researcher, who operated at the intersection of designer, academic, and participant in a larger research group. This positionality shaped the framing of research questions, engagement strategies, and interpretation of results, as well as the ability to respond to shifting conditions in the field.

Despite these limitations, the research offers meaningful insights into how resilient and adaptable housing design approaches can be explored in contexts of socio-environmental challenges. It underscores the value of co-creative approaches while pointing to the necessity of sustained, ethically engaged, and reflexive research practices.

This research is a part of a research program titled Island(er)s at the Helm: Co-creating Sustainable and Inclusive Solutions for Social Adaptation to Climate Challenges in the (Dutch) Caribbean, which is supported by funding from The Dutch Research Council (NWO), file number NWOCA.2019.021. It is important to note that this funding institution did not play a role in the design of the research or the writing of this thesis. The analysis and conclusions expressed in this dissertation are the results of an independent academic research and do not necessarily represent the perspectives of the funding organization.

The research has been approved by the Human Research Ethics Committee at TU Delft ethics committee with the reference number 3389.

During the preparation of this work the author(s) used Grammarly and ChatGPT in order to refine and improve the writing. After using these tools, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published research.

1.7 Thesis structure

This dissertation follows an article-based structure. Chapters 2, 3, 4, and 5 each present one of four studies prepared as peer-reviewed scientific articles (published or under review).

Chapter 2 introduces and develops the initial "Designing for a Flow" framework, which combines residents' incremental building practices with circular building principles, building on the concept of designing with layers to enhance the adaptability of self-organized housing in hazard-prone Caribbean contexts.

Chapter 3 provides broader contextual information regarding affordable and self-organized housing in St. Martin by documenting and analysing residents' incremental building, adaptation, and maintenance practices, and by presenting diverse dwelling types, material choices, and adaptations that address various challenges, changing needs, and climate-related risks.

Chapter 4 investigates ways to strengthen knowledge exchange and collaborative decision-making between residents and building professionals on design and material choices through co-creative citizen science and the development and testing of a card-based tool.

Chapter 5 explores the potential of co-design to support adaptable and resilient housing through the development and testing of a gamified card-based tool, offering insights into the tool's development, application, and reflections on its implementation.

The final chapter summarizes the studies by drawing together the conclusions, addressing the research gap and questions, and reflecting on the key findings and contributions.

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2 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.

2.1 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 (Kellett & Napier, 1995; Smets et al., 2014). In fact, most of the world's dwelling delivery is organized in this way, including housing on various Caribbean Islands (McTarnaghan et al., 2016; M. Mycoo, 2020). These units are typically small, standalone structures, that are built by households with limited professional support (Goldwyn et al., 2021; Meredith Lochhead et al., 2022). 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 (Prevatt et al., 2010). 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 (Pimentel Walker & Arquero de Alarcón, 2018; Wakely & Riley, 2011). 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 (Doberstein & Stager, 2013; Schilderman & Lyons, 2011). It includes, for instance, steep hillsides, flood-prone areas, sites near landfills, and railway or road reserves (Dangol & Carrasco, 2019; Usamah et al., 2014). Building in such locations increases the risks of being affected by hazardous events and requires additional adaptations during construction to ensure the households' safety (Marques & Saraiva, 2017).

Self-organized housing often develops incrementally, becoming an ever-ongoing, gradual process driven by individual resources and needs (Nielsen, 2016). It can begin with the development of a small unit using temporary materials to reduce costs (Celentano & Habert, 2021; Cronin & Guthrie, 2010). Limiting the expenses can also be achieved by using fewer materials or replacing them with lower-quality alternatives (Rodgers, 2012). Over the years, the house may undergo modifications, adaptations, or enhancements based on the owner's needs, preferences, and specific

TOC

site conditions. Those changes happen when the household gathers sufficient funds or construction materials, allowing the building process to continue (Feliciano et al., 2022). The houses are constructed with diverse materials and building techniques often without complying with building regulations (UN-Habitat, 2008).

Although self-organized housing often lacks planning and has technical shortcomings (Kowaltowski et al., 2005), 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 (Goethert, 2010). 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 (Mota, 2021) by mimicking how self-organized houses are developed (Goethert, 2010). 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 (Wakely & Riley, 2011).

2.2 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 (Kowaltowski et al., 2005). 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'' (Turner, 1972). Nowadays, both the housing form (product) and the process are considered crucial components in dwelling assistance (Mota, 2021). By supporting residents in developing incremental housing that enhances safety, comfort, and overall experience, architects can contribute to the process of self-organized housing.

TOC

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 (J. Till, 2013), 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 ***aesthetic appeal*** (Venustas) (Vitruvius, 1999). To provide a better understanding of Vitruvius's ideas in the context of modern architecture, Guyer supported them with a series of questions (Guyer, 2021) (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, aesthetic 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 aesthetic 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 (Bhan, 2017; Lombard, 2013; Moatasim, 2019; J. Till, 2007, 2009; K. E. Till, 2012), 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 (Archer, 2016; Barakat, 2003; Barenstein, 2006; De Bruijn, 2005; Elkharboutly & Wilkinson, 2022; Mitlin, 2011; Schilderman & Lyons, 2011; Twigg, 2021). In many designs, durability is addressed through structural resistance and integrity, ensuring the ability to withstand risks without making irreversible changes to relevant characteristics (De Bruijn, 2005). 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 (Elkharboutly & Wilkinson, 2022; Twigg, 2021). The consequences of such choices become apparent in the long run, impacting the ability to maintain

TOC

and repair the units, which is crucial for ensuring structural safety over time (Barenstein, 2006). 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 (Barakat, 2003; van Leersum & Arora, 2011).

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 stand the test of time (Delgado & Antipova, 2010; Kamalipour & Dovey, 2020; Marinovic, 2020; Mota, 2021; Napier, 2005; Wainer et al., 2016). 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 (R. Askar et al., 2019; Carrasco & Brien, 2022; O'Brien & Carrasco, 2021). 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 ***aesthetic appeal*** are rarely encountered in the context of housing design in low-income and hazard-prone areas. Even though aesthetic appeal extends beyond physical and material aspects to include culture, social relations, and individual expression (Kellett & Napier, 1995; Kowaltowski, 1998), it is frequently given a lower priority to the debates on durability and functionality. If aesthetics are taken into account, the focus typically lies in customizing provided units, allowing for minor modifications such as colors, ornaments, or external elevations (Marinovic, 2020).

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 and aesthetically 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? And how would the house accommodate an income-generating activity? Additionally, how does the aesthetic of the house get 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 aesthetic 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 aesthetic 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 aesthetic 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 (Brand, 1995), 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 aesthetic 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 key findings into conclusive insights (section 10).

2.3 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 (Singh, 2007), emphasizing the testing and refinement of conceptual ideas before 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 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 (Whitehead, 2005), 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 temporal considerations in relation to the durability, functionality, and aesthetic 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 review, fieldwork, ethnographic studies, and iterative approaches to comprehensively investigate 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".

2.4 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 (Hofman et al., 2021). 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 (M. A. Mycoo, 2018). 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 (Caribbean Community Climate Change Centre (CCCCC), 2009; Douglass & Cooper, 2020). In 2017, 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 (Hofman et al., 2021; Prevatt et al., 2010; UN Habitat, 2011). 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 (Prevatt et al., 2010).

St. Martin Island (Figure 2.1) 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 made it unaffordable for low-income households, leaving many of the residents without assistance (Collodi et al., 2021; World Bank, 2020). The last hurricanes that made landfall in 2017 caused life loss and large damage to the dwellings on the island. Even though most of the houses were (re)built in the aftermath of 4th-category Hurricane Louis (1995) to withstand similar risks (Medina et al., 2019), the World Bank estimated that Irma and Maria damaged around 70-80% of residential buildings (World Bank, 2020). Since then a lot of houses were repaired or rebuilt, but many households living in self-organized housing did not qualify for housing support (Collodi et al., 2021; World Bank, 2020).

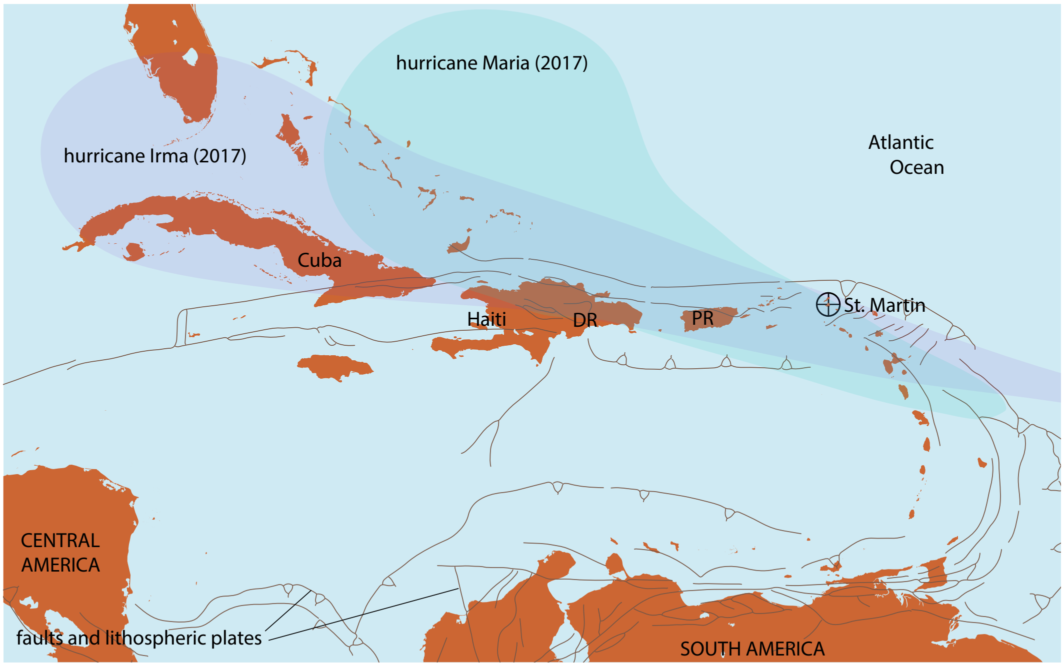

FIG. 2.1 Map of Caribbean Islands indicating St. Martin Island. *[Source: Adapted from: Free Vector Maps (Free Vector Maps, n.d.); faults and lithospheric plates (Muhs et al., 2017) (p. 21); the approximate path of hurricane Irma (National Hurricane Centre)]*

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 (World Bank, 2020). After Irma, the demand for social housing grew rapidly, increasing the number of applicants from 1,500 to more than 9,000 (almost 25% of the population); however, a large part of the applicants did not meet the aid requirements (World Bank, 2020). The reasons for increased social housing demand include a large scale of damage caused by poor structural quality of housing cyclically impacted by tropical storms (Medina et al., 2019).

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 (World Bank, 2020) (Figure 2.2). These residential units belong to low-income households, which include recent migrant families and people who are not registered as residents of St. Martin (World Bank, 2020). The majority of the units are self-organized and have inadequate access to basic infrastructure, such as electricity, water supply and sewage (World Bank, 2020). Additionally, they are often positioned in high-risk locations, and the housing lacks structural qualities adequate to the risks (M. Mycoo, 2020). Those units are primarily single-standing houses, clustered in few different districts of the islands.

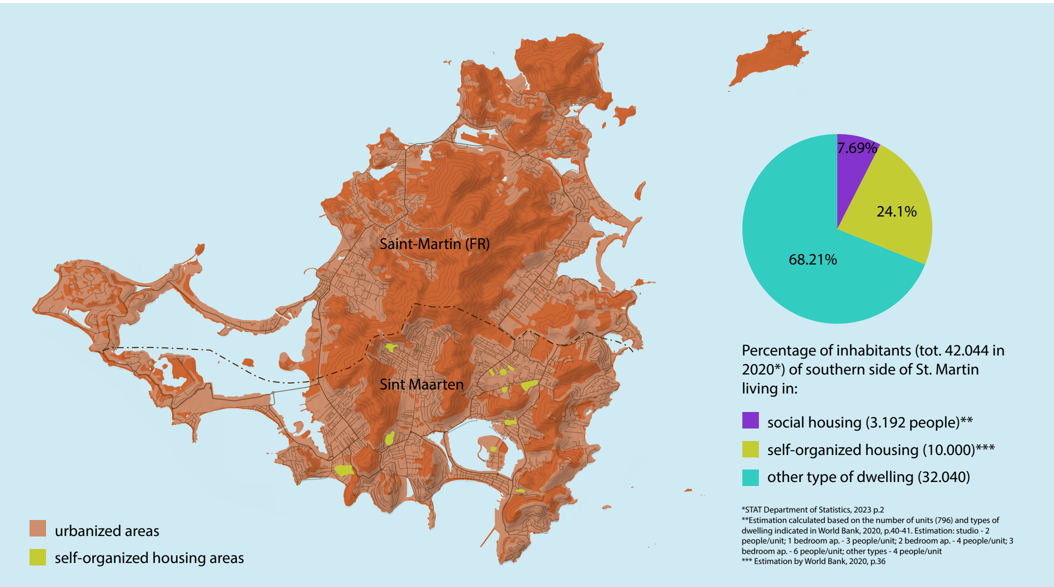

FIG. 2.2 Map of St. Martin Island indicating urbanized areas and self-organized housing areas with a diagram presenting the percentage of inhabitants of the southern side living in various types of dwelling. *[Source: Adapted from: map (Open Street Map)]*

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 2.3 A), 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 light balloon-frame construction, as in the Caribbean vernacular style (Figure 2.3 B). 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 Luis in 1995. Individuals have modified and adapted these houses over the years (Figure 2.3 C). The most common type of self-organized housing is constructed using concrete blocks (Figure 2.3 D). These houses are built incrementally, with rooms added around the initial 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.

FIG. 2.3 Impressions of different types of self-organized housing on St. Martin.

2.5 “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 (Twigg et al., 2017). Unfortunately, design practitioners often fail to consider the **contingency and unpredictable forces** that will inevitably change the designs over time (J. Till, 2013). 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 (Brand, 1995). Moreover, ‘’ALL BUILDINGS are predictions. All predictions are wrong’’ (Brand, 1995) (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* (Brand, 1995), 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 (Brand, 1995). 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 (Estaji, 2017). He puts this concept forward, building on the work of Frank Duffy, who was a theorist of **layers of change** (Duffy, 1990). These ‘’shearing layers of change’’ are organized based on their durability, noting that the longer-lasting ones have a greater influence on the ones that do not last as long (Brand, 1995) (p. 47). The order of these **layers is the site, structure, skin, services, space plan, and stuff** (Figure 2.4). This approach addresses each building layer individually, according to its lifespan length.

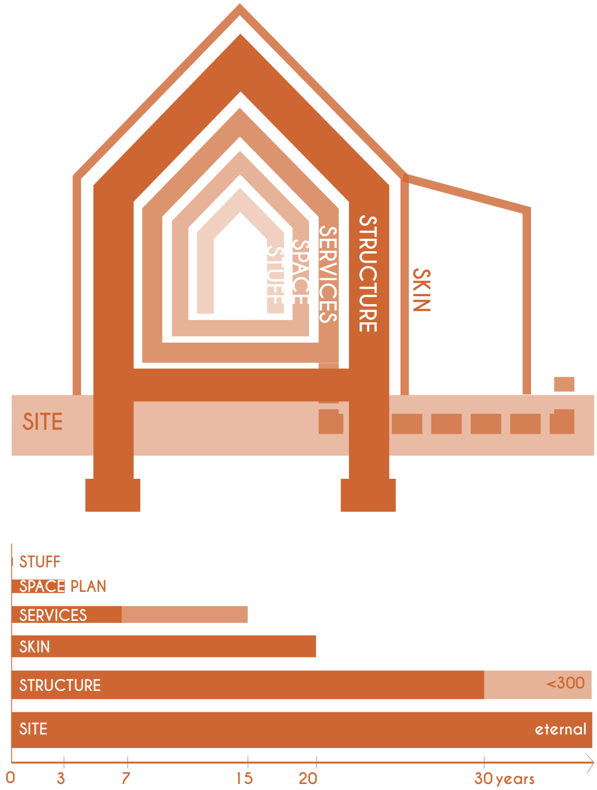

FIG. 2.4 Shearing layers diagram. *[Source: Adapted from (Brand, 1995) (p. 38).]*

Brand defined the layers and their expected durability in relation to their function (Brand, 1995) (p. 38). He considers ''site'' as eternal, regardless of the challenges it may encounter. It is followed by ''structure'', related to structural elements and dated to last between 30 to even 300 years. The third category is ''skin'', describing exterior surfaces that last up to 20 years. The next one is ''services'', including wiring, and piping, and also communication, dated for 7 to 15 years. ''Space plan'' referring to interior layout and partitions comes next. Brand suggests that they usually change around every 3 years, besides the case of ''exceptionally quiet homes'' where it may remain the same for up to 30 years. The last layer is ''stuff'' that 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 (Duffy, 1990). It facilitates making changes, replacements, and repairs of building. It also helps to determine accountabilities within the building by using the layers to define the boundaries of user interventions and responsibilities (Duffy, 1990). 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 impact, it is often implemented in various sustainable design strategies, including Circular Economy (Rand Askar et al., 2021). Applying this concept to housing design in low-income and hazard-prone contexts could help incorporate time aspects into design considerations.

2.6 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’’ (Brand, 1995) (p. 24) noting that ‘’[h]omes are the domain of slowly shifting fantasies and rapidly shifting needs.’’ (Brand, 1995) (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 (Brand, 1995) (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. 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 (Wakely & Riley, 2011). The house-building is commonly an incremental process (Goethert, 2010), based on the dynamic and productive efforts of residents (Lombard, 2013).

Moreover, Brand’s proposal suggests that all layers of a building start their life cycle at the same time - during the building’s development (Brand, 1995). After this, each layer continues its life in a linear form (Figure 2.4), with its longevity depending on

TOC

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 (Bredenoord et al., 2014a) and reuse materials (Maynard et al., 2017). 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.

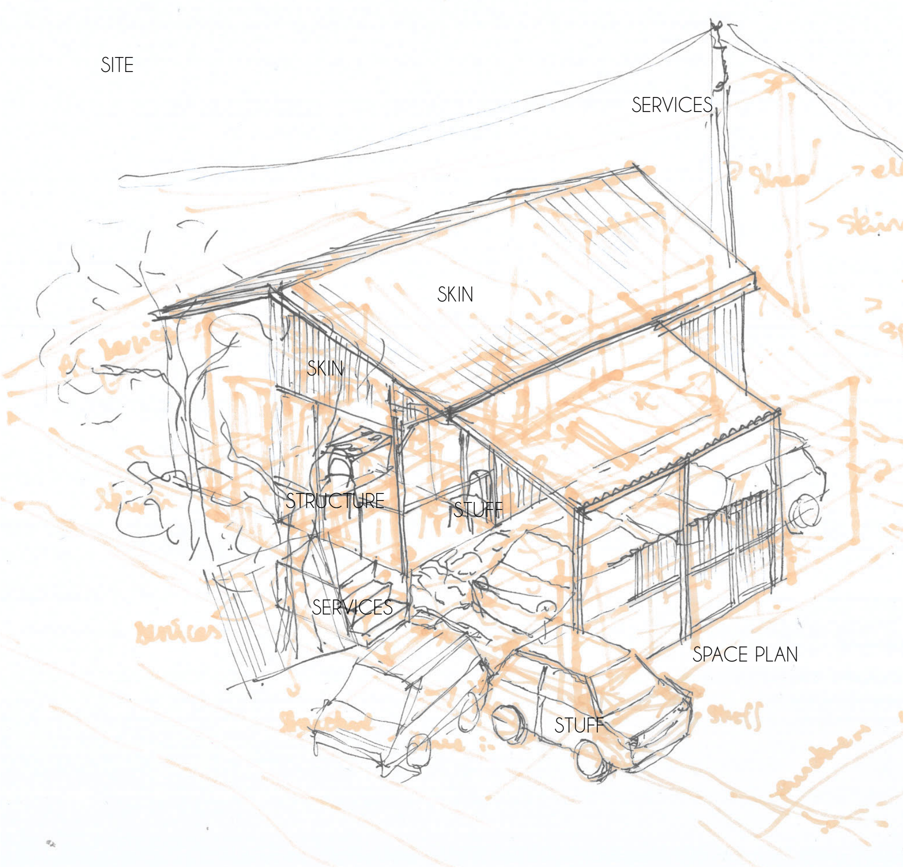

FIG. 2.5 Sketch of an example of self-organized housing on St. Martin.

Accessing the site is often the first step in the development of self-organized housing (Greene & Rojas, 2008). The *site* is also the most long-lasting layer in Brand's hierarchy, and the changes to this layer affect all the other layers (Brand, 1995). 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 (Kowaltowski et al., 2005).

After getting 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 (Goethert, 2010). It starts with ***structure***, which pertains to load-bearing elements like foundations, columns, walls, or slabs (Brand, 1995). 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 aesthetic 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.

2.7 Housing Considerations and Layers of Change

2.7.1 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 buildings' ability to weather various hazards (Parrack et al., 2014). 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 durability of a unit are site, structure and skin (Figure 2.6).

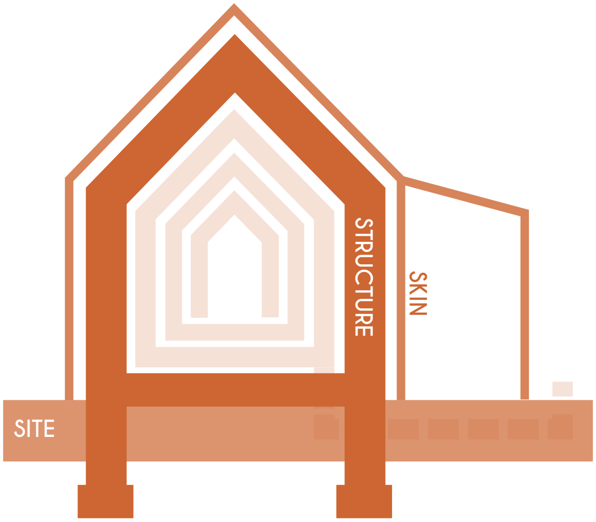

FIG. 2.6 Layers related to durability.

Changing environmental factors can influence durability. Depending on the **site**, it can be compromised because of climatic, geographical, environmental, and other challenges (Douglass & Cooper, 2020; Gibbs, 1994; Prevatt et al., 2010). 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 implications of climate change. Hurricanes are examples of compound risks, as they may cause significant wind speeds, torrential rains, storm surges, flooding (Prevatt et al., 2010), 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 (Gibbs, 1994; Indrianingrum et al., 2019).

The durability of housing in high-risk areas largely depends on the structural characteristics. The **structure** is the first layer that gets built, and it is characterized by form, building technique, and type and quality of materials (Gibbs, 1994; Meredith Lochhead et al., 2022). In the Caribbeans, the structures of self-organized units are most commonly erected using preexisting cores, poured concrete, concrete blocks, and timber (Figure 2.7). 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 (Murray et al., 2023; World Bank, 2020). It is related to the households' perception that concrete structures are more durable against hurricanes and wooden structures as safer against earthquakes (Murray et al., 2023).

They make the design and construction decisions based on risk perception, available resources, and individual building knowledge and skills (Goldwyn et al., 2021). 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 (Meredith Lochhead et al., 2022; Rodgers, 2012). This process also leads to building with lower quality or homemade materials (Rodgers, 2012), making it challenging to assess the durability of the structures based on material types.

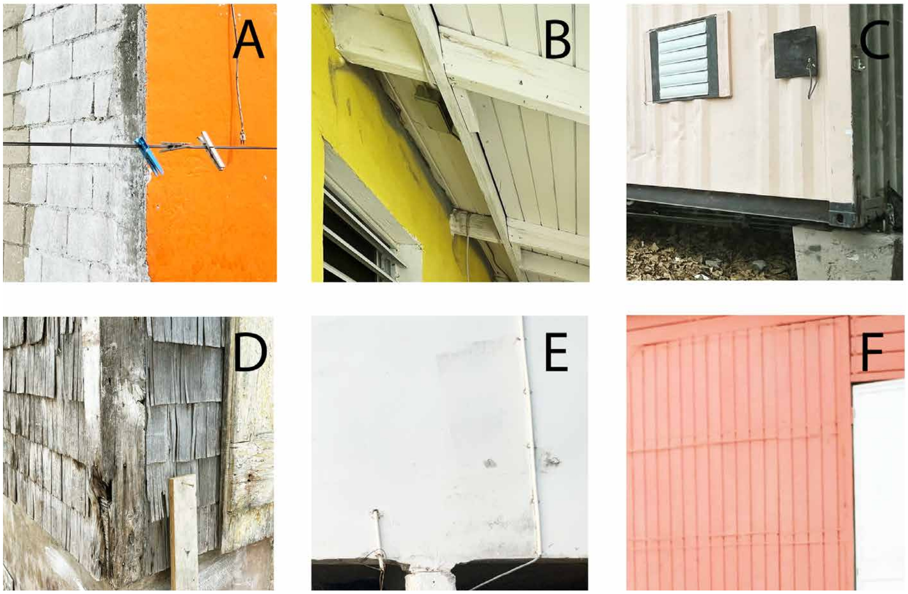

FIG. 2.7 Building materials used for structure: (A) concrete blocks; (B) concrete wall and timber rafters; (C) container on poured concrete pillar. Materials used for skin: (D) wooden shingles; (E) cement; (F) wooden cladding.

The durability can be affected in several ways. Households may modify and expand the units over time, which can weaken the structure (Goldwyn et al., 2021). 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 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 done by households themselves or with the help of skilled local builders (Archer, 2016; Harriss et al., 2020). The required maintenance depends on the materials used in construction and implemented building techniques. For example, wood must be protected against water and insects (Indrianingrum et al., 2019; M Lochhead et al., 2022). 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 (Barenstein, 2006; Twigg, 2021).

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 (Goldwyn et al., 2022; Osborne et al., 1992; Prevatt, 1994). The durability of self-organized houses varies, depending on the type and strength of the event, site characteristics, and building features (Goldwyn et al., 2022). If damages occur, most households fix or rebuild the units themselves using their resources and help from neighbors, friends, and family members (Goldwyn et al., 2021; Twigg et al., 2017). This is often an incremental process, and includes reusing undamaged building elements to reduce costs (Maynard et al., 2017; Parrack et al., 2014). While the majority of the households rebuild in the same way as before the hazard (Hendriks et al., 2018), some households implement modifications to prevent the damages. Those modifications often mimic formal solutions or practices applied in units that were undamaged during the hazard. Some of those practices tend to repeat unsafe building practices, often due to not considering the changing circumstances between cases (Rodgers, 2012). As noted by Venable, the most common modifications are strengthening the roof and reinforcing the walls (Venable et al., 2021). These modifications only focus on individual elements and do not consider the relationships between them (Venable et al., 2021). 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 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. 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 (Gibbs, 1994; Prevatt et al., 2018). Similarly, if any element of the skin, like door handles or shingles, gets ripped off, it may affect other parts of the building or damage other houses (Prevatt et al., 2018). If the skin of the building is compromised, the structure and other layers may be affected by secondary damage.

2.7.2 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.

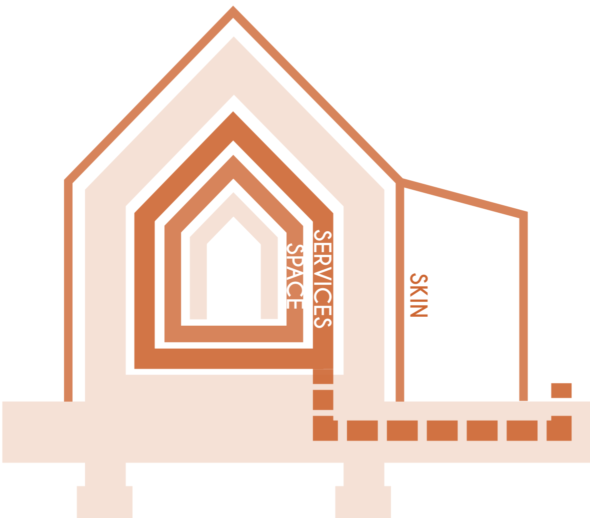

FIG. 2.8 Layers related to functionality.

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'' (Guyer, 2021). 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 (Brand, 1995). 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 (J. Till, 2007). 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.'' (Boudon, 1979; J. Till, 2007).

The space plan of the self-organized houses changes gradually. What contributes to answering to 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 (Goethert, 2010) or an extension of an existing house (Kamalipour & Dovey, 2020). 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 (Bredenoord, 2016; Kowaltowski et al., 2005). The initial development of the house also impacts the opportunities for space expansion (Greene & Rojas, 2008). Not considering 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. It relates to spatial rearrangements created by walls, floors, ceilings, and other non-necessary indoor components that do not compose the main structure. It happens by extending, attaching, replacing, dividing, connecting, and infilling (enclosing) the spaces (Kamalipour & Dovey, 2020). 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.

Changes in the needs of the households can also result in the need to alter the function of the house. It may happen by changing, upgrading, or including new ones (Slaughter, 2001). 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. 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 (Kowaltowski et al., 2005).

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. Besides for the shading and weather protection, porches are frequently used as transitional spaces and for socializing (Kowaltowski et al., 2005). Ceilings also play an important role in the 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 the spaces (Bredenoord, 2016).

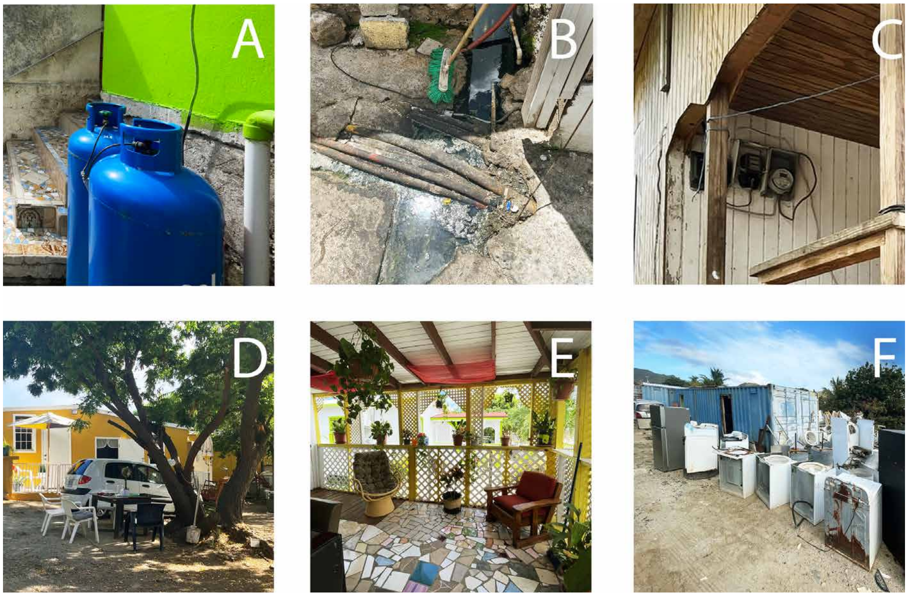

FIG. 2.9 Examples of services: (A) gas bottles; (B) pipes in front of a unit; (C) gas and electricity me-ters. Examples of space organization: (D) outdoor leisure space; (E) extended porch; (F) repair workshop.

The layer of **services** also plays an important role in providing comfort. This layer includes electricity, water, sewage, air conditions, and other systems. 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 finishing, 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. 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.

2.7.3 Aesthetic appeal

Aesthetic 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 aesthetics in mind (Kellett & Napier, 1995; Kowaltowski, 1998). 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 aesthetic appeal in housing. Aesthetic 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** (Kellett & Napier, 1995) (p. 5). This allows for the houses to have meaning and for individuals to **express their unique identity**. How the house is experience is relates mostly with the layers of skin and stuff.

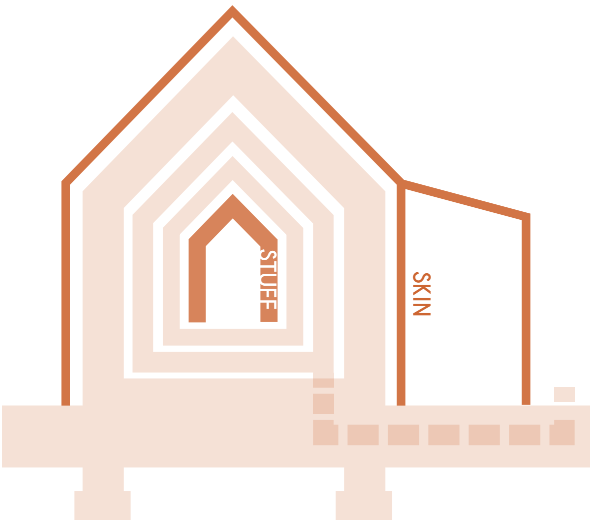

FIG. 2.10 Layers related to aesthetic appeal.

TOC

The **skin** of a unit plays an important role in visual aspects. Usually, those aspects are considered aesthetically pleasing due to a shared design language with individual variations expressed by their owners (Kellett & Napier, 1995). The similarities can be compared by observing characteristics related to form, detail, quality, context, style, size, and status (Sanoff, 2000). The lack of these consistencies, as well as the lack of diversity, maintenance, and decorations, may lead to perceived ugliness (Kowaltowski, 1998) (p. 2). This is often the case for self-organized houses, where despite shared aspects such as street layout and vegetation, building height, and materials used, the units remain distinctive (Kellett & Napier, 1995; Nielsen, 2016). They show income differences, cultural values, household structure, building life cycle, and its function (Kellett & Napier, 1995).

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" (Potter, 1994), are made of balloon frames, elevated from the ground, and covered with a gable roof made of corrugated iron (Aponte-Parés, 1995). These houses are often painted in bright colors, which gradually soften due to sun exposure. They have windows with shutters and ample porches (Aponte-Parés, 1995) and sometimes are decorated with fretwork. Over the years, some of them were additionally wrapped in corrugated iron. In Saint Martin, few such units remained due to unfavorable environmental conditions. In 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 (Goldwyn et al., 2022).

The life cycle 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 (Bredenoord & van Lindert, 2010; Clarke, 1974; Goethert, 2010). Over time, the house built with temporary materials gets consolidated, and the temporary materials are replaced with more permanent ones (Bhan, 2017, 2019; Bredenoord et al., 2014b). If contextual conditions, such as tenure security, allow for it, the house may gradually develop into a typical middle-income house (Goethert, 2010). 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 (Lombard, 2013). This connection leads to the creation of places that hold personal meaning and memories (Lombard, 2013).

FIG. 2.11 Examples of stuff: (A) repair and material recovery; (B) stock of building materials; (C) arm-chairs on a porch. Examples of skin: (D) painted wooden cladding; (E) floor tiles mosaic; (F) porch covered with painted lattice.

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 (Vale et al., 2014). The ability for expression through visual aspects contribute to the articulation and validation of identity (Aponte-Parés, 1995). The visual aspects of a home reflect the social status perceived by neighbors and state officials (Nielsen, 2016). This can lead to a particular visual aesthetic being chosen, including mimicking middle-income houses or using materials that are associated with a particular social status like concrete or certain cladding materials (Murray et al., 2023; Nielsen, 2016).

In addition, the appearance of a house, especially that of a self-organized one, reflects the personal taste and style of its inhabitants. Those 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 (Kowaltowski, 1998; Marinovic, 2020). Architects usually leave this aspect to the users as preferences can change quickly (Bredenoord et al., 2014b). Over time, people often make minor modifications to the skin of their houses over time, 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 (Delgado & Antipova, 2010).

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. It provides information on the kind of interactions and activities happening in that space. It is also the layer that the households can be changed and reorganized most easily, making it suitable for them.

2.8 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 enabling 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 2.12). 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.

Considerations	Layers of change		Time-based factors
Durability		Site Structure Skin	Gradual building consolidation Maintenance Reparations and replacements of building components
Functionality		Services Space plan Skin	Step-by-step building process Spatial adaptations and extensions Comfort and privacy adjustments Inclusion of small-scale economic activities
Aesthetic appeal		Skin Stuff	Cultural alignment and spatial attunement Personalization and individual expression Creation of collective and individual identities Adaptations to trends, technology, and aspirations

FIG. 2.12 Diagram summarizing relations between housing considerations, layers of change, and time-based factors.

Enabling layering influences 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 can result in environmental benefits. 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 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 lifecycle, 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.

2.9 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 on the case of St. Martin, a specific region in the Caribbean with unique socioeconomic 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 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 aesthetic 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.

2.10 Conclusion

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 aesthetic 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 such 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 aesthetic appeal revealed layers corresponding to each consideration, shedding light on the intricate temporal dimensions influencing housing considerations. 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. Aesthetic 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, aesthetic 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 present a novel approach to enhance the durability, functionality, and aesthetic 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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3 Narratives of Caribbean Housing Flows

Step-by-step development and changes in self-organized homes in St. Martin

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ABSTRACT

Purpose – The global housing shortage, intensified by climate change, poses unique challenges for low-income populations, particularly in regions highly vulnerable to environmental hazards, such as the Caribbean. This study investigates housing in Saint Martin, where communities face severe housing shortages and increased exposure to climate-related threats, such as Hurricane Irma in 2017. With limited external support, many residents have adopted self-building strategies, constructing and incrementally modifying their homes to withstand local environmental risks and accommodate changing needs.

Design/methodology/approach – This research, conducted through ethnographic observations and semi-structured interviews with 30 residents, explores how low- and middle-income households built and adapted their homes over time, focusing on the construction process, materials, forms and aspects of safety, comfort and beauty. It follows the narratives of six housing units that exemplify a proposed housing typology and documents residents' efforts to enhance durability, functionality and aesthetics under challenging circumstances.

Findings – The findings highlight that self-organized housing practices in Saint Martin are shaped by financial constraints, climate risks and evolving household needs. Residents use incremental construction, climate- responsive design elements, materials perceived as durable and community-based support to adapt their homes.

Originality/value – Documented housing practices reflect both resilience and cultural expression, emphasizing the need for community-inclusive, safe, flexible and climate-adapted housing design approaches. Additionally, by analyzing these adaptive strategies, the study offers insights for the Designing for Flow Framework, promoting housing solutions that align with local contexts and contribute to sustainable development in hazard-prone areas like the Caribbean.

3.1 Introduction

The worldwide housing shortfalls, exacerbated by **climate change**, pose significant challenges for low-income populations, particularly in regions highly susceptible to environmental hazards. Currently, nearly 40% of the world's population (approximately 3.3 – 3.6 billion people) live in areas considered **highly vulnerable** to climate change, with many of these regions already experiencing severe impacts (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2022). The duration, frequency, and/or intensity of extreme events—such as heatwaves, droughts, wildfires, floods, and hurricanes/cyclones—are expected to increase, further affecting the built environment, the housing sector, and households. Despite contributing the least to global emissions, **low-income populations and those living in self-organized housing** are the most exposed to environmental hazards and face the highest risk of losing their lives (UN-Habitat, 2024).

The Caribbean, one of the most vulnerable regions in the world (United Nations Office for Disaster Risk Reduction (UNDRR), 2023), is facing severe impacts of climate change (Kelder et al., 2025) alongside housing shortages (Greene & Rojas, 2008; Jha, 2007; McTarnaghan et al., 2016; Prevatt et al., 2010; Rojas & Medellin, 2011; United Nations Economic Commission for Latin America and the Caribbean, 2023; United Nations Office for Disaster Risk Reduction (UNDRR), 2023). In Saint Martin, residents encounter significant obstacles in accessing affordable housing that is both suitable for local climate conditions and resistant to related

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risks, such as recurring tremors, tropical storms, and extreme heat that accelerates material degradation. This shortage has been further compounded by rising construction costs, land scarcity and disputes (World Bank, 2020), energy access issues (Der Sarkissian et al., 2021; TNO et al., 2024), as well as recent climate-related events, including Hurricanes Irma and Maria in 2017 (Collodi et al., 2021; Der Sarkissian et al., 2021; Jouannic et al., 2020; Mehdizadeh et al., 2023; Mycoo, 2020).

Since **affordable housing** is inaccessible to many, residents are often forced to adopt self-reliant strategies to meet their housing needs. This process, referred to as self-built or self-organized housing, accounts for the majority of housing for low-income populations both globally (J. F. Turner, 1972; J. F. C. Turner, 1976) and in the Caribbean (McHardy & Donovan, 2016; Mycoo, 2020; Potter, 1994; Potter & Conway, 1997). These developments are particularly common among households with irregular incomes or informal employment, who face barriers to traditional financing (International Recovery Platform & UNDP-India, 2012; Usamah et al., 2014; Wakely & Riley, 2011). Housing development tends to be a long-term, incremental process where residents construct and adapt their homes over time, frequently relying on the assistance of neighbors, family members, or local contractors (L. Delgado & Antipova, 2010; Gattoni, 2009; Goethert, 2010; Greene & Rojas, 2008; Mota, 2021; UN-Habitat, 2015; Wakely & Riley, 2011). The houses often evolve continuously, following residents' financial abilities and adapting to urgent needs and changing circumstances.

Self-organized housing practices are complex and diverse, resulting in a **wide range of home types** that navigate challenges related to limited construction knowledge, material availability and quality, financial constraints, and other factors. These challenges are particularly pronounced in climate-vulnerable areas, where structural resistance is a critical concern. Despite these difficulties, **collaboration with residents** in the building process has been recognized as a key factor in developing affordable homes that address individual household needs while also contributing to local capacity-building (Christopher Alexander, 1979; Hamdi, 2010; Harris, 2003; Schilderman, 2004; J. F. Turner, 1972; J. F. C. Turner, 1976). Strengthening this process through adequate support systems—such as improving risk awareness, planning, technical and construction knowledge, and financial options (Hendriks et al., 2016; Jan Bredenoord & Luz María Sánchez Hurtado, 2022; Karki et al., 2022; Lewis, 2003)—is essential not only for developing affordable homes that are resistant to environmental hazards, but also building capacities and enabling residents to carry out necessary repairs and reinforcements when needed.

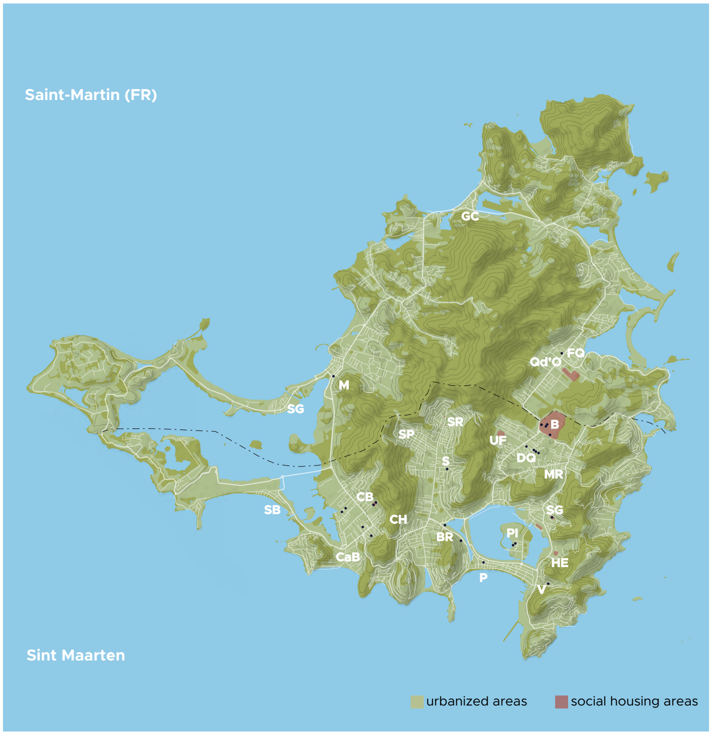
Studies of self-organized housing developments provide valuable insights into the challenges residents face, material properties, construction preferences, and local building methods (A. Delgado & De Troyer, 2011; Iftekhar, 2007; Khassawneh & Khasawneh, 2022; Salama, 2011; Salama & Sengupta, 2011). They also contribute to improving design considerations for future housing developments. In the Caribbean, research has primarily focused on the risks posed by earthquakes and hurricanes, particularly regarding housing forms (Eaton, 1982; Miranda et al., 2020; Mycoo, 2020; Osborne et al., 1992; Prevatt, 1994; Prevatt et al., 2010) and materials used in affordable, self-built housing (Goldwyn et al., 2021, 2022; Goldwyn & Gonz, 2022; Lang & Marshall, 2011; Meredith Lochhead et al., 2022; Marshall et al., 2011; Miranda et al., 2020; Mix et al., 2011; Murray et al., 2023; Valdivieso et al., 2024; Venable et al., 2020), with an emphasis on post-disaster studies. Understanding these housing challenges and climate-related adaptations is crucial for developing more resistant affordable housing solutions.

Building on this foundation, the need to develop **resilient homes** that respond to local climate conditions and adapt to the evolving needs of residents is more pressing than ever. While interest in climate-adaptive and resistant strategies for affordable housing has grown, the ways in which residents construct, modify, and personalize their homes to address local challenges over time remain understudied. These adaptations—ranging from construction techniques and material choices to spatial organization and lived experiences—offer valuable insights into the practical and cultural dimensions of housing resilience. Addressing this gap, this study examines housing in **St. Martin**, focusing on how low- and middle-income residents navigate environmental challenges and economic constraints through continuous modifications. By analyzing these evolving housing practices, this research aims to reveal the interplay between durability, functionality, and aesthetic preferences, ultimately informing the development of more adaptable and contextually responsive housing solutions for hazard-prone regions.

3.2 Methods

This research examines the housing conditions on St. Martin, a small island located in the Atlantic hurricane belt, with a focus on low- and middle-income residents living in small-scale detached housing units who have encountered financial barriers in securing housing. The study was conducted in three phases.

In the first phase, which involved field studies over several weeks during the spring of 2022, researchers reviewed existing literature on affordable housing on the island, conducted ethnographic observations, documented findings through photography, and engaged in discussions with architects, builders, and residents. This phase provided a preliminary understanding of housing activities, the variety of housing developments and self-organized units, and connections with key stakeholders and residents. It helped identify primary building practices and materials, which informed the draft classification of housing types, as well as pinpoint specific areas where these housing types were concentrated (Figure 3.1).



Social housing [SMHDF]
B Belvedere (474 Houses + 24 Senior Homes)
UF Union Farm (105 'Emergency' Homes)
SR South Reward (8 'Emergency' Homes + Plantz 4 apartments)
CB Cole Bay (~24 'Emergency' Homes)
SG Sucker Garden (30 'Emergency' Homes Foga + 33 'Emergency' Homes The Keys)
HE Hope Estate (94 apartments)
Affordable housing [FR]
Qd'O [FR] Quartier-d'Orleans

Self-organized housing areas:
DQ Dutch Quarter
MR Middle Region
SG Sucker Garden
PI Pond Island
GC Grand Case
CH Cay Hill
CaB Cay Bay
CB Cole Bay
SP St. Peters
SB Simpson Bay (?)
SG [FR] Sandy Ground
M [FR] Capital Ghost (Marigot)
Qd'O [FR] Quartier-d'Orleans
FQ [FR] French Quarter

Other:
P Philipsburg
BR Bush Road
SG Saunders

FIG. 3.1 Map indicating social housing, self-organized housing areas, and interviewed houses. *[Adapted from the Island Map in Gaba (2009)]*

The second phase, which included field studies conducted over two several-week periods between 2023 and 2024, involved continued ethnographic observations and open-ended, semi-structured interviews with 30 residents. This phase was carried out in collaboration with researchers and students from the University of St. Martin. Participants for the interviews were selected based on information gathered during preliminary field studies and interviews with community gatekeepers, ensuring representation of diverse housing types on the island, with a primary focus on low-income residents and affordable housing. These recorded interviews provided detailed accounts of the history, development, and repair of residents' homes, as well as their future plans. Based on these narratives, researchers and residents collaboratively created drawings of the housing layouts and modifications, mapping changes over time to illustrate the range of building activities (Figure 3.2).

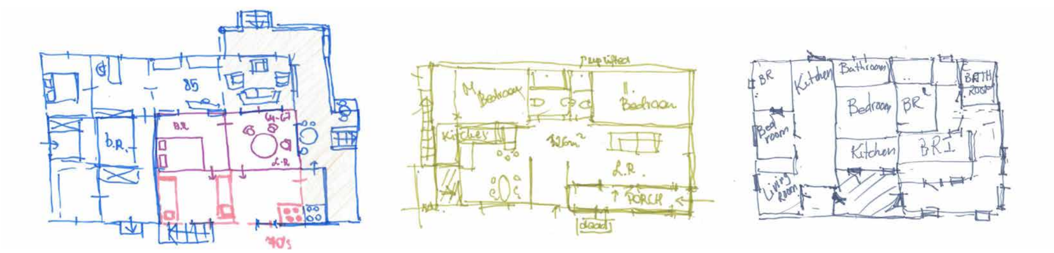


FIG. 3.2 Examples of drawings of the housing layouts and modifications.

In the third phase, preliminary findings prompted the research team to categorize the diverse housing structures based on the primary construction materials used, leading to a proposed classification of housing types. Considering the extensive information gathered and the unique circumstances of each resident, the researchers narrowed the study to six housing units that represent distinct housing typologies. This allowed for a comparative analysis focused on how residents have adapted, modified, and contributed to the durability, functionality, and aesthetics of their homes presented in this article.

This research also has limitations. It provides valuable insights through the in-depth analysis of selected housing types, utilizing ethnographic observations, photographic documentation, and semi-structured interviews with residents. The housing types chosen were based on their relevance and representativeness within the study's context, reflecting the diversity of housing developments on the island. The selection process was informed by strong collaborations with local gatekeepers and networks, ensuring that the findings are grounded in the unique social and cultural context of the community. While the study focuses on a representative sample of housing types, it offers a comprehensive understanding of the dynamics at play within the local housing context.

The narratives of each house were constructed based on information shared by the residents and interpreted by the researchers through drawings. As such, the plans and histories may show slight deviations in terms of specific years, dimensions, and other precise details that could not be recorded or were lost in translation. Additionally, it is necessary to recognize that although the island is also affected by tremors, the primary concern of residents revolves around the risks posed by hurricanes, which is why reinforcement and resistance strategies primarily address hurricane resilience.

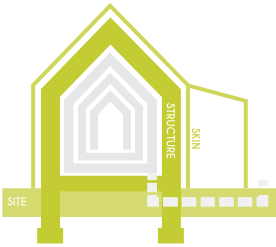
Although the research clearly highlights the importance of self-organized housing and the active role of residents in these processes, it is important to note that these practices emerged out of necessity, due to a lack of structural support and inadequate social housing solutions on the islands. The research provides an overview of the residents' active involvement in housing practices, along with lessons on how to improve housing approaches based on their preferences. However, it does not advocate for self-organized, independent housing solutions as a substitute for providing adequate housing support to the residents.

3.3 Housing Flows and Designing for a Flow

The houses we see today in St. Martin are the **result of years of building activities, repairs, and adaptations influenced by financial constraints, climate challenges, and evolving spatial needs**. Residents have demonstrated creativity, commitment, and perseverance in constructing, repairing, and modifying their homes. This approach is not unique to St. Martin but is part of a broader trend of dynamic housing processes, resulting in incremental housing, which is observed in many countries across Latin America, the Caribbean, and other regions where access to affordable housing is limited (Greene & Rojas, 2008; Jha, 2007; McTarnaghan et al., 2016). These modifications are part of an ongoing process, referred to as a housing "Flow."

Many affordable housing designs tend to overlook the dynamic nature of housing by offering standardized units that, while resilient to climate challenges, may not fully accommodate unique family dynamics, adapt to households' changing needs over time, or provide a pleasant living experience. The absence of these qualities contrasts with Vitruvius's core design considerations of durability, functionality, and aesthetic appeal (Guyer, 2021; Vitruvius, 1999). Studies of housing flows—how residents interact with, **develop, adapt, and modify their homes**—can enhance our understanding of local challenges, specifically regarding durability and material resilience, functionality to meet evolving resident needs, and aesthetic appeal to improve both the experience and visual comfort of living spaces.

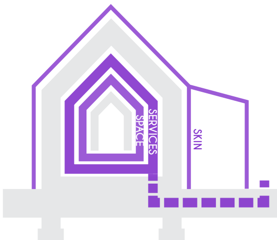
This article builds on the concept of Designing for Flow (Kuś et al., 2024) to explore how housing changes can reveal a deeper understanding of residents' needs and motivations. It integrates Vitruvius' design triad with Brand's concept of viewing a house as a system of distinct layers—namely **site, structure, skin, services, space plan, and stuff** (Brand, 1995)—through the lens of residents' building activities that address these considerations (Figure 3.3).



Durability

Site | Structure | Skin

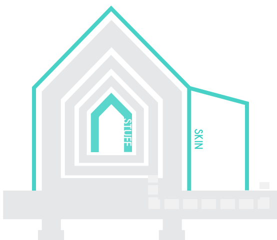
- Installing and reinstalling
- Maintaining and upkeeping
- Repairing
- Reinforcing



Functionality

Services | Space plan | Skin

- Arranging
- Improving
- Extending
- Adapting



Aesthetic appeal

Skin | Stuff

- Creating
- Attuning
- Personalizing
- Enhancing

FIG. 3.3 Diagram of building activities connected to Durability, Functionality, and Aesthetic appeal. *[Based on Brand (1995); adapted from Kuś et al. (2024).]*

By examining existing housing and residents' interactions through various building activities, this study aims to draw lessons for future housing designs, considering aspects such as construction processes, material choices, layouts, and personalization. Insights gained from studying housing flows in St. Martin can inform resilient and more adaptable affordable housing approaches for communities facing similar constraints and challenges.

3.4 Affordable housing in St. Martin

In the case of St. Martin, the issue of **affordable housing** is particularly pertinent, as it requires an understanding of the social, economic, and environmental challenges that residents face. The topic of affordable housing worldwide generates considerable debate and diverse opinions, with varying definitions and perspectives (Bredenoord et al., 2014; Daud et al., 2017; Vale et al., 2014). Some studies define affordable housing as housing that is accessible to most residents and costs around 30% of their income (Daud et al., 2017), regardless of income level. However, for this research, affordable housing specifically refers to **homes accessible to lower- and lower-middle-income residents** living on the island, where financial and environmental challenges shape both the availability and quality of housing.

3.4.1 Overview of affordable housing and levels of customization

Accessing affordable housing in St. Martin is a significant challenge due to limited apartment availability and a growing demand for such accommodations (World Bank, 2020). The level of customization allowed in these housing options also varies. The most standardized units are pre-built apartments provided by the St. Maarten Housing Development Foundation (SMHDF). Residents with limited financial means have access to a small number of those **state-supported social housing units**, which come in various sizes but generally do not permit modifications. Due to the scarcity of these options, many residents turn to renting or subletting homes from private owners.

A slightly more flexible option is the limited number of housing units with **rent-to-own agreements**. While these homes were pre-built with identical sizes and forms, many residents have adapted and customized them over time to better meet their needs. They are also developed by the SMHDF with a promise of ownership after approximately 30 years. An example is the prefabricated housing project initiated after Hurricane Irma (Emergency Housing). Similar types of modifications are permitted for residents developing their own housing units in more organized neighborhoods, particularly where land is leased and the development plan is controlled by an investor. In these areas, homes are often pre-designed but offer limited opportunities for customization.

The most flexible option involves **self-built homes,** constructed either through formal contractors or by the residents themselves. These homes are built with varying levels of support from formal or informal networks, including friends, local carpenters, or builders. This approach offers the greatest degree of customization, as residents can make decisions and plan their homes based on the specific needs of their households.

3.4.2 Construction materials and housing types

Houses on St. Martin presents **various types of construction processes and techniques and building materials** as a result of materials accessibility, financial availabilities of the residents, and other factors. The affordable houses also vary in size and form and have been shaped through various modifications and adaptations performed by the residents over the years. To represent the diversity of housing construction types on the island, this research introduces six housing types organized based on the primary construction materials (Figure 3.4).

TOC

FIG. 3.4 Proposed housing typology and examples of various housing types.

Timber Houses

Timber houses are one of the most common types of housing on the island. Historically, wooden housing was popular across the Caribbean due to its affordability and accessibility. These lightweight homes feature wooden walls and roofs, with variations in roof design such as pitched, flat, or inclined. Timber is typically purchased in local stores or imported from nearby islands. Over time, due to the need for frequent maintenance and the hurricane risks, this type of housing became a less preferred choice.

Concrete Houses

Concrete houses are a popular housing choice due to the availability of materials, climate considerations, and reduced upkeep. This construction type has become increasingly prevalent in recent years, especially after the devastation caused by Hurricane Irma in 2017. This method involves erecting a concrete frame with walls filled with concrete blocks and typically features a flat concrete roof designed for future vertical expansion.

Timber-Concrete Houses

Timber-concrete construction combines the two most commonly used materials: concrete and concrete blocks for the walls, with a timber roof structure. This composite approach creates durable, heavy-weight structures while reducing costs by incorporating wooden elements instead of using only concrete. This approach is also motivated by climate performance, as it reduces overheating in comparison to a flat concrete roof.

Prefabricated Houses

The next quite common housing type is prefabricated houses. Those pre-casted concrete structures were introduced as a quick and efficient housing solution in the aftermath of Hurricane Luis (1995). These homes were shipped to the island and assembled rapidly to meet urgent housing needs. While initially intended as emergency shelters, many of these homes have persisted over the years.

Steel-Framed Housing

Another common type of affordable housing is steel-frame construction, based on containers adapted for residential use. This housing type became part of the island's housing stock after Hurricane Luis in 1995, with residents further modifying them to better suit their needs.

Mixed Materials Houses

In addition to houses built with common materials mentioned above, another significant part of the housing stock consists of homes constructed using a mix of different materials, often combining concrete, timber structures, and other elements. Sometimes, different sections of these houses are built with varied materials. This building approach is often linked to the scarcity of available materials, the gradual accumulation of materials over time, or the process of rebuilding or reinforcing existing structures.

In order to understand the impact of environmental challenges and user modification on the development of different types of houses, this paper has identified exemplary cases for each of the housing types (Figure 3.5). Specifically, we have selected six houses that represent low-income housing on the island, enabling us to conduct comparative studies on their developments and modifications.

	Timber house	Concrete house	Timber-Concrete house	Prefabricated house	Steel-framed house	Mixed materials house
Foundation	wooden poles with lime-based cement	concrete slab	concrete spread footing	precast concrete poles	concrete slab	concrete slab
Walls	mahogany or kousher wood	concrete blocks	concrete blocks	precast concrete	steel beams (40 ft container)	timber; concrete blocks
Walls skin	plywood siding (T1-11)	plaster	plywood siding (T1-11)	-	steel panels	plywood siding (T1-11)
Roof	timber (2x4)	concrete slab	timber	precast concrete	steel beams (40 ft container)	timber (2x4)
Roof skin	zinc plates	-	zinc plates	-	steel panels	zinc plates

FIG. 3.5 Selected exemplary housing types and materials overview.

Each of these six houses represents a distinct housing type. While the narratives surrounding each home differ, focusing on these **representative cases** allows for a deeper exploration of the challenges residents face, as well as the ongoing processes of adaptation and modification over time. By examining these homes, we gain insights into how residents have navigated environmental challenges, financial constraints, and changing needs. This approach highlights the dynamic and evolving nature of housing in St. Martin, providing a clear foundation for understanding the broader housing flows and construction processes discussed in the following sections.

3.5 Narratives of housing Flows

3.5.1 Construction process

In St. Martin, as in other Caribbean islands, many homes were shaped by limited financial resources. Since constructing a large, durable house all at once was beyond the means of many residents, different strategies were employed to reduce costs. These included a gradual construction process, opting for less expensive building materials, reducing labor expenses, or a combination of these approaches.

To reduce labor costs, community support played a crucial role for many residents. Homes like the Timber House and Concrete House were built with the assistance of family and friends through a local tradition known as "**jollification,**" where community members work together in exchange for food and drinks provided by the host (Hale, 2015; The World Bank, 2017). This process took varying amounts of time depending on the particular case and the skill of the community; however, it would usually be a more time-consuming and gradual process in comparison to houses built by professional builders. Although residents were often constrained by financial limitations and the availability of materials in local stores, this process allowed for **a high level of customization**. In contrast, not all residents had the same freedom to personalize their homes. For example, the Prefabricated House and Timber-Concrete House were initially designed as standard units by external practitioners, which limited residents' influence over the final layout and features. These prefabricated and steel-framed homes have emerged as practical solutions for post-hurricane reconstruction, as their components are manufactured off-site and can be quickly assembled to provide immediate shelter and structural integrity.

3.5.2 Durability - Materiality

Unit Development

Housing construction in St. Martin has **evolved to address environmental challenges**, particularly hurricane resilience, flood protection, and heat management. Historically, mahogany or kosher wood was traditionally used for timber structures, with larger elements placed in the building's corners to enhance hurricane resistance. One of the climate adaptation techniques already adopted at that time was raising the house to protect it against water, as seen in early 20th-century timber houses. As one resident recalls:

'It used to be on wood. On pegs [referring to the piles], because of the rain. And you're able to go play under the house. Anyway… [it's] because of the rain. There used to be a lot of flooding, I gather. So all the houses were on wooden pegs...'
[timber house]

The wooden piles were strengthened with lime-based cement, a locally sourced material made from limestone and gravel, to improve water resistance. As time passed, more resilient materials such as precast concrete replaced wood, providing stronger, water-resistant **foundations** while following the same approach of raising the houses. This also allowed for adaptation to uneven terrain, as seen in the case of the Prefabricated Panels House, which utilized different pile heights for this purpose.

The construction techniques on the island are diverse, with common materials including concrete, concrete blocks, and timber. The frequent threat of strong storms has made concrete structures increasingly popular due to their durability and lower maintenance requirements. In the past, residents made their own concrete blocks using forms and beach sand to reduce costs, but this approach compromised durability because of the unsuitable grain size and high salt content of the sand.

Today, the methods of building with concrete have evolved. Concrete slabs reinforced with steel, as seen in the Concrete Frame and Timber-Concrete Construction Houses, have become the standard foundation material, providing improved resistance against storms. Two distinct construction processes are now used for concrete **walls**: one in which the frame is built first and blocks are added later, and another where the blocks are laid first before pouring concrete—the latter being preferred for its enhanced structural integrity. Many residents also reinforce concrete blocks with steel bars when feasible for added strength. Additionally, modern concrete houses often feature a ring beam that connects the walls, further enhancing their resilience to extreme weather conditions.

Roof shapes have also adapted to environmental conditions. Flat concrete roofs, like those in Concrete Frame Houses, are designed to allow future expansions while mitigating storm damage. In contrast, slanted timber roofs, common in homes like the Mixed Materials House and Timber-Concrete Construction House, are covered with zinc, which reflects heat and improves ventilation in the island's warm climate. Another risk adaptation strategy involves constructing separate roofs over porches to ensure that, in the event of a hurricane, damage to the porch roof does not impact the main structure.

Additions and adaptations

Housing developments in St. Martin illustrate a diverse range of material approaches and adaptation motivations, deeply influenced by **family circumstances, work-related needs, cultural adaptations, and climate challenges** (Figure 3.6). The housing construction methods also affect the potential for future expansions, and the choice of building materials is linked to the types of modifications residents make.

Concrete provides a robust foundation for various types of **expansions**, both vertical and horizontal, using a range of materials. Common adaptations often involve adding extra rooms, as seen in the Timber-Concrete House (Figure 3.6), or even additional floors if financial resources allow. These modifications are typically motivated by the need to accommodate growing or multi-generational families, as demonstrated in the Concrete House.

Homes that are originally constructed with less resilient materials, such as Timber House or Mixed Materials House, often expand their houses by building additions **using more resistant materials** like concrete. These extensions increase the usable space and enhance the home's safety against weather challenges, such as strong storms. For homes initially built with timber, transitioning to concrete for extensions is an important step in ensuring durability and protection, although it often requires residents to save up for these more expensive materials.

Timber remains a practical choice for certain types of expansions. For houses where **additional reinforcement** is not necessary, like in the Timber-Concrete House or the Prefabricated House, timber and plywood are used for creating new spaces. **Additions** built in wood are usually more affordable and quicker to construct. Timber is also employed for less critical extensions, such as laundry rooms, additional kitchens, or porches, which enhance living conditions while maintaining a cost-effective approach.

An alternative expansion method is exemplified by the Steel-framed House, where the homeowner utilized modular, prefabricated elements to **extend** the living space. By adding another container and building a connecting roof, they increased the home's layout. To enhance hurricane resistance affordably, the homeowner innovatively repurposed discarded street lamp poles as steel beams, which were welded between the containers and filled with concrete.

	Timber house	Concrete house	Timber-Concrete house	Prefabricated house	Steel-framed house	Mixed materials house
Foundation and slab	-installing a back slab extension (1975) - installing a front slab extension as a porch (1980s)	-installing a back slab extension (1964) -installing a slab extension (1980)	-installing a side slab extension (1995) -installing a back slab extension (2013)	-installing a front and side slab extension (1999) - installing a back slab extension (2001)	-installing a side slab extension (2019)	-installing a side slab extension (2005)
Walls	-installing additional concrete walls in the back (1975) - installing additional timber wall structure in the front (1980)	-installing additional concrete walls in the back (1964-67) - installing additional concrete walls (1980-85) -installing additional concrete walls on the upper floor (1991)	-installing additional timber walls on the side (1995) - installing additional timber wall structure in the back (2013)	-installing additional timber walls in the front and on the side (1999) -installing additional timber wall structure in the back (2001)	-installing additional container (2019)	-installing additional concrete walls on the side (2005)
Walls skin	-painting the walls (1975)	-painting the walls (1967), -painting the walls (1985)	-installing a cover over the timber extension (1995)	-installing a cover over the timber extension in the front and on the side (1999) -installing a cover over the timber extension in the back (2001)	-	-painting the walls (2005)
Roof	-installing an concrete slab in the back (1975) - installing a timber roof extension in the front (1980)	-installing an concrete slab in the back (1964-1967), - installing an concrete slab (1980-85)	-installing an extension timber roof extension on the side (1995) - installing a timber roof extension on the back (2013)	-installing an extension of the roof in the front and on the side (1999) - installing an extension on the back (2001)	-installing additional container (2019) - installing additional roof extension between the two containers (2019)	-installing a timber roof over the extension on the side (2005)
Roof skin	-installing a cover over the timber extension (1980)	-	-installing a cover over the timber extension (1995) - installing a cover over the timber extension (2013)	-installing a cover over the timber extension (1999) - installing a cover over the timber extension (2001)	-installing zinc cover over additional roof (2019)	-

FIG. 3.6 Overview of housing additions and adaptations.

Maintenance: Upkeep and Repairs

	Timber house	Concrete house	Timber-Concrete house	Prefabricated house	Steel-framed house	Mixed materials house
Foundation and slab	-installing wooden floor (1975) -reinforcing the foundations by adding cement (1990s)	-	-	-installing tiles (1999) -addressing septic tank issues (2001)	-installing concrete slab inside the container for hurricane resistance (2017)	-installing anchors in the slab as an additional hurricane measure (2017)
Walls	-repairing and reinforcing rooting posts (1990s)	-	-	-	-	-repairing hurricane damages (2017)
Walls skin	-repairing skin damaged due to rooting (1990s)	-painting the walls (2018)	-painting the walls (2023)	-painting the walls (1999) -repairing hurricane damages (2017)	-protecting the walls against corrosion (2017) -repairing damages after hurricane around windows and doors (2017) -replacing the door (2017) -painting the walls with a protective coating (2024) -installing new windows and doors (2024)	-
Roof	-repairing significant hurricane damages (1950s) -repairing hurricane damages (1995) -repairing and reinforcing of rooting elements (1990s) -repairing hurricane damages (1995) -unable to repair significant hurricane damages (2017)	-repairing roof damages and concrete cracks (2018)	-	-	-	-repairing significant hurricane damages (2017)
Roof skin	-repairing significant hurricane damages (1950s) -repairing hurricane damages (1995) -repairing and reinforcing of rooting elements (1990s) -repairing hurricane damages (1995) -unable to repair significant hurricane damages (2017)	-	-	-repairing hurricane damages (2017)	-installing new zinc (2024)	-repairing hurricane damages (2017) -repairing leakages (2023)

FIG. 3.7 Overview of housing upkeep and repairs.

The upkeep and repairs across various housing types in St. Martin reveal how residents **interact with their homes to combat weather-related challenges** such as sun exposure, salty sea breeze, strong winds, torrential rains, hurricanes, earthquakes, and the natural aging of structures (Figure 3.7). These factors influence the lifespan of materials, making it shorter. The residents also report that the material quality available on the island is lower compared to other places. The level of maintenance needed depends largely on the materials used and their vulnerability to environmental damage.

Houses using timber demand frequent **upkeep** due to the organic nature of wood, which is susceptible to decay, rot, and insect damage. Weather cycles, especially intense sun exposure and the swelling caused by the salty sea breeze accelerate the degradation of timber. Wooden elements must be regularly treated to prevent these issues, and residents often perform maintenance to protect the structural and exterior wooden components. Residents also inspect the connections between rafters and roof coverings, especially before the hurricane season.

Repairs are often necessary after hurricanes, and timber houses tend to require the most significant structural fixes, especially to roofs and posts (Figure 3.8C). The residents of Timber House reported frequently repairing roof elements or dealing with wood rot by removing softened sections and filling them with a mixture of wood fragments and glue. That house suffered significant damages after Irma in 2017 and was not repaired or inhabited afterward.

FIG. 3.8 Examples of damaged elements (A) damaged concrete piles; (B) patched concrete ceiling; (C) damaged wooden rafters.

Concrete and steel homes, on the other hand, require less **maintenance**. In these structures, upkeep is primarily focused on water protection, with residents applying coatings or repainting to guard against water infiltration. Recoating helps prevent water damage and the corrosive effects of salt, which can cause paint to swell and crack. Steel frame houses also require anti-corrosion treatments to prevent rust, reflecting how different materials dictate the type and frequency of upkeep.

In the event of a hurricane, roofs are typically the most susceptible to damage. Concrete roofs tend to perform better in this regard. Residents of Concrete and Timber-Concrete houses also reported necessary repairs, primarily related to fixing cracks in the concrete (Figure 3.8A). For Concrete houses, this involved filling the cracks with cement mixes or specialized mixes available in local stores (Figure 3.8B).

Reinforcements

Building strategies and practices in St. Martin have evolved over the years to construct homes that can withstand the island's challenging climate. Residents have taken an active role in reinforcing their houses to **ensure longevity and preparedness for tropical storms**. These reinforcement strategies vary depending on the materials used and focus primarily on the roof, the building's base, and the connections between various structural components.

One key strategy involves using **stronger and heavier** roof elements. For instance, in the Timber House, the wooden rafters were upgraded to larger ones, while the Steel House employed innovative techniques like connecting containers with additional roofing and filling steel beams with concrete for greater stability. Many homes also improved the roof-to-rafter connections by replacing nails with screws or fasteners, which provide a stronger hold during intense storms.

Securing the **connection** between the roof and walls is another critical safety measure. This is often achieved using reinforced concrete. For example, a modern approach in the Concrete House is the use of a ring beam, now widely adopted to bolster storm protection. In other homes like the Timber-Concrete House, roof rafters are anchored in concrete, preventing them from being lifted by hurricane winds.

Another technique focuses on **reinforcing** the base of the building and anchoring it to the ground, particularly for lightweight structures, to prevent them from being uprooted during storms. This is often achieved by adding concrete for weight and stability. The Timber House, for example, enhanced its foundation with concrete to improve resistance, while the Steel Frame House achieved additional storm resilience by adding a concrete slab. The Mixed Material House utilizes alternative reinforcement methods to strengthen their bases using anchors attached to concrete foundations. They are used to secure straps around the house, tying it down to prevent it from being lifted or blown away during hurricanes.

Another significant risk residents address is the vulnerability of windows and doors. Many windows are protected by installing wooden shutters or covering them with plywood to shield against flying debris like roof tiles or handles. In well-sealed concrete houses, it’s crucial to manage internal pressure during storms. This is often done by leaving two windows slightly open on opposite sides, which doubles as an emergency ventilation method. Additionally, after Hurricane Irma, many residents modified their doors to open outward, reducing the risk of them being forced open by strong winds.

3.5.3 Functionality – Form and Layout

Initial house

The initial layouts and forms of the six houses in St. Martin reveal varying degrees of complexity, with differences in size, indoor amenities, outdoor spaces, and placement on their respective plots (Figure 3.9).

The **positioning** of the initial house development on the plot has a significant impact on future expansion possibilities. Most of the houses in this study were centrally located, a layout that facilitates growth in multiple directions. Exceptions include the Steel Frame House, which was aligned to the side, and the Mixed Materials House, which was set further back—both choices leaving room for work activities or potential additions.

In terms of **size**, the Timber House and the Concrete House began as relatively simple units, consisting of just a bedroom and a living room. These modest layouts reflect limited finances during their initial construction, focusing only on essential spaces. Despite budget constraints, the Mixed Materials House featured two bedrooms and corresponding bathrooms, constructed with less expensive materials. In contrast, the Prefabricated Panels, Timber-Concrete, and Steel Frame Houses were constrained by standardized, pre-designed plans.

TOC

The **layouts** of the houses reflect cultural preferences, adhering to a logic of increasing privacy. Entrances typically lead through a porch—often an elevated, roof-covered space visible and accessible to guests. From the porch, the main entrance opens into the living room, a semi-private area often connected to the kitchen and bathroom, which serve as boundaries to more private spaces like bedrooms. Kitchens often feature back doors for functional use or emergency access. Additionally, outdoor areas are frequently used for work-related activities, as seen in the Steel Frame and Mixed Materials Houses.

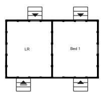
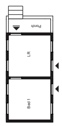
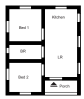
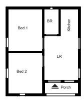
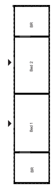
	Timber house	Concrete house	Timber-Concrete house	Prefabricated house	Steel-framed house	Mixed materials house
initial layout						
position	rectangular, in the centre	rectangular, in the centre	rectangular, in the centre	rectangular, in the centre	rectangular, aligned to the side	rectangular, in the back
indoor spaces	bedroom, living room	bedroom, living room	2 bedrooms, open living room with kitchen, bathroom	2 bedrooms, open living room with kitchen, bathroom	2 bedrooms, 2 bathrooms	2 bedrooms, 2 bathrooms, open living room with kitchen
outdoor spaces	outdoor kitchen, outdoor bathroom	small porch, outdoor bathroom and kitchen	small porch, garden on the side	small porch, garden in front and in the back	outdoor kitchen	garden used as workshop

FIG. 3.9 Overview of initial housing layout.

Adaptations and modifications

Many houses in St. Martin were initially influenced by family growth and financial constraints, **starting as smaller units and gradually expanding** over the years (Figure 3.10). The incremental growth illustrates how these homes began as simple structures and were expanded over time with additional rooms and amenities. For example, both the residents of Timber House and Mixed Materials House initially focused on adding missing essential amenities, such as a larger or indoor kitchen (Figure 3.11). Other houses, such as Concrete, Timber-Concrete, and Prefabricated Houses, required **expansions** to accommodate growing families by adding extra bedrooms. The Concrete House, in particular, underwent a significant transformation, starting as a two-room structure and evolving into a five-bedroom home with an extended porch. This gradual expansion sometimes resulted in complex layouts, with rooms being added one after another over the years, leading to many spaces functioning as pass-through areas. This house was also designed to allow for an additional floor to accommodate future generations; however, this expansion was never completed due to a lack of interest from younger family members.

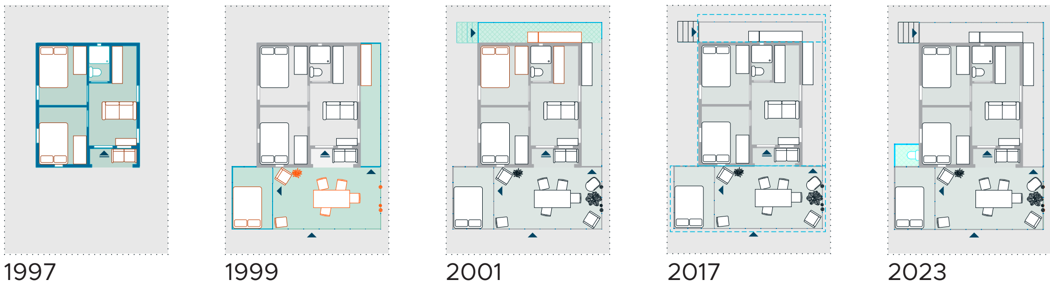


FIG. 3.10 Detailed studies of the changes over the years of the Prefabricated House.

In contrast, the Timber-Concrete House and Prefabricated House underwent only minor modifications, maintaining their original layouts with **small updates** like adding a laundry room or an outdoor kitchen, focusing on functional improvements rather than substantial expansions (Figure 3.11). In homes like Concrete House, Timber House, and Prefabricated House, porches were added as part of incremental expansions, serving as transitional spaces between indoor and outdoor living areas.

TOC

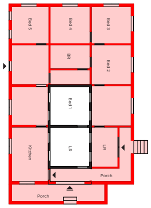
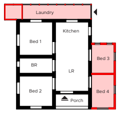
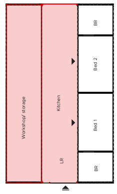
	Timber house	Concrete house	Timber-Concrete house	Prefabricated house	Steel-framed house	Mixed materials house
layout						
indoor spaces	bathroom, kitchen	kitchen, bathroom, storage, 5 bedrooms, other rooms	2 bedrooms, laundry	bedroom, 2 kitchens and laundry	kitchen, living room, workshop/ storage	kitchen
outdoor spaces	porch	large L-shape porch	back porch	large porch	-	-

FIG. 3.11 Overview of changes in housing layouts.

Another type of modification is related to **work activities**, as seen in the Steel Frame House. These modifications were driven by the need for additional storage and workspace for a repair workshop. This was achieved by adding an extra container some distance from the original unit and covering the space between them. The Steel Frame House also faced a unique challenge due to issues of land tenure, necessitating relocation to a different plot. The resident managed to move the entire structure using a crane, keeping the house intact and functional at its new location.

3.5.4 Aesthetics – spatial preferences and attunement

Building preferences

The aesthetic appeal of houses in St. Martin is shaped by personal preferences, cultural practices, financial constraints, and environmental factors, reflecting the island's rich cultural diversity.

The location of each plot influences aesthetic choices, with proximity to natural elements such as water, wind, and surrounding greenery impacting decisions about the form and materials of homes. Residents often enhance their **surroundings** with gardens featuring fruit trees, such as mangoes, workshops for appliances or car repairs, and privacy elements like fences or latticework. These design features reflect the ambiance residents wish to create in their homes.

Climate considerations significantly influence the form and appearance of houses. Older residents tend to prefer wooden roofs, which are more effective at coping with extreme heat, while large windows facilitate natural cooling breezes, reducing reliance on air conditioning. Shaded porches are another prominent feature, protecting against harsh sunlight while enhancing the enjoyment of outdoor living spaces.

Durability concerns, especially following the hurricanes of 1995 and 2017, have also influenced the aesthetic appearance of homes. While older residents still favor wooden structures—often adorned with decorative fretwork along the roof edges—many have begun opting for more durable materials like concrete and steel to safeguard their properties. This shift has resulted in bunker-like designs with lower ceilings that can lead to overheating.

Moreover, homes serve as **symbols of status**, visible to others from the outside, prompting many residents to curate their homes with this consideration in mind. Aesthetically, vibrant paint colors are commonly used not only for their visual appeal but also for practical reasons, such as protecting the house from water damage, further contributing to the island's colorful architectural identity.

Attunement, personalization, and enhancements

Family size, strong ties, and a challenging housing market particularly for young and older individuals have significantly influenced the appearance and structure of homes in St. Martin. **Multi-generational living** is common on the island, leading to homes with distinct living areas, multiple entrances, and additional bathrooms to cater to diverse needs and offer a degree of independence to family members. **Family memories** also play an important role in shaping the identity and personal expression of these homes, often resulting in the thoughtful curation of spaces. As one resident recalls:

[…] [a family member recalling the house of the responder] […] and you had, um…, a dresser, I mean, a cabinet with your dishes… You had a round table, in the corner… and pictures, pictures of Hyde Lacy, and, um, … what was the president? What's his name? Um… John F. Kennedy. [timber house]

The gradual development of homes often resulted in visible differences between sections built at different times. These **expansions** included additional bedrooms, bathrooms, or other functional spaces. Outdoor kitchen extensions were sometimes added to support cultural cooking practices. To create a cohesive look from the street view, some residents actively connected these parts using features like porch extensions, as seen in the Concrete House and Prefabricated House.

The need for **functional workspaces**, particularly for repair workshops, has also shaped the visual experience of many homes. Appliances or cars awaiting repair are often stored for spare parts, occupying substantial areas. Some residents store these items in yards or garages, while others place them in front of the house or on nearby empty plots. Although this practical use of space may impact the home's visual appeal, it is essential for many households.

Privacy and security concerns also significantly influenced the appearance of homes in St. Martin. Many residents installed anti-burglar bars on street-facing windows, allowing them to remain open at night or during absences for ventilation. Larger louvered windows, made from glass or steel, are also common for their airflow benefits and storm resistance. The bars can also be installed on entrance doors or even replace them entirely, creating semi-open spaces for better ventilation, as seen in the Steel Frame House. Additionally, the bars often serve as a base for hurricane protection by holding plywood sheets between the bars and windows.

The aesthetic appeal of homes in St. Martin is also shaped by residents' efforts to **maintain, personalize, and beautify** their living spaces. For example, the resident of the Concrete House, despite their advanced age, continues to regularly paint the home and tend to the surrounding plants. Similarly, the resident of the Prefabricated House carefully maintains the external space, decorating it with greenery and adding elements such as curtains for various occasions.

This ongoing engagement between residents and their homes reflects a broader pattern of self-organized housing practices in Saint Martin, where residents continuously adapt their living spaces in response to personal, financial, and environmental factors. This dynamic housing process, described as 'flow,' highlights the evolving nature of housing.

3.6 Discussion: Lessons for Designing for a Flow

As presented in the study, the houses in Saint Martin ‘flow,’ meaning that they evolve over time, shaped by the active involvement of residents who continuously add, repair, maintain, modify, and reinforce their homes to improve safety, comfort, and appearance. This process aligns with Vitruvius’ design considerations of balancing durability, functionality, and aesthetic appeal. Based on the challenges faced by residents and the actions they take to address these issues, the study offers valuable lessons that can inform future housing developments. These include the importance of involving residents in the housing process, utilizing diverse locally available materials, and understanding the climate-related implications of using such materials. Additionally, the study highlights the significance of housing typology, form, layout, and space curation in creating resilient and adaptive living environments.

Role of residents in housing processes

Many St. Martin’s residents actively participate in modifying, repairing, and beautifying their homes, often with the help of friends or family members (a practice known as “jollification”). This collective effort not only helps reduce costs but also strengthens social bonds and promotes knowledge sharing, which can be invaluable in the context of hazard-prone self-organized housing. It fosters a sense of belonging and self-expression among residents. However, a key challenge to consider is the potential impact on construction quality. Acknowledging this, similar to other studies (Bredenoord et al., 2014; Bredenoord & van Lindert, 2010; Greene & Rojas, 2008; McTarnaghan et al., 2016), the authors highlight the importance of community participation, emphasizing its role not only during the design phase but throughout the entire lifecycle of the homes.

Material choices

The most accessible and commonly used construction materials on the island are concrete and wood. Concrete is often seen as more durable during storms due to its heavy weight, strong connections between parts, and perceived low maintenance requirements (Goldwyn et al., 2021; M Lochhead et al., 2022; Prevatt et al., 2010). However, its effectiveness relies heavily on the quality of the materials and the construction process. On the other hand, wood tends to perform better during earthquakes, and its components are easier to repair or replace when damaged, which can be more difficult with concrete. A key takeaway from this study is the observed practice of using different materials for different parts of the building, depending on their function and expected lifespan. This hybrid approach offers a cost-efficient balance between storm-resistant concrete and easily repairable wooden elements.

Housing typology, form, and layout

The preferred housing typology in St. Martin remains private, single-family, small detached houses, but in areas where land is scarce and difficult to acquire, this model presents challenges. While multi-story apartment buildings are not a popular choice, they offer a more efficient solution in terms of both land use and costs.

Houses with modern, cubical forms and flat concrete roofs are often preferred because they facilitate future vertical expansions. However, these designs perform poorly in the local climate, leading many residents to rely heavily on air conditioning. In contrast, sloped roofs with larger spaces can enhance light reflection and ventilation, while outdoor shaded areas, such as porches, improve living conditions. There are many effective climate-adaptive strategies that can help lower indoor temperatures and make homes more suited to the environment (Bulbaai & Halman, 2021). A promising solution is a hybrid approach, using different forms based on the function of each space, as proposed in the material section.

The layouts of self-organized houses often evolve over time, shaped by the active involvement of residents. Despite financial constraints and tenure insecurities, residents have found ways to develop their homes according to their needs, building incrementally—starting with units that meet basic needs and gradually expanding as resources allow, ideally without sacrificing material quality or quantity (Lang & Marshall, 2011; Marshall et al., 2011). This study emphasizes the importance of an incremental approach, beginning with simple and resistant units that adapt over time. Planning for future expansion should be incorporated into the initial decision-making process, as the placement of the building on the plot, along with communication pathways, can significantly affect the space's functionality. Additionally, planning for multigenerational living—such as designing separate units within a house for elderly family members, young adults, or potential rental spaces—is a key component of this approach. Moreover, spaces for repair workshops or other in-home economic activities should be factored into future housing plans.

Space curation and personalization

Given that each household has unique needs, homes must be adaptable to accommodate the specific requirements of the families living in them. This adaptability also allows for the expression of individual backgrounds, traditions, and preferences, which are deeply embedded in the culture and ethnic diversity of St. Martin. Personalization plays a key role in shaping identity and fostering a sense of ownership and care for the spaces. It includes not only interior modifications but also the maintenance and management of surrounding areas. Actively beautifying and personalizing their homes is a common practice among residents, reflecting their connection to the space and their desire to create environments that align with their values and lifestyles.

The study highlights how residents actively adapt their homes through various activities. Implementing a design framework like Designing for Flow—which supports these activities while balancing durability, functionality, and aesthetics—enables residents to build and modify their homes incrementally. This approach not only fosters the homes' evolution in response to changing needs but also encourages cultural expression. A key component of Designing for Flow is finding a balance between areas of the building that can be adapted by residents and those that must remain fixed. This ensures safety in the face of hazards while providing the flexibility needed for continuous, context-specific adaptations.

3.7 Conclusion

This research underscores the pressing need for resistant, climate-adapted housing developments in vulnerable regions, particularly for low-income populations. As demonstrated in the case of Saint Martin, limited access to affordable, durable housing forces residents to rely on self-organized construction, navigating financial constraints, environmental challenges, and evolving household needs. This process results in a diverse range of self-organized housing types that reflect both practical adaptations and cultural expressions.

By examining self-organized housing in Saint Martin, this study highlights how residents actively modify their homes over time, employing cost-saving strategies such as incremental construction, material substitution, and community support networks like jollification. The study also reveals the impact of increasing climate risks on housing materials and construction techniques, showing a shift from wood to more durable materials like concrete, as well as structural reinforcements to withstand extreme weather conditions. These adaptations, while resourceful, also present challenges, such as inefficient layouts or material vulnerabilities.

Furthermore, this research emphasizes the importance of collaboration between residents, local stakeholders, and policymakers to strengthen housing resilience. Supporting locally driven construction efforts with technical knowledge, safer building practices, and access to quality materials can enhance long-term durability while preserving affordability and cultural relevance. Striking a balance between structural safety and flexible adaptation is key to creating homes that can withstand environmental hazards while evolving with residents' changing needs.

Ultimately, this study contributes to broader discussions on designing adaptable, contextually responsive affordable housing. By drawing lessons from the lived experiences of Saint Martin's residents, it offers valuable insights for future housing strategies in other hazard-prone regions. Balancing between structural safety and flexible adaptation, as presented in the Designing for Flow approach, supports creating homes that can withstand environmental hazards while evolving with residents' changing needs. Moving forward, it is crucial to integrate community-based approaches that build local capacities, recognize the value of self-organized housing, and provide the necessary support systems to ensure safer, more sustainable, and climate-resilient homes.

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4 Collaboratively Shaping Housing Flows

A Participatory, Card-Based Tool for Adaptation and Resilience in Self-Organized Homes

Under submission (March, 2026)

ABSTRACT

In rapidly urbanizing regions self-organized housing has become a primary alternative for low-income residents with limited access to formal affordable housing. These homes evolve through continuous adaptations, modifications, and repairs—a process we define as Housing Flows. While residents rely on extensive experiential and contextual knowledge to develop their homes, financial constraints, uneven access to technical resources, and increasing climate-related hazards affect these processes. Simultaneously, the complexity of material and design decisions can limit opportunities to reflect on how individual choices affect safety, comfort, and long-term adaptability. This underscores the need to support knowledge exchange and collaborative decision-making between residents and building professionals.

This study introduces Housing Flows Cards, a co-creative citizen science tool designed to facilitate joined reflection on design and material choices in self-organized housing. Grounded in housing studies conducted in Caribbean between 2022 and 2024 and inspired by Brand's "shearing layers" concept, the tool positions residents as partners in collecting, analysing and interpreting knowledge about design and material choices, challenges, and trade-offs.

Tested in St. Martin, the tool fostered dialogue, knowledge exchange, and shared understanding, demonstrating how co-creative citizen science can support assisted self-organized housing toward safer, more comfortable, and adaptive homes in hazard-prone areas.

4.1 Self-organized Housing and Climate Challenges

In many rapidly urbanizing regions, housing shortages and socioeconomic inequalities leave residents with little option but to construct their own homes. As a result, **self-organized housing** has emerged as an integral element of urban environments (Khan, 2014; Malaque III et al., 2015; O'Brien et al., 2020b), driven by the proactive and necessity-led driven building efforts of residents. The scale of these practices has expanded, making self-organized housing a primary solution for the majority of low-income residents, particularly those who cannot access formal affordable housing (Bredenoord et al., 2014b; Finucane et al., 2020; Kellett & Napier, 1995).

Self-organized homes develop incrementally, following a **step-by-step process** (Bhan, 2019; Bredenoord, 2016). Residents, often with minimal assistance, build **using locally available materials**—either purchased from nearby stores or sourced from the environment (Celentano & Habert, 2021; Cronin & Guthrie, 2010). **Construction methods** draw on historical knowledge, trial-and-error practices, and previous building experience (Khan, 2014; Mukherji, 2014). This type of housing is inherently dynamic, as residents continuously engage with their living spaces—modifying, expanding, reinforcing, and repairing them to accommodate evolving needs and circumstances. This ongoing adaptation, which we refer to as Housing Flows (Kuś et al., 2024), highlights the **temporality** of architecture: homes are not static products but dynamic living environments shaped though ongoing building activities in response to changing household structures, circumstances, and resource availability (Hudson, 2015b; Lall, 2022b; Lombard, 2013b; Till, 2007).

TOC

Residents who construct self-organized homes face significant challenges, including financial constraints, land insecurity, and limited access to technical and planning knowledge, which frequently result in dysfunctional layouts, limited comfort, and structural problems (Kessler, 2014). Reliance on low-cost, poor-quality materials, construction practices inadequate to site conditions and environmental risks further **increase susceptibility to hazards and deterioration** (Maynard et al., 2017b; McTarnaghan et al., 2016a; Murray et al., 2023b). This often creates an ongoing cycle of repairs and modifications that consumes residents' time, financial resources, and energy, affecting well-being and limiting overall opportunities.

This cycle is even more pronounced in regions with **harsh and extreme climate**, where environmental risks demand greater effort from residents to upkeep and repair homes. In tropical areas, such as the **Caribbean**, intense sun, salt exposure, and fluctuating humidity accelerate deterioration, requiring constant maintenance and repairs. The use of low-cost materials and building practices unsuitable for local conditions leads to structural weaknesses such as foundation damage, wall cracking, and roof leaks (Goldwyn et al., 2022b; Murray et al., 2023b; Rodgers, 2012). Additionally, hazards such as earthquakes and the increasingly frequent hurricanes—exacerbated by climate change (Kelder et al., 2025b)—further heighten vulnerability of self-organized homes (IPCC, 2022; Medina et al., 2019b; UN-Habitat, 2024).

While self-organized housing continues to provide shelter for a large share of low-income residents, it also faces numerous challenges, particularly in hazard-prone regions such as the Caribbean. These houses are continuously adapted, modified, and repaired over time. Each of these interventions require residents to make decisions about materials, construction methods, and layouts. Although these processes are **not guided by formal design processes, they are preceded by planning** and directly **affect housing conditions** including structural stability, environmental performance, and exposure to environmental hazards. Limited access to technical and planning knowledge often results in design choices that reduce comfort, accelerate material deterioration, and increase vulnerability to hazards. Improving **access to accessible technical guidance and planning support** can therefore play a critical role in enhancing quality of self-organized housing.

4.2 Assisted Self-Organized Housing and Co-creative Citizen Science

In hazard-prone contexts, one promising approach to improve the quality of self-organized housing is to reconsider the extent and form of **involvement of residents and building professionals in design processes and decision-making**. Historically, formal affordable housing has prioritized efficiency and low cost, often excluding residents from the design process (Fairus & Zairul, 2023; Lizarralde, 2011a). As a result, such housing frequently failed to meet individual needs or reflect cultural aspects, limiting residents' ability to improve their living conditions and cope with economic or social pressures (Greene & Rojas, 2008b; Wainer et al., 2016b). This raises important questions about resident involvement and agency in affordable housing, including **whose voices are foregrounded and how power is distributed** within decision-making processes (Awan et al., 2011; Kapp et al., 2008; Vale et al., 2014).

Assisted self-organized housing approaches—based on joined efforts between residents and building professionals—offer a viable alternative to formal affordable housing. Since the 1960s, scholars like Turner, Abrams, and Mangin have advocated for these approaches, which typically involve the provision of land, a basic housing core, and essential services to support incremental development (Abrams, 1964b; Harris, 2003b; Mangin, 1967b; J. F. Turner, 1972b; J. F. C. Turner, 1976b). These approaches seek to **optimize limited resources by combining design assistance with residents' involvement**, improving housing conditions and strengthening tenure security. They also emphasize a defining quality of self-organized housing: the development of non-standardized dwellings that allow residents to adapt their homes to individual needs and changing circumstances (Bredenoord et al., 2014b; Goethert, 2010b; Johnson & Lizarralde, 2012; Mota, 2021b; Mukhija, 2014b; Newton, 2013; O'Brien & Carrasco, 2021; Wainer et al., 2016b; Wakely & Riley, 2011b).

Such approaches that foreground residents' involvement offer multiple benefits in comparison to formal affordable housing. They can foster sense of ownership and **belonging and strengthen social ties** within communities (Sinha, 2012). They also support development of housing that **better align with local building practices, cultural preferences, and household priorities** (L. Harriss, Parrack, et al., 2020; Hendriks & Opdyke, 2020; Jan Bredenoord & Luz María Sánchez Hurtado, 2022; Zapata Campos et al., 2022). Furthermore, they can enable **knowledge exchange** on safe construction practices—especially important aspect in hazard-prone areas,

TOC

where residents rely on their own skills and resources to improve housing quality and post-disaster recovery (Bredenoord, 2023; Celentano et al., 2019; Lyons et al., 2010b; Maly, 2018; Satterthwaite et al., 2020; Schilderman & Lyons, 2011b).

Yet not all forms of resident involvement yield these benefits. Achieving substantive outcomes depends on involving residents from the earliest stages of a project, including in defining and framing the problem itself (Shalowitz et al., 2009). This is especially important when research addresses challenges that directly affect residents' everyday lives, such as those faced by people living in self-organized housing in hazard-prone contexts.

Public participation in scientific research—commonly referred to as citizen science—offers an approach for such early and substantive resident involvement. **Citizen science** engages participants across different stages of the research process, including data collection, methodological development, analysis, and interpretation (de Sherbinin et al., 2021; Gunnell et al., 2021; Kullenberg & Kasperowski, 2016). By grounding research in local knowledge and lived experience, citizen science can produce outcomes that are more relevant, actionable, and responsive to the needs of the communities concerned (de Sherbinin et al., 2021; Fraisl et al., 2022; Hecker et al., 2018; Parrish et al., 2018; Vohland et al., 2021). In addition, citizen science can increase awareness, knowledge, skills related both to research practices as well as the subject under study, while also fostering engagement and capacity for action among participants (Bonney et al., 2009, 2016; Laihonen et al., 2025).

Citizen science encompasses different levels and forms of engagement, commonly described as contributory, collaborative, and co-created approaches (Bonney et al., 2009). These levels vary in the degree of influence participants have over the research process, with higher levels of involvement generally associated with greater benefits for participants. Co-creation refers to working together and making shared decisions about the goals, meanings, and directions of a project, resulting in shared ownership of both the process and its outcomes (Brandsen et al., 2018; Dudau et al., 2019; Grindell et al., 2022; Nguyen et al., 2024; Sanders et al., 2008).

In this sense, co-creation can be integrated within citizen science approaches to enhance residents' agency, while citizen science itself can serve as a pathway toward co-creation and co-design. Co-created or **co-creative citizen science**, in particular, emphasizes full collaboration across multiple stages of a project and involves non-academic partners not only in research activities, but also in **decision-making processes such as defining problems, setting objectives, and shaping research aims** (Bonney et al., 2009; Gunnell et al., 2021; Laihonen et al., 2025; Robinson et al., 2024). Such approaches can strengthen residents' agency by valuing and integrating their knowledge and by enhancing their **capacity to make decisions, take action, and influence change.**

Facilitating resident involvement—particularly through **co-creative approaches**—often relies on innovative communication methods between participants. These methods commonly use tools, such as visual aids, prototypes, and games to support joint exploration, engagement, and mutual learning (Bridi et al., 2024b; Felstead & Thwaites, 2024; Hsieh et al., 2023; Palmieri et al., 2023; Peters et al., 2021). Designed as **interactive or gamified activities**, these tools can translate complex design decisions into accessible, visual, and participatory formats, enabling people without formal training to actively participate (Bunæs et al., 2023; Girard et al., 2013; Keeton et al., 2021; Spitz et al., 2018; Zheng et al., 2021).

Unlike conventional methods such as surveys and interviews, which can be experienced as extractive or inaccessible (Hecker et al., 2018), these tools invite interaction, dialogue, reflection, and collaboration(Vaajakallio & Mattelmäki, 2014). Among them, **card-based tools** have proven particularly effective in supporting co-creative processes. In various design fields, they have been used to structure discussion, visualize options and explore trade-offs (Carvalho et al., 2020; Christopher Alexander, 1979; Cunin & Dang Maéva, 2023; Dawes & Ostwald, 2017; Pieroni et al., 2020; Vickery et al., 2018).

Despite growing recognition of the benefits of co-creative citizen science, its application and associated tools remain limited, particularly in self-organized housing in hazard-prone regions such as the Caribbean. Such approaches can enable residents, researchers, and building professionals to co-create knowledge on design and material choices, risks, and trade-offs, fostering shared understanding, learning, and informed decision-making. These processes can produce locally grounded knowledge about materials, construction practices, and environmental exposure, supporting improvements in the conditions of self-organized housing. Moreover, co-creative citizen science can serve as a pathway to the co-design of housing, enhancing residents' agency in decision-making.

To address these challenges, this article develops and implements a co-creative citizen science tool, Housing Flows Cards, to **support knowledge exchange and structured reflection on self-organized housing in hazard-prone contexts**. The article presents the design and development of the tool, its implementation on St. Martin Island, and key insights gained from this process. The study contributes methodologically and practically by demonstrating how interactive, co-creative tools can facilitate citizen science and the co-production of knowledge on design and material choices, risks, and trade-offs. It explores participatory approaches that support engagement, dialogue, and reflection between residents and building professionals, and generates situated insights that can inform housing-related decision-making. Finally, the study evaluates the tool's usability, accessibility, and potential for refinement, offering lessons for applying co-creative approaches in self-organized housing contexts.

4.3 Methods

This study employs a qualitative research approach grounded in participatory methods and co-creative citizen science to examine challenges and decision-making processes in self-organized housing in hazard-prone areas. It focuses on the development and testing of a co-creative tool to support residents in reflecting on housing adaptation and design decisions related to safety and comfort through fostering knowledge exchange, shared reflection, and informed design and material choices, while also co-producing knowledge on housing adaptation practices and preferences.

To establish a theoretical and contextual foundation, the study integrates fieldwork with a literature review. The review explores key themes introduced in the paper, including self-organized housing in hazard-prone regions—particularly in the Caribbean—assisted self-organized housing approaches, and participatory methods—such as co-creation and citizen science. Insights from the literature informed an initial version of a Designing for a Flow framework, which guided the design of the empirical research process.

Field studies were conducted on St. Martin between 2022 and 2024 using ethnographic methods, including observations, photographic documentation, and semi-structured interviews with 30 residents. The interviews explored various aspects of self-organized housing, including layout, building materials, sourcing and construction processes, modifications over time, and climate-related challenges. The selection of interview participants was based on a pre-defined housing typology to ensure a representative overview of self-organized housing on the island (Kuś et al., 2025). The identified housing types included timber houses, concrete houses, timber-concrete houses, prefabricated houses, steel-frame houses, and mixed-material houses. The study adhered to ethical research standards, ensuring informed consent from participants and providing clear information about the research aims and data use. Findings from the fieldwork were synthesized and integrated with theoretical insights to further refine the framework, which was subsequently translated into the Housing Flows Cards tool, as detailed in Section 4.

The tool was tested on St. Martin in 2024 through interactive and co-creative sessions with individual residents and group workshops with building professionals and other partners connected to the construction sector, to evaluate its effectiveness in fostering engagement and knowledge exchange. The co-creative sessions focused primarily on low-income or lower-middle-income residents and consisted of 18 sessions, including participants representing each of the pre-defined housing types, ensuring a diverse range of self-organized and affordable housing on the island. Two group workshops were conducted, each with approximately 10 participants. Recruitment relied on local networks and gatekeepers, as well as invitations distributed through messages, emails, word of mouth, and other media.

The evaluation focused on four dimensions: (1) engagement, assessed through observations of participation and dialogue; (2) knowledge exchange, evaluated as the extent to which residents and professionals shared their perspectives and expertise; (3) usability and accessibility, examined through participants' ability to use the tool independently or with minimal facilitation; and (4) opportunities for refinement, identified through reflexive field notes documenting interactions, challenges, and suggestions for improvement. These findings are further explored in Sections 6 and 7.

4.4 Housing Flows and Tool development

Self-organized housing evolves over time as residents engage in construction, modification, and repairs. This ongoing process results in incremental housing development, reflecting how households respond to changing needs, resources, and environmental conditions. We refer to this dynamic process as **Housing Flows**, emphasizing the evolving nature of self-organized housing.

To address this continuous process of change, the **Designing for a Flow** framework (Kuś et al., 2024) proposes supporting housing adaptations by enabling the modification or replacement of individual building components, drawing on principles of circular design. The framework follows the typical construction sequence of a house, beginning with components that are the most permanent components and crucial for safety, and progressing toward components that are more frequently modified. By intentionally separating building components, the approach allows parts of the house to be altered over time without disturbing the entire structure, supporting gradual adaptation and long-term flexibility.

This framework draws on Brand's concept of **shearing layers** (Brand, 1995b), which distinguishes six layers of a building: **site, structure, skin, services, space plan, and stuff** (Figure 4.1). Each layer is defined by its function—for example, site refers to the building's location, while structure encompasses its load-bearing components. While site and structure are the most permanent, stuff are replaced or rearranged frequently (Figure 4.1). Understanding housing through these layers highlights how different design and material decisions have distinct **implications over time**.

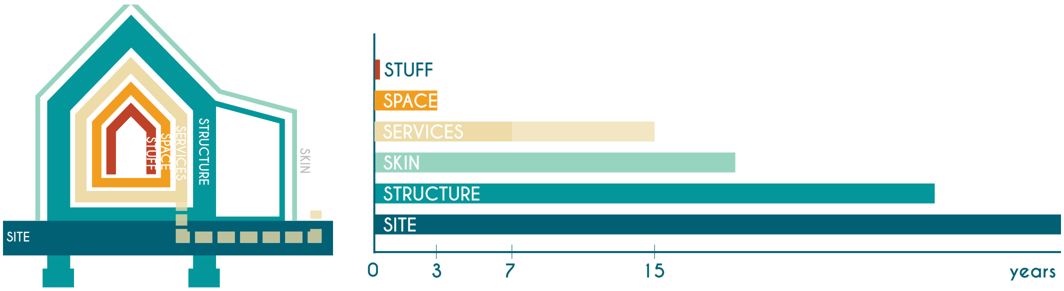


FIG. 4.1 Housing layers. *[Source: Based on (Brand, 1995b), adapted from (Kuś et al., 2024)]*

Conceptually separating housing into layers helps clarify how different **design and material choices relate to specific building components and their functions**. By isolating components, this approach allows the implications of individual design and material decisions to be discussed and reflected on separately, rather than treating the house as a single, fixed entity. Such separation supports structured reflection and data collection around housing decisions, creating opportunities for knowledge exchange between residents and building professionals and enabling the application of citizen science approaches.

To operationalize this approach and facilitate co-creation of housing knowledge, the Housing Flows Cards were developed. Drawing on the logic of layered construction, the tool adopts familiar vocabulary from traditional card games. The full set of cards is referred to as a **deck**, divided into six **suits**, each corresponding to one of Brand's identified layers (Figure 4.2). Within each suit, cards are organized into **ranks**, representing key elements of that specific suit. Each rank includes multiple

TOC

options, reflecting different materials or design components that players can choose from. These options are based on previous housing studies and represent the most common materials and design components available in the study's context.

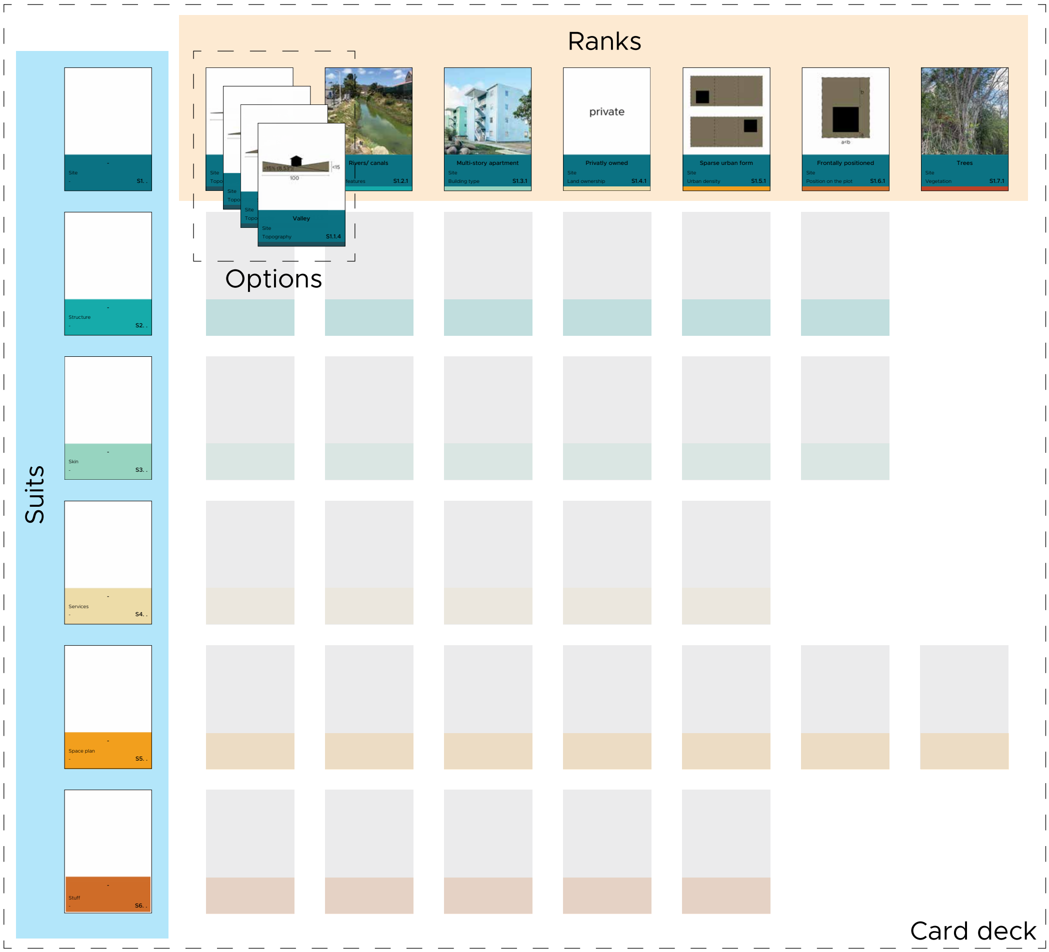


FIG. 4.2 Housing Flows Cards: Suits, Ranks and Options.

Defining the ranks and the options required identifying commonly used building materials and design components. To do so the research drew on self-organized housing analysis based on data collected on St. Martin (Figure 4.3). This material informed identification of commonly used components and materials, which were translated into the structure of the card deck.

SUITS	RANKS	Timber house	Concrete house	Timber-Concrete house	Prefabricated house	Steel-framed house	Mixed materials house
							
S1: SITE	Topography	Flat terrain	Flat terrain	Flat terrain	Flat terrain	Flat terrain	Slope
	Water features	Water stream	Water stream	Water stream	Water stream	Rivers/ canals	Water stream
	Building type	Detached unit	Detached unit	Detached unit	Detached unit	Detached unit	Detached unit
	Land ownership	Privatly owned	Privatly owned	Long-term lease	Privatly owned	Brief lease	Privatly owned
	Urban density	Open urban form	Compact urban form	Compact urban form	Compact urban form	Compact urban form	Compact urban form
	Position on the plot	Frontally positioned	In the back of the plot	Frontally positioned	Centrally positioned	Frontally positioned	In the back of the plot
	Vegetation	Shrubs and bushes	Shrubs and bushes	Shrubs and bushes	Trees	Soil/ no cover	Soil/ no cover
S2: STRUCTURE	Foundation system	Basement walls	Slab	Slab	Spread footing	Slab	Slab
	Structural system	Timber framing	Concrete framing	Composite construction	Prefabricated panels	Steel framing	Composite construction
	Floor system	Wood joists	Concrete slab	Concrete slab	Concrete slab	Concrete slab; Steel beams	Concrete slab
	Wall system	Wood framing	Concrete blocks	Concrete blocks; Wood framing	Prefabricated panels	Steel columns	Concrete blocks; Wood framing
	Roof system	Wooden gable roof	Concrete flat roof	Wooden gable roof	Concrete gable roof	Steel beams	Concrete flat roof
S3: SKIN	Insulation/ Vapor proofing	-	Vapor barrier	Vapor barrier	Vapor barrier	-	-
	Wall finish	Wood siding	Colored plaster	Colored plaster; Wood siding	Colored plaster	Metal panels	Colored plaster; Wood sidding
	Floor finish	Wooden floor	Tiles	Tiles	Tiles	Concrete; Tiles	Tiles
	Rooftop finish	Metal panels	Coated concrete	Metal panels	Asphalt	Metal panels	Metal panels
	Doors	Inward opening	Outward opening	Outward opening	Outward opening	Large gate	Outward opening
	Windows	Opening windows	Jalousie windows	Jalousie windows	Mixed window types	Fixed windows	Jalousie windows
S4: SERVICES	Electrical system	Electricity line	Electricity line	Electricity line	Electricity line	Electricity line	Electricity line
	Plumbing	Water cistern	Water cistern	Water cistern; Water lines	Water lines	Water lines	Water lines
	Sewage	Septic tank	Septic tank	Septic tank	Sewer pipes	Septic tank	Sewer pipes
	Heating	No heating	No heating	No heating	No heating	No heating	No heating
	Gas system	Gas bottle	Gas bottle	Gas bottle	Gas bottle	Gas bottle	Gas bottle
S5: SPACE PLAN	Access and circulation	Front and rear access	Front and rear access	Front and rear access	Front and rear access	Front access	Front access
	Bedrooms	1-bedroom	4 or more bedrooms	4 or more bedrooms	3 bedrooms	2 bedrooms	1-bedroom
	Kitchen	Kitchen	Kitchen	Open kitchen	Kitchen	Open kitchen	Kitchen
	Washroom	Bathroom	Bathroom (inc. toilet)	Bathroom (inc. toilet)	Toilet and bathroom	2 or more bathrooms	Bathroom (inc. toilet)
	Workplace	Only housing	Home-office	Only housing	Only housing	Carport, workshop	Carport, workshop
	Outdoor spaces	Porch	Private porch and yard	Private porch and yard	Private porch and yard	Private yard	Private yard
	Fencing	No fencing	Wire mesh/lattice fence	Fence wall	Wire mesh/lattice fence	Wire mesh/lattice fence	Fence wall
S6: STUFF	Cooling	Celling fans/ fans	Celling fans/ fans	AC and fans	AC and fans	AC and fans	AC and fans
	Lighting	Floor/ table lamps	Celling fixtures	Wall lighting	Wall lighting	Celling fixtures	Celling fixtures
	Window finishes	Window shutters	Window shutters	Window shutters	Window bars with shutters	Window bars	Curtains or blinds
	Storage	-	In-house storage	Outdoor storage shed	In-house storage	Large storage room	Open yard storage
	Furniture and décor	Cozy	Traditional	Contemporary	Traditional	Upcycled	Modern

FIG. 4.3 Overview of housing layers, suits and ranks for the exemplary housing types.

TOC

Although the Housing Flows Cards include materials and design components commonly used in St. Martin, they are designed as an open-ended, flexible tool that can be adapted to different contexts and accommodate unforeseen conditions. Cards that do not reflect local circumstances can be removed, and blank cards allow participants to introduce additional materials or components. This flexibility ensures that the tool remains responsive to diverse housing practices and evolving needs, reinforcing its co-creative quality.

The deck was developed as a set of laminated ISO 216 A6-sized cards, making them weatherproof and durable. Each card featured a large image, an option, a rank, a suit, and an identification number (Figure 4.4). To enhance usability, each suit was assigned a different colour. Additionally, coloured stripes at the bottom of each card visually indicate which cards belong to the same rank.

In the following sections we describe the deck in detail, elaborating on the ranks associated with each suit, and the options included in each rank.

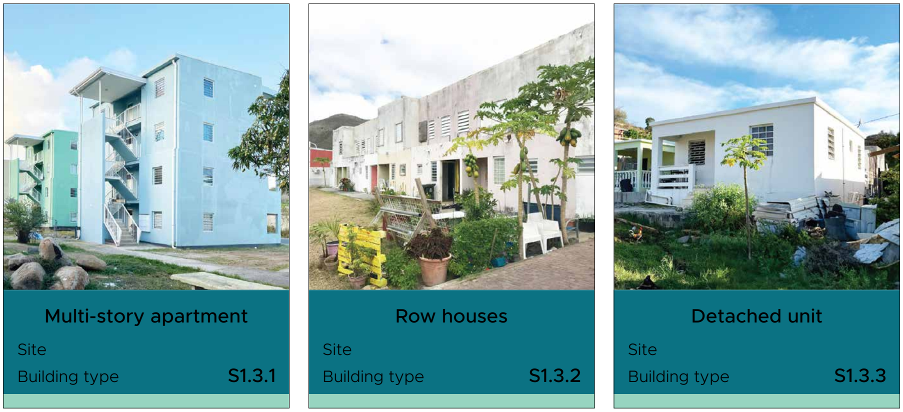
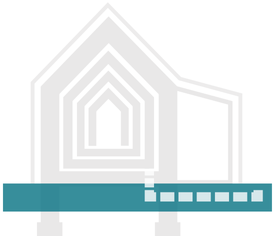


FIG. 4.4 Three options for Building Type Rank of Site Suit: Multi-story apartment, Row houses, Detached unit.

4.5 Housing Flows Cards: Suits, Ranks, and Options

4.5.1 Suit 1: Site



Site > **location and surroundings of the building, including:**

- **topography** (flat terrain, slope, steep slope, valley)
- **water features** (rivers/ canals, lakes/ ponds, wetlands, coastal, water stream)
- **building type** (multi-story apartment, row houses, detached unit)
- **land ownership** (privatly owned, long-term, short-term, brief, customary)
- **urban density** (sparse, open, compact)
- **position on the plot** (frontally, centrally positioned, in the back)
- **vegetation** (trees, shrubs and bushes, ground cover, soil/ no cover)

FIG. 4.5 Site Suit: Rank, and Options. Examples: (a) valley; (b) canal; (c) detached unit; (d) sparse urban density; (e) frontal position.

The ***Site*** suit defines key elements that shape housing design, including **environmental conditions, legal factors, and spatial constraints** (Figure 4.5). As the initial and crucial phase of the design process, site characteristics influence construction feasibility, long-term safety, and opportunities for incremental growth. While site characteristics are usually pre-existing, understanding them helps residents anticipate challenges and make informed choices about the construction while considering both constraints and opportunities.

Each rank within the *Site* suit focuses on a specific element or characteristic. Options within the *Topography* rank (Figure 4.6), for example, affect foundation design, construction costs, and maintenance needs. Discussing the options facilitates reflection on the challenges related to terrain—sloped sites may require reinforcement against erosion, while flat areas might need improved drainage. Similarly, the *Water Features* rank examines proximity to water bodies, opening discussions on risks such as flooding and the need for mitigation strategies like elevated foundations and drainage systems.

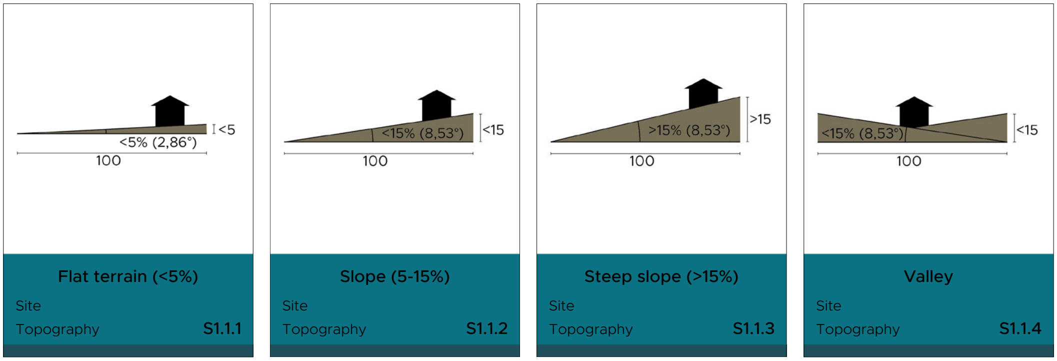


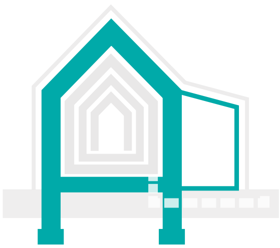
FIG. 4.6 Options for topography rank.

Four additional ranks within this suit—*Building Type*, *Land Ownership*, *Urban Density*, and *Position on the Plot*—address spatial and legal aspects. *Building Type* and *Urban Density* affect exposure to natural hazards like hurricanes and earthquakes, as well as access to ventilation, daylight, and space for expansion. Compact settlements, in particular, require careful safety planning and efficient space use. The *Position on the Plot* rank determines future incremental growth possibilities by considering the positioning of the initial development, accessibility to infrastructure, and privacy concerns. Meanwhile, *Land Ownership* plays a crucial role in construction decisions, as uncertain land rights often discourage investment in durable materials.

The final rank, *Vegetation*, highlights how greenery affects housing safety and comfort. Strategically integrating trees and plants can mitigate heat, improve air quality, and reduce maintenance costs by providing shade and erosion control.

By outlining these interconnected elements, the *Site* suit helps residents navigate key considerations related to a building's location and surroundings, facilitating the implementation of site-appropriate design choices.

4.5.2 Suit 2: Structure



Structure > **load-bearing elements and structural features, including:**

- **foundation system** (spread footing, slab, basement, post and pier)
- **structural system** (timber, steel, concrete, masonry, prefab, composite)
- **floor system** (concrete, wood, steel)
- **wall system** (concrete blocks, brick, wood, prefab, metal)
- **roof system** (concrete flat, concrete gable, wooden gable, wooden hip)

FIG. 4.7 Structure Suit: Ranks, and Options. Examples: (a) concrete structure; (b) metal structure; (c) concrete blocks wall; (d) wooden flat roof; (e) wooden gable roof.

The ***Structure*** suit includes key **load-bearing elements that ensure a building's stability, longevity, and comfort** (Figure 4.7). As one of the earliest stages in construction, the foundation and structural systems are the physical skeleton of a house. Because these elements are costly and difficult to modify, selecting appropriate design and material choices from the outset is essential for durability and minimizing future repairs. This suit consists of five ranks: *Foundation System, Structural System, Floor System, Wall System,* and *Roof System*, each addressing a critical aspect of structural integrity.

The *Foundation System* serves as the base of the structure, ensuring stability and proper weight distribution. Options like spread footings, slabs, and post-and-pier systems accommodate different site conditions and building specifications. While foundations are rarely altered after construction, selecting a suitable type is crucial for preventing settling or structural damage over time. Similarly, the *Structural System* determines the building framework which affects how the building bears and distributes weight. A well-chosen system—aligned with site characteristics, environmental conditions, and design needs—enhances structural resilience and the building's ability to withstand stress.

TOC

The options included in *Floor System, Wall System,* and *Roof System* ranks contribute to both safety and comfort. The *Floor System* must be strong enough to bear loads while resisting wear from long-term use and climate conditions. The *Wall System* supports load distribution while influencing thermal insulation, energy efficiency, and acoustics. Meanwhile, the *Roof System* provides critical protection from the environmental conditions. Different design options serve varying needs—flat roofs allow for easier expansion, whereas gable roofs perform better in tropical climates by improving thermal comfort.

By understanding the function of each structural component, residents can make informed choices that enhance the durability, performance, and adaptability of their homes.

4.5.3 Suit 3: Skin

Skin > **envelope of the building, including:**

- **insulation and vapor proofing** (rigid foam, mineral wool, vapor barrier)
- **wall finish** (brick, tiles, plaster, colored plaster, stone, wood, metal)
- **floor finish** (concrete, tiles, wood, stone)
- **rooftop finish** (concrete, shingles, asphalt, metal, concrete tiles, clay tiles)
- **doors** (outward opening, inward opening, large gate)
- **windows** (fixed, opening, jalousie, mixed types)

FIG. 4.8 Skin Suit: Ranks, and Options. Examples: (a) wooden wall finish; (b) floor tiles; (c) metal rooftop panels; (d) outward opening door; (e) jalousie windows.

The ***Skin*** suit includes ranks that describe the **building's protective outer layer, influencing durability, energy efficiency, and indoor comfort** (Figure 4.8). Comprising five ranks—I*nsulation and Vapor Proofing, Wall Finishes, Rooftop Finishes, Doors, and Windows*— each addressing key aspects of the building's envelope.

Insulation and Vapor Proofing regulate indoor temperature and moisture, affecting energy efficiency and material longevity. Options like rigid foam, mineral wool, and vapor barriers offer varying levels of thermal resistance and humidity control, essential for adapting to climate conditions. The *Wall Finish* and *Rooftop Finish* ranks determine exterior durability and aesthetics, with materials such as concrete, wood, and metal providing different levels of heat retention, weather resistance, and maintenance demands.

Openings, described in the *Doors* and *Windows* ranks, play a crucial role in ventilation, security, and access to natural light. In tropical climates, particularly in hazard-prone areas, *Doors* must balance durability with airflow, while their opening direction and hurricane impact rating are critical for resilience. Similarly, W*indows* influence air circulation, lighting, safety, privacy, and thermal efficiency, with options such as fixed, louvered, or operable designs offering varying levels of ventilation and climate control.

By organizing the elements of the outer layer of a building into ranks with distinct options, the *Skin* suit opens discussions on how materials and design components facilitate construction that is safe, comfortable, and suited to the environment.

TOC

4.5.4 Suit 4: Services

Services **> plumbing, electrical, and other systems, including:**

- **electricity** (electricity line, solar panels)
- **plumbing** (water lines, water cistern)
- **sewage** (sewer pipes, septic tank)
- **water heating** (boiler, no heating)
- **gas** (gas line, gas bottle)

FIG. 4.9 Services Suit: Ranks, and Options. Examples: (a) solar panels; (b) water cistern (Haase, 2017) ;(c) water pipes (Wfmillar, 2007); (d) electric boiler (DryPot, 2011); (e) gas bottles (Monkey, 2005).

The ***Services*** suit encompasses essential **systems that support a home's functionality**, including *Electricity*, *Plumbing*, *Sewage*, *Water Heating*, and *Gas* ranks (Figure 4.9). The options within this suit distinguish between on-grid solutions, reliant on local infrastructure, and off-grid alternatives, which affect costs, maintenance, and efficiency.

The *Electricity* rank features options for on-grid supply via overhead or underground lines, or off-grid solutions like solar panels, providing energy independence. The *Plumbing* rank includes choices between municipal water lines for consistent supply or independent cisterns for self-sufficiency. Similarly, the *Sewage* rank compares centralized systems, which require less maintenance, with septic tanks that demand more frequent upkeep.

The *Water Heating* rank offers options such as gas-powered boilers or the use of unheated water, reflecting varying levels of energy dependence. Finally, the G*as* rank distinguishes between centralized gas networks for continuous supply and replaceable gas bottles for more flexible use. These systems collectively define a home's operational efficiency, allowing residents to balance between on-grid convenience and off-grid autonomy based on infrastructure availability and environmental factors.

4.5.5 Suit 5: Space

Space > **layout and spatial organization, including:**

- **access and circulation** (front, side, rear, front and rear)
- **bedrooms** (1-bedroom, 2-bedrooms, 3 bedrooms, 4 or more bedrooms)
- **kitchen** (kitchen, open kitchen, open kitchenette)
- **washroom** (toilet and bathroom, bathroom, 2 or more bathrooms, toilet)
- **workplace** (home-office, carport/ workshop, only housing)
- **outdoor spaces** (private porch and yard, porch, private yard, shared yard)
- **fences** (no fence, wooden, iron, wall, wire mesh/lattice)

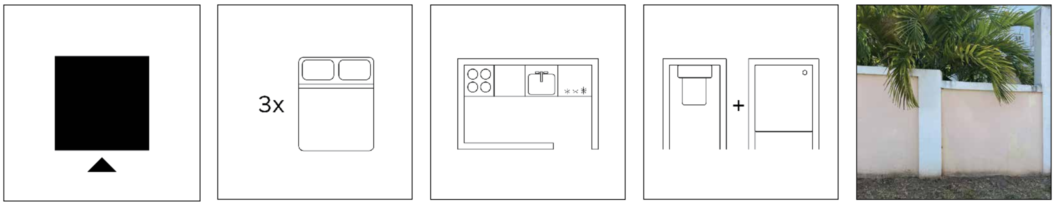


FIG. 4.10 Space Suit: Ranks, and Options. Examples: (a) front access; (b) 3-bedrooms; (c) kitchen; (d) toilet and bathroom; (e) wall fence.

The ***Space Plan*** suit defines a house's **functional organization** (Figure 4.10), **shaping movement, interaction, and adaptability**. In self-organized housing, where residents make incremental modifications, effective spatial planning is crucial for long-term functionality and adaptability. The arrangement of access points, plot boundaries, and types of indoor/outdoor areas directly affects comfort, privacy, and functionality over time.

The *Access and Circulation* rank addresses the organization of entry points, influencing circulation, security, and environmental resilience. It determines transitions between public and private areas, ensuring smooth movement while considering privacy. Similarly, *Outdoor Spaces* (e.g., yards, porches, or communal areas) strengthen the connection between private and community life, offering spaces for social interaction and recreation. The *Fences* rank, including plot boundary elements, defines privacy, security, and aesthetic choices, serving both functional and decorative purposes.

The organization of interior spaces, including *Bedrooms, Kitchen, Washroom,* and *Workplace* ranks, affects comfort and flexibility. The *Kitchen* rank, with options for open or enclosed layouts impacts household dynamics and interaction. The *Washroom* rank covers configurations ranging from shared to separate facilities, influencing both privacy and convenience. The last rank in the *Space Plan* suit—*Workplace*—emphasizes multifunctional spaces, such as home offices or workshops, highlighting the need for homes that accommodate both professional and domestic activities.

By organizing the *Space Plan* options into ranks, the tool guides discussions on how homes can remain adaptable to evolving household needs, cultural preferences, and environmental conditions, enhancing long-term functionality and minimizing costly future modifications.

4.5.6 Suit 6: Stuff

Stuff **> furniture, fixtures, and equipment, including:**

- **cooling** (air conditioners, AC and fans, celling fans/ fans)
- **lighting** (celling fixtures, wall lighting, floor/ table lamps, outdoor lighting)
- **window finishes** (curtains, bars, bars with shutters, shutters, rolling shutters)
- **storage** (in-house storage, storage room, outdoor storage, open yard storage)
- **furniture and décor** (minimalist, modern, art deco, traditional, mid-century, industrial, contemporary, upcycled, coastal, classic, eclectic, cozy)

FIG. 4.11 Stuff Suit: Ranks, and Options. Examples: (a) celling fan; (b) celling lamp; (c) window shutters; (d) window with bars and shutters; (e) outdoor storage.

The final suit, ***Stuff,*** addresses elements that shape **daily living and interactions within the home, directly influencing both functionality and aesthetics** (Figure 4.11). It is organized into five ranks—*Cooling*, *Lighting*, *Window Finishes*, *Storage*, and *Furniture and Decor*. While elements within these ranks are relatively easy to rearrange or replace, they play a crucial role in the overall living experience, cultural preferences, and personal expression.

TOC

The *Cooling*, *Lighting*, and *Window Finishes* ranks have a direct impact on comfort. The *Cooling* rank is particularly important in tropical climates, influencing indoor temperature, productivity, and health. Options such as air conditioning, ceiling or portable fans, or a combination of both affect energy consumption and thermal regulation. The *Lighting* rank influences both functionality and ambiance, with options like ceiling fixtures, wall-mounted lighting, movable lamps, and outdoor lighting offering varying levels of illumination and flexibility. The *Window Finishes* rank contributes to security, weather protection, and heat regulation, with options such as curtains, shutters, or security bars influencing privacy and indoor climate management.

The *Storage* rank is essential for organization and efficiency, with options ranging from built-in compartments to dedicated storage rooms, outdoor sheds, or open yard storage, all of which affect spatial utilization and household order. Lastly, the *Furniture and Decor* rank defines the home's character, balancing aesthetic preferences with practicality. Options such as minimalist, modern, traditional, or upcycled styles reflect individual identity while influencing spatial perception and comfort. By reflecting on the implications of choices within these ranks, residents can create adaptable, well-functioning environments that meet their long-term needs and improve living conditions.

4.6 Implementation, results, and observations

4.6.1 Implementation

To examine how co-creative citizen science can support knowledge exchange, structured reflection, and data collection around housing decisions, the Housing Flows Cards were tested through two types of activities conducted in mid-2024: (a) co-creative sessions with individual residents, and (b) workshops with residents, contractors, and building professionals.

All activities were structured around three key housing considerations: durability (safety), functionality (comfort), and aesthetic qualities (appearance). Together these activities provided insights into the tool's capacity to facilitate engagement and knowledge exchange, as well as usability, accessibility, and opportunities for refinement.

Co-creative sessions with residents

The sessions with individual residents were conducted through door-to-door visits at participants' homes. It total 18 sessions were carried out, primarily involving low-income or lower-middle-income residents. Participant selection process aimed to include representatives from each of the pre-defined housing types, ensuring a diverse overview of self-organized and affordable housing in St. Martin.

The sessions were designed to facilitate exchange knowledge and reflection on design and material choices and their perceived implications for housing durability, functionality, and aesthetics. Each session began with an introduction to the research scope and a brief explanation of how the tool works. Participants were then presented with the cards corresponding to the first rank and asked to select one card in response to series of questions.

The first question asked participants to choose the option they perceived as **the safest** option, defined as how well and safely the building is constructed. The second question focused on **comfort**, asking which card depicted the most functional and climate-adequate option. The third question was about **aesthetic qualities,** prompting residents to choose the option they found most satisfactory or beautiful. Finally, participants were asked to indicate the card that represented their **current housing situation**.

All card selections were recorded on a pre-prepared data sheet. In addition, residents' explanations, reflections, and comments were documented, including insights related to design and material choices as well as observations about the tool itself. This process was then repeated for each subsequent rank.

Workshops with building professionals

For the group workshops, building professionals and individuals connected to the construction sector were invited to participate. Recruitment relied on local networks and gatekeepers, as well as invitations distributed via messages, emails, word of mouth, and other media. This process resulted in two workshop sessions, each with approximately 10 participants (Figure 4.12). Although the invitations primarily targeted building-sector professionals, some residents also joined the workshop.

FIG. 4.12 (a) Picture from the workshop (b) set of selected cards.

The workshop followed the same structure and sequence of questions as the co-creative sessions, using a digital version of the tool for facilitation. Due to time constrains and the group setting, capturing individual reflections on each option was not always possible. Instead, after completing the ranks within each suit, participants we encouraged to collectively share their expertise and reflect on the reasoning behind their choices. This often led to in-depth discussions and exchanges of expertise among participants.

4.6.2 Results

The activities conducted in mid-2024 provided insights into the potential of the Housing Flows Cards as a co-creative citizen science tool to facilitate engagement and knowledge exchange between residents and building professionals on material and design choices in self-organized housing in hazard-prone contexts, such as the Caribbean.

Both residents and building professionals engaged actively with the tool, demonstrating strong interest in discussing current housing conditions, material and design choices, and the priorities shaping decision-making. Engagement was evident through sustained dialogue, participants' willingness to share personal experiences and opinions, and the frequent extension of sessions beyond their planned timeframe. Participants articulated perspectives on safety, comfort, and aesthetics, with particular emphasis on the role of design and material choices in relation to safety in hazard-prone environments. Discussions frequently addressed housing adaptations, material performance, and climate-related challenges, revealing how priorities—especially durability and hazard resistance—emerged in response to environmental exposure and resource constraints. This process reflects co-creative citizen science in practice, as participants did not merely provide information but actively contributed to knowledge co-production by jointly reflecting on decisions, risks, and trade-offs.

The visual and layered structure of the cards supported usability by allowing housing components to be considered separately while maintaining an overall view of the building process. Both participants and researchers found the card-based format engaging and accessible, as it provided a clear structure that was easy to follow while accommodating diverse viewpoints. The sequencing aligned with construction stages was perceived as intuitive, facilitating structured discussion and reflection and supporting inclusive participation across different knowledge backgrounds.

Data collected through survey sheets and compiled into spreadsheets provided a comparative overview of material and design choices across the identified housing types, capturing considerations of durability, functionality, aesthetics, and the current housing situation (Figure 4.13). The tool made visible trade-offs between those considerations and pointed out participants' priorities. Across sessions, durability was consistently emphasized, while functionality and aesthetics were often secondary. Reflections further highlighted how financial constraints, environmental risks, and material availability shaped decision-making processes.

	concrete frame		com/ c + w			com/ mix			prefab			steel frame			timber frame	
Feature/ type	2604	15B	3004	1405	15D	605	15C	17A	105	205	17B	2904	15A	17D	505	SUM
Spread footing	1		1	1	1		1			1		1				7
Slab		1											1		1	3
Basement walls						1			1							2
Post and pier foundation																0
Timber framing		1	1													2
Steel framing																0
Concrete framing	1				1		1		1	1			1		1	7
Masonry construction				1					1							2
Prefabricated panels												1				1
Composite construction						1										1
Concrete slab	1		1		1	1	1					1			1	7
Wood joists		1														1
Steel beams										1			1			2
Concrete blocks			1	1					1			1	1		1	6
Brick masonry					1		1			1						3
Wood framing						1										1
Prefabricated panels	1	1														2
Metal wall												1				1
Concrete flat roof	1		1	1	1		1		1	1			1			8
Concrete gable roof		1														1
Wooden gable roof						1						1				2
Wooden hip roof															1	1

FIG. 4.13 Example of compiled data from individual sessions on durability considerations.

TOC

While the tool fostered engagement and supported the co-creation of knowledge, several limitations emerged. Some cards were set aside when options were unfamiliar or deemed less relevant to immediate needs. Sessions often exceeded planned durations, reflecting both the depth of engagement and the time required for participants to articulate perspectives, particularly in group settings. Participants suggested refinements, including simplifying the deck and integrating climate-specific considerations more explicitly. These observations underscore the need for iterative development and the importance of adaptability in co-creative citizen science tools. These observations are explored further in the following section.

4.6.3 Observations

These results and observations highlight the importance of co-creation not only in testing tools, but throughout their development, refinement, and use. Co-creating knowledge and tools with people directly affected by housing challenges supported the development of shared understanding and revealed context-specific needs that would not have emerged through researcher-led design alone. Engagement across multiple stages of the process underscored how co-creation contributes to outcomes that are more relevant, usable, and adaptable.

The co-creative sessions—often held in residents' homes or on porches—used the card-based format to structure dialogue and guide discussion. At the same time, practical challenges emerged, such as navigating a large number of cards (e.g., as in the *Furniture* rank), and managing sessions in outdoor environments affected by wind or limited shade. These experiences emphasized the need for adaptable formats that can accommodate varying environmental conditions.

Differences in interpretation further illustrated the value of co-creation for refining the tool. For instance, residents often interpreted "slope" as the lower part of a hill and "steep slope" as the upper section, rather than as variations in inclination. Similarly, "metal structure" was frequently understood as reinforced concrete rather than a steel-frame construction. Rather than being treated as misunderstandings, these moments became opportunities to adapt the terminology and visuals with locally grounded meanings.

Participants also identified missing cards, such as the absence of options representing the lack of water features nearby, or material options like wood imitation or linoleum. The inclusion of blank cards enabled participants to introduce these alternatives, reinforcing the importance of keeping the tool open-ended and responsive to local realities.

The sessions also revealed how lived experience shapes housing priorities, pointing to biases in decision-making. Despite frequent power outages, solar panels were viewed with caution, due to perceived unreliability and hurricane vulnerability. Insulation was rarely prioritized, as it was considered more suitable for colder climates, while concrete remained the preferred option due to its durability—even when it offered limited thermal comfort in tropical conditions.

Overall, these co-creative exchanges informed key refinements to the tool, including clearer visuals, locally adapted terminology, and maintaining openness for additional options. More broadly, the process demonstrated how co-creation enables shared learning, surfaces situated knowledge, and strengthens collective reflection on housing decisions. This highlights the critical role of co-creative approaches in developing participatory tools that are context-sensitive, usable, and responsive to the realities of self-organized housing in hazard-prone environments.

4.7 Insights and recommendations

Easing interaction: Consistency, simplicity, and adaptability

Co-creative tools should be consistent, simple, and adaptable, to facilitate design engagement among diverse users, including those without technical expertise. The Housing Flows Cards showed both strengths and gaps. Some cards focused on materials, while others emphasized design components, causing occasional confusion. Similarly, some ranks, like *Furniture* offered too many options, making decisions harder. Clearer categories and fewer choices can improve usability.

Blank cards supported adaptability but were infrequently used, suggesting that customization requires explicit prompts or guidance. Future iterations of this and similar tools should actively encourage participants to add their options, ensuring that outcomes reflect local circumstances and aspirations.

Housing innovation: Supporting co-produced knowledge and co-design

Co-creative tools help generating contextual knowledge and collect data, but they are limited by their scope, content, and session structure. In the case of the Housing Flows Cards, while effective in promoting discussion on housing materials and design components, they did not fully capture the complexity of incremental building processes, such as the use of mixed materials over time.

The tool can also be adapted to move from analysis to co-design. In the context of housing, fostering future-oriented conversations means expanding the tool's scope beyond commonly used materials and design components, including options such as insulation, ventilation, renewable energy, or other innovative solutions.

Another improvement to support co-design of incremental housing is to complement the cards with visualizations that show how different components combine into a house—for instance, through drawing or sketching. These additions provide broader context and support more open-ended, collaborative, and reflective engagement. Specifically for the Housing Flows Cards, integrating them with floor plans or sketches would allow participants to collaboratively visualize existing or future houses. This approach would also strengthen co-creation by assisting residents communicate informed material and design decisions while expanding awareness of climate-adaptive possibilities.

Active participation: Collaboration and engagement

Fostering collaboration depends on structured session design, effective facilitation, and sustained interest. Sessions using Housing Flows Cards required active facilitation, indicating that they are more effective with at least two facilitators, particularly when participants speak multiple languages.

Gamification elements could further enhance interaction. For example, cards including point-based system rewarding comfort, safety, or cost-effective choices may encourage playful competition, deeper reflection on the design trade-offs, and balanced design solutions strengthening both creativity and collaboration.

Informed choices: Supporting autonomous design exploration

Although often designed for facilitated sessions, co-creative tools can be adapted for autonomous use, broadening accessibility. To support this, they need to integrate clear visuals and concise, user-friendly information. The Housing Flows Cards showed potential as a self-guided tool, especially for residents interested in exploring design choices and their implications at their own pace.

Adding short, easy-to-understand explanations and information about implications of each choice assists residents in making informed decisions and reduces reliance on facilitators. This would also extend the usability of such tools beyond structured sessions, making it more accessible and meaningful in everyday contexts.

4.8 Conclusion

Self-organized housing remains a prevalent form of shelter for many low-income residents, particularly in rapidly urbanizing regions. These homes develop incrementally through extensions, modifications, and repairs—a process referred to here as Housing Flows—largely guided by residents' experiential knowledge. While such practices demonstrate resourcefulness and adaptability, increasing climate-related risks expose significant constraints, especially in hazard-prone regions such as the Caribbean. These challenges affect safety, comfort, and long-term adaptability. At the same time, the complexity of material and design decisions can limit opportunities for residents to reflect on how individual choices shape overall housing conditions. This underscores the need to strengthen knowledge exchange and collaborative decision-making between residents and building professionals.

Assisted self-organized housing offers one pathway to address these challenges by bringing residents and professionals together. Such approaches can be further strengthened by enhancing residents' agency throughout the housing process, including early stages such as problem framing. Co-creative citizen science provides a framework for such collaboration by involving residents in data collection and joint interpretation. The Housing Flows Cards operationalize this approach by translating Brand's concept of shearing layers and insights from Caribbean housing studies into a co-creative, card-based tool that structures discussion, reflection, and data collection around material and design choices in relation to safety, comfort, and appearance.

Empirically, testing the tool in St. Martin demonstrated its capacity to foster engagement, dialogue, and knowledge exchange among researchers, residents, and building professionals. The co-creative sessions and workshops supported knowledge co-production by integrating diverse perspectives and enabling structured reflection on design and material decisions in relation to priorities, risks, and trade-offs. Beyond facilitating dialogue, the cards provided a systematic framework for organizing comparative data across housing types, highlighting shared concerns—particularly durability—as well as context-specific constraints linked to finances, environmental exposure, and material availability.

Beyond these findings, the study also contributes conceptually by foregrounding housing as an incremental and evolving process. The tool supports discussion of complex design decisions while valuing both residents' lived experience and professional expertise, highlighting the importance of visual, co-creative formats that are consistent, adaptable, and accessible across diverse knowledge backgrounds. While the Housing Flows Cards successfully facilitated knowledge co-production around material and design choices, iterative refinements—such as clearer visuals, expanded climate-adaptive options, and enhanced gamification—offer concrete directions for strengthening engagement and knowledge exchange.

Beyond the facilitated sessions, such tools also hold potential as self-guided resources that enable residents to explore design options and make informed decisions independently. They further suggest pathways toward housing co-design by building on co-created knowledge and fostering forward-looking conversations about adaptation and resilience.

Overall, the Housing Flows Cards illustrate how participatory tools can connect research with situated housing practices by operationalizing co-creative citizen science through a card-based format. Rather than producing design solutions directly, the tool supports shared understanding of material choices, risks, and trade-offs. In this study, it proved valuable for residents, building professionals, and researchers, while indicating relevance for policymakers and designers. Together, these findings demonstrate how structured, co-creative approaches can contribute to more context-sensitive engagement with housing adaptation in settings marked by limited resources and increasing climate-related risks.

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5 Co-creating Housing Resilience

A Gamified Approach to Designing for a Flow

Under submission (March, 2026)

ABSTRACT

In climate-affected and hazard-prone regions, conventional housing development models frequently fail to reflect the lived realities, cultural practices, and environmental conditions of local communities. This research investigates the potential of co-design to support more inclusive and resilient housing through the development of a gamified co-creation tool—Designing for a Flow—a card-based design game that facilitates collaboration with residents, students, architects, and built environment professionals. This tool, tested on the island of St. Martin, supports collaborative exploration of housing design, guiding users through decision-making around the development trajectory, material options, cost, and climate-adaptiveness. Gamification elements—including a fictional currency and comfort and performance factors—encourage playful, critical engagement and collective learning. Deployed in the co-design of a student housing project, the tool enabled participants to articulate context-sensitive proposals grounded in local knowledge, priorities, and constraints. The process not only fostered knowledge exchange but also strengthened participant agency, reframing housing as a negotiated, situated, and ongoing process. This study contributes to emerging scholarship on co-design tools by offering a replicable framework for facilitating meaningful participation in housing development across diverse, under-resourced contexts.

5.1 Introduction

5.1.1 Rethinking housing

Housing is often framed as a market commodity or a long-term financial investment. Yet its meaning extends far beyond economic value. A home is a site of memory, identity, and security—a place where daily life unfolds, where personal milestones are marked, and where individuals build a sense of belonging (Easthope 2004; Flinn 2020; Oliver 2006). For many, it is the most significant financial and emotional investment of their lives.

In recent decades, **access to adequate and affordable housing** has become increasingly limited. This trend affects diverse regions, including Europe (Eurostat 2024), Latin America, and the Caribbean (McTarnaghan et al. 2016; Sánchez 2024), where rapid urbanization and growing socio-economic disparities make it difficult for many residents to find housing within their financial means (Czischke 2019). The **financialization and commodification of housin**g—as homes are increasingly treated as investment assets—have further exacerbated these challenges. While existing homeowners and investors benefit from rising property values, this dynamic often contradicts the goal of providing affordable housing, creating a more complex and systemic problem (Gallent 2022). The impacts are **most acutely felt by those systematically marginalized within housing systems**, including students, young professionals, low-income families, elderly residents, migrants, people with disabilities, and certain ethnic groups.

In response, many governments have promoted **top-down solutions**, such as state-led or subsidized social housing programs. These approaches rely on professional leadership and external resources throughout the planning, development, and implementation of projects (Macdonald 1995; Larrison 1999). However, these approaches often lead to the further marginalization of those in need of housing (Hughes 2021; Chaskin 2016). Moreover, these initiatives often overlook middle-income households, who fall between the cracks—earning too much to qualify for social housing, yet unable to afford market-rate options due to high housing costs (Czischke and van Bortel 2018).

While **social housing** schemes aim to improve affordability, they frequently exclude residents from meaningful participation in the design, construction, and decision-making processes. This disconnect is often rooted in the separation between those who fund or manage the projects—such as developers or foundations—and those who ultimately inhabit the homes (Sani, Ulucay, and Ulucay 2011). This **lack of involvement** can result in standardized units that provide shelter but fail to meet households' social, cultural, or spatial needs—raising critical questions about their long-term sustainability and the notion of what makes a house a *home* (Chiu 2006; Wainer, Ndengeingoma, and Murray 2016; Buckley, Kallergis, and Wainer 2016).

In contrast to top-down housing developments, alternative housing movements emphasize **bottom-up** approaches rooted in community initiative and self-determination. These processes often emerge through **proactive efforts by individuals** or communities to construct their own homes, drawing on local knowledge, mutual aid, and social networks (Khan 2014; Cronin and Guthrie 2010; Mukhija 2014; Wakely and Riley 2011). In many contexts, residents build their homes independently or in collaboration with neighbors, creating solutions that directly respond to their lived realities.

A compelling example of this is the concept of **jollification** in the Caribbean, where friends and neighbors come together to collectively construct a home for a household over time (Hale 2015; The World Bank 2017). In exchange for food, drinks, and shared social experiences, community members contribute their labor and support. While such homes may not always conform to formal building codes or legal frameworks, they frequently offer more culturally relevant, adaptable, and immediate responses to residents' needs than state-led housing solutions.

The urgency of context-sensitive housing—recognizing homes as more than mere shelters but as lived spaces shaped by community, culture, and environment—is even more pronounced in regions impacted by **climate change and environmental hazards** (Hendriks et al. 2016; Schilderman 2010; Davidson et al. 2007; De Sylva 2018; Lizarralde 2008). The loss of a home due to a disaster such as a hurricane or earthquake is not just the destruction of a structure; it represents a profound disruption to social networks, emotional well-being, and livelihoods. In the Caribbean, amongst other places, the aftermath of the catastrophic 2017 hurricane season highlighted the need for a **more holistic housing approach** (Collodi et al. 2021; Jouannic et al. 2020)—one that goes beyond rebuilding physical infrastructure to restoring identity, memory, and local economies.

Such approaches signal a broader shift from extractive models of development toward **co-creative, inclusive practices**. Housing is no longer seen as a static product to be delivered, but as a dynamic process shaped collaboratively. Participatory design, in particular, has proven effective in promoting education, fostering agency, and supporting the right to adequate housing—especially in hazard-prone regions where resilience is vital to long-term sustainability.

TOC

5.1.2 Participatory approaches to housing: assisted self-help, co-housing and co-design

The housing crisis has prompted a rethinking of how we plan and implement development—and critically, **who is included and to what extent** (Vale et al. 2014; Kapp, Baltazar, and Morado 2008; Awan, Schneider, and Till 2011; Czischke 2019). Participatory approaches challenge traditional, top-down housing models that treat residents as passive recipients. Instead, they recognize **residents as active agents** with valuable knowledge and lived experience. These methods also push back against the commodification of housing, reframing it as a human right and a dynamic, community-driven process.

Rooted in bottom-up strategies, participatory housing approaches emerged to support **self-built** efforts, acknowledging the many challenges such homes face (Mangin 1967; Abrams 1964; J. F. C. Turner 1976; Harris 2003; Goethert 2010; Mota 2021). In Latin America, this perspective was notably advanced by John Turner, who argued that housing should be understood as an ongoing process rather than a static product imposed through centralized planning (J. F. Turner 1972). This paradigm shift emphasized **supporting self-builders** throughout the development of their homes, through partnerships between those responsible for development and the future residents.

Expanding this view, Livingston advocated for continuous technical support throughout the building process—comparing the **architect's role to that of a family doctor: accessible, supportive, and engaged** beyond the design phase (Stenberg, Harling, and Berglund 2022; Valladares 2017; Molina, Jori, and García 2025).

More recently, re-emerging **co-housing** initiatives have evolved into models that deepen resident participation while emphasizing social relationships, sustainability, and collective well-being (Giorgi 2020; Jakobsen and Larsen 2019; Tummers 2016; Czischke 2019). Although these models have primarily served middle-income residents so far, they stand in contrast to market-driven developments by prioritizing shared ownership, mutual support, and community-centered design. Co-housing typically combines private dwellings with shared facilities and collaborative activities, fostering a sense of community and mutual responsibility.

Co-housing developments are often driven by ideological commitments: to strengthen social capital, resist housing's commodification, and realign priorities toward inclusive, environmentally conscious living (Hagbert 2012). These models echo and reinforce principles from assisted self-help and incremental housing strategies. Beyond design **participation,** they offer cost-saving advantages (Stenberg, Harling, and Berglund 2022)—particularly important in post-colonial contexts, where reliance on imported materials, expertise, and decision-making structures can perpetuate inequality and dependency.

Within these frameworks, **co-production** and **co-design** have emerged as key participatory methods. They involve iterative, collaborative processes that integrate multiple forms of knowledge (Norström et al. 2020). These approaches blend the situated expertise of residents with the technical and theoretical insights of professionals (Sanders et al. 2008). Grounded in the belief that all individuals are inherently creative, co-design practices use tools such as visual collaborative methods (for example cards, diagrams, or sketches), workshops, and role-playing to challenge hierarchical planning norms and foster inclusive knowledge exchange (Sanoff 2000; Cruz et al. 2022; Sleeswijk Visser et al. 2007).

Such methods are essential for ensuring meaningful **resident involvement** throughout the housing development process. In hazard-prone and climate-affected regions, designing resilient housing requires **both technical expertise and situated knowledge**. However, achieving this level of participation remains challenging. Participatory processes are often time- and resource-intensive, with uncertain outcomes, and conventional development frameworks rarely allow the flexibility or duration they require.

This research addresses that gap by exploring how co-design can be effectively applied in real-world housing contexts. It introduces **Designing for a Flow**, a card game developed to support the co-creation of resilient homes through a **gamified, participatory approach**. The tool was implemented in the co-design process of a student housing project in the Caribbean, bringing together students, community members, researchers, and built environment professionals in a collaborative setting. Serving as both a participatory tool and an educational prompt, the game facilitated the development of context-sensitive housing proposals and offered a replicable model for inclusive, community-driven design process.

5.2 Methods

This study employed qualitative research methods, combining literature review, field interviews, tool development, and participatory design workshops. The methodology was structured in three interrelated phases.

The initial phase involved a review of literature on housing challenges in hazard-prone areas, with a particular focus on the Caribbean region. Special attention was given to themes of climate adaptability and the role of participatory approaches in housing development. Context-specific insights were drawn from fieldwork conducted in 2023 on the island of St. Martin. This included interviews with residents living in affordable housing, which revealed needs for integrating resident participation into construction practices. The findings emphasized the importance of designing context-sensitive, climate-adaptive housing solutions that respond to local needs. This phase also incorporated a review of co-design strategies and participatory tools relevant to community-engaged housing development.

Building on the insights from Phase 1, the second phase focused on adapting an existing participatory analytical tool—Housing Flows Cards—into a design tool. Initially used to facilitate discussions with residents about housing challenges and local building practices, the tool was enhanced through a literature review on gamification, participatory design games, and strategies for resilient housing. Consultations were held with local architects and housing professionals to explore context-specific design improvements, emphasizing structural resistance and performance, as well as comfort and adequacy. This process culminated in the development of a revised participatory design tool, titled Designing for a Flow Cards.

The final phase involved testing the newly developed design tool in the context of St. Martin through three participatory design workshops held at the University of St. Martin in January 2025. These workshops aimed to co-design student housing proposals using the Designing for a Flow Cards as the engagement instrument. Participants included university students, staff, community members, and built environment professionals. The sessions provided opportunities for collaborative design exploration and practical application of the tool within a localized context.

5.3 Involving the residents towards co-design of climate-adaptive housing

Involving residents across the diverse stages of the design process is a challenging task. It is rooted in the belief that all people are inherently creative and that a successful project requires various types of knowledge—including design expertise, theoretical understanding, and situated knowledge (Sanders et al. 2008; Norström et al. 2020). In co-design processes, this is often achieved through iterative collaboration across all phases (Norström et al. 2020; Steen 2013).

5.3.1 Step one - Context studies and housing

Context studies are essential in shaping design hypotheses and developing responsive, grounded proposals. Actively involving participants at this early stage is key to ensuring that the design outcomes are relevant, inclusive, and reflective of real needs. However, this phase is often the most ambiguous and, in many cases, reverts to conventional design practices that may overlook the situated knowledge of local communities (Sanders et al. 2008).

In this project, we prioritized applied ethnographic methods, working collaboratively with residents to understand the housing context and its associated challenges. This was a deeply iterative process, combining literature reviews on building design issues—particularly around affordability—with community-based exploration of how people navigate the balance between safety, comfort, and aesthetics in their homes.

Through this engagement, it became clear that incremental and adaptive building practices are embedded in the region's construction culture. Historically, residents in the Caribbean have often started with modest structures built from readily available, often natural, materials—gradually expanding and reinforcing their homes over time (Figure 5.1). This long-standing, **layered approach** to construction directly informed our subsequent theoretical inquiry into housing models that support user-led modifications.

FIG. 5.1 (A) Layered housing approach observed in a historic home in Aruba. Initially constructed using wattle and daub techniques, later reinforced with concrete. (B) The same home from the opposite side, showing a newer annex constructed with wooden panels.

To deepen our understanding of these evolving building practices, the study included the co-creation of housing narratives. Through interviews with residents, we co-developed housing layouts and personal stories that traced the transformation of homes over time—revealing patterns of development, adaptation, and lived experiences (Figure 5.2). We refer to these ongoing processes as **housing Flows** (Kuś et al. 2025). These insights, rooted in collaborative design thinking and proactive engagement, informed the development of a design framework that supports the types of changes residents already make, while promoting a balance between **durability, functionality, and aesthetic value**—the three core architectural principles proposed by Vitruvius (Vitruvius 1999) (Figure 5.3).

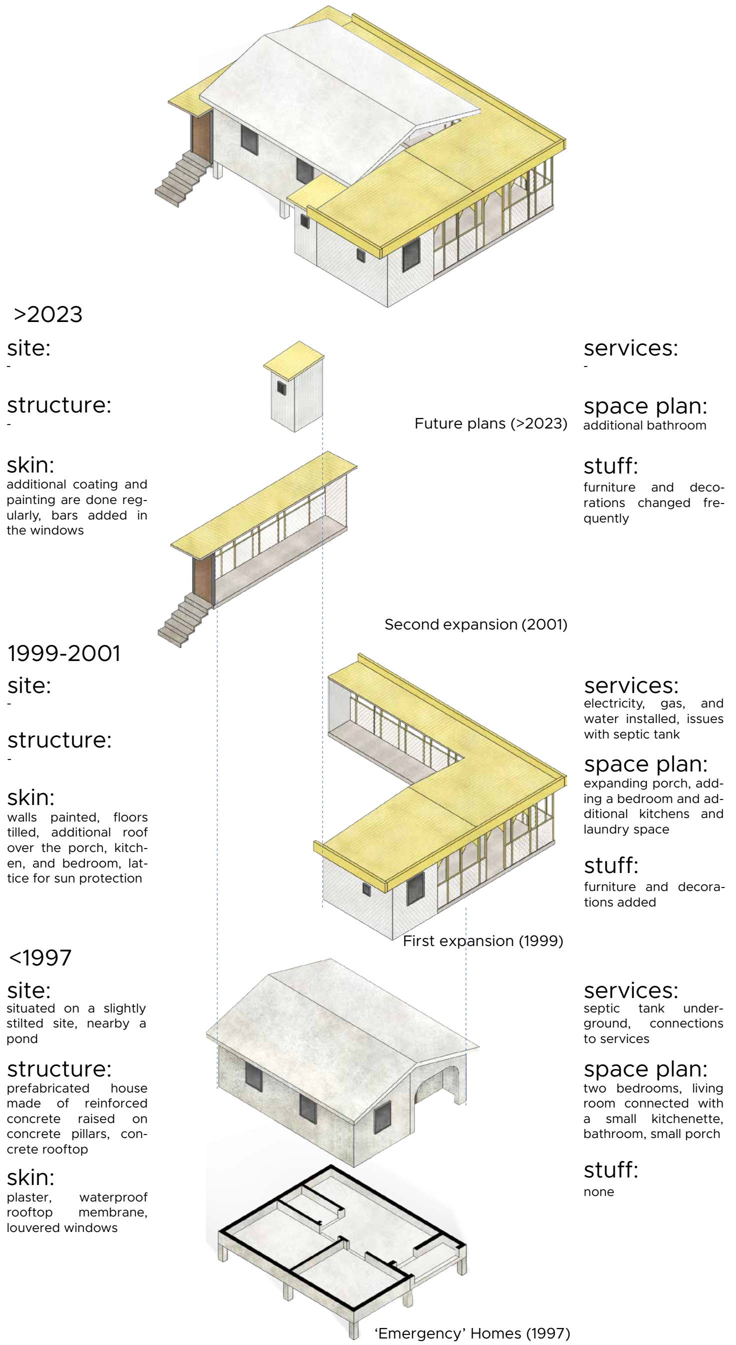

FIG. 5.2 Studies of housing Flows, presenting the gradual modification of a home in St. Martin.

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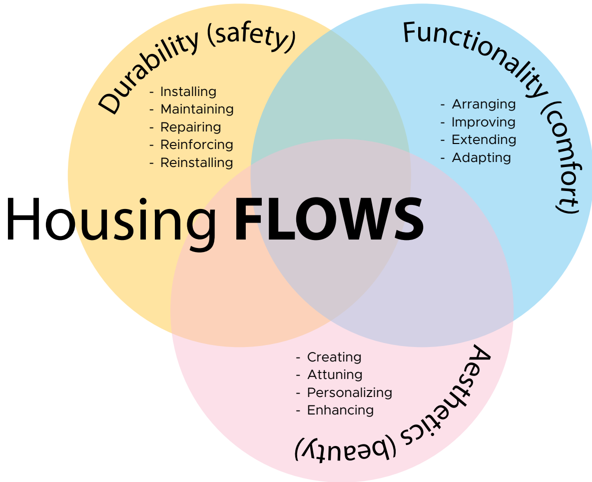

FIG. 5.3 Framework of housing Flows, indicating housing adaptations related to durability, functionality, and aesthetics.

This framework is anchored in principles of the circular economy and intentionally builds upon the organic, resident-driven practices already present in the region. Rather than imposing a fixed or external design logic, the research sought to recognize, support, and enhance existing modes of adaptation. The resulting approach—**Designing for Flow**—draws inspiration from Brand's concept of *shearing layers* (Brand 1995), reinterpreted through the lens of Caribbean housing traditions (Kuś et al. 2024). It envisions homes **as composed of distinct, physically separated layers, allowing for modifications and extensions over time** without compromising the integrity of the entire structure.

This progression—from context studies to collaborative narratives and theoretical framing—highlights the vital role of early-stage community engagement in co-design processes.

5.3.2 Step two – Housing perceptions and preferences: Housing Flows Cards

Building on the shared understanding developed through the initial contextual studies and housing narratives, the second step of the design process focused on collaboratively exploring residents' housing perceptions, preferences, and everyday challenges. This phase created space for deeper dialogue with participants to co-investigate the lived realities of housing—mapping aspirations, constraints, and priorities that shape their environments. These collaborative insights played a vital role in guiding the design direction and ensuring residents remained co-authors in shaping future housing possibilities.

To support this inclusive engagement, we co-developed a participatory and analytical tool called Housing Flows Cards (Kus et al.) (Figure 5.4). Used in both individual sessions and group workshops, the tool helped facilitate conversation while allowing for structured, yet flexible, data gathering. Rooted in the Designing for Flow framework—which values adaptability, sequencing, and user-led transformation—the tool translated the idea of **layered construction into a card game format**, drawing inspiration from a familiar cultural activity enjoyed by many residents.

FIG. 5.4 Display of Housing Flows Cards.

Each suit of the deck corresponded to a layer of the home (e.g., site, structure, skin, services (Brand 1995), and each rank within a suit represented relevant aspects of that layer. These ranks offered a range of material and design options, grounded in local housing practices and informed by analytical studies of collaboratively developed housing narratives. This ensured the tool reflected real decisions residents face while also introducing alternative possibilities. The format encouraged participants to share housing stories, reflect on lived experiences, and explore new paths in a playful, inclusive setting.

Piloted in St. Martin, the Housing Flows Cards facilitated meaningful conversations around housing needs, values, and design trade-offs. Beyond data collection, the tool served as a platform for mutual learning—raising awareness and affirming participants' expertise while creating space for collective reflection.

While highly engaging, the sessions revealed challenges. Discussions often diverged due to participants' strong experiential knowledge, and some sessions ran long. These insights highlighted the need for adaptive facilitation and led to the tool's refinement into a more structured projective simulation—offering a participatory, step-by-step exploration of the housing process.

These transformations aimed to simulate the housing development process—from early site decisions to detailed choices like window selection—shifting the tool from an analytical format to a co-creative simulation that enabled participants to explore potential scenarios and engage in dialogue about trade-offs, consequences, and aspirations, grounding design in both everyday realities and future possibilities.

5.3.3 Step three- Co-creative design process

Building on this evolution, the third step in the design process focused on generating design ideas collaboratively. Instead of relying on architects or designers to propose concepts later validated by the community, this approach positioned residents as co-creators from the outset—recognizing the value of lived experience and local knowledge in shaping meaningful solutions.

To support this, we developed the **Designing for a Flow Cards**, an extension of the earlier Housing Flows Cards. While the first iteration focused on gathering insights into housing perceptions and needs, this version was crafted **to facilitate informed decision-making and co-design dialogue**. Still grounded in Brand's theory of shearing layers, it reflects the phased nature of incremental housing typical of Caribbean contexts.

Participants used the cards to make a **sequence of choices**—from broad planning decisions like building form, to detailed architectural elements like windows and finishes. The tool embedded critical information about material options, design trade-offs, and practical financial implications, enabling participants to navigate the housing journey in a playful yet reflective way.

This structured, participatory format supported the bridging of technical design knowledge with everyday experience, empowering residents to envision and shape housing solutions that are **feasible, resilient, and rooted in their realities and aspirations**.

5.4 Designing for a Flow cards: Towards gamification of housing design

To create a more interactive and projective tool, we drew on the concept of gamification—the use of game design elements in non-game contexts (Deterding et al. 2011). **Gamification** has been shown to transform routine or complex tasks into engaging, memorable experiences (Franzoni and Sauermann 2014). By incorporating **playfulness, challenge, and positive competition**, it increases attention, emotional investment, and participation (Rabah, Cassidy, and Beauchemin 2018; Brull and Finlayson 2016; Spitz et al. 2018)—qualities we found essential in previous co-design sessions for encouraging dialogue, mutual learning, and reflection.

Building on this approach, we designed the tool to **actively involve participants**, facilitate the exchange of diverse knowledge, and make visible the real-world trade-offs involved in housing decisions. These elements were embedded into the game structure, transforming the tool into a collaborative space for imagining alternatives, navigating constraints, and negotiating priorities. By combining lived experience with design thinking in a playful yet grounded way, the game fostered more meaningful engagement. To support this, several core elements were introduced, each aimed at encouraging informed decision-making and collective exploration.

5.4.1 Narrative context: Following a housing development trajectory

Learning through doing enhances both understanding and outcomes (Shute and Ventura 2013)—especially when grounded in narrative. Framing activities within the storyline of a housing project helps participants connect with real-life experiences and reflect on the purpose behind each decision. While research does not definitively prove that firsthand experience guarantees full understanding of structural risks, it does show that such experiences heighten awareness—particularly when paired with **access to information and resources**, which are critical for building resilient homes (Charles and Chang-Richards 2023; Mehdizadeh et al. 2023; Peacock, Brody, and Highfield 2005). Simulating the housing process in a step-by-step format **acts as a rehearsal**. It reveals how each decision influences the next and deepens understanding of construction complexity.

The game design **mirrors real-world housing development** by structuring the experience into phased stages, based on Brand's "shearing layers" concept (Figure 5.5). It begins with site and form decisions, followed by structure, skin, services, space planning, and furnishings. Since each decision influences the next, the initial cards focus on the building's position and conceptual form, followed by more tangible elements—starting with structural components, from foundations to the roof. By revealing these interdependencies, the tool fosters holistic thinking and helps participants understand the cascading effects of each choice, especially in hazard-prone contexts.

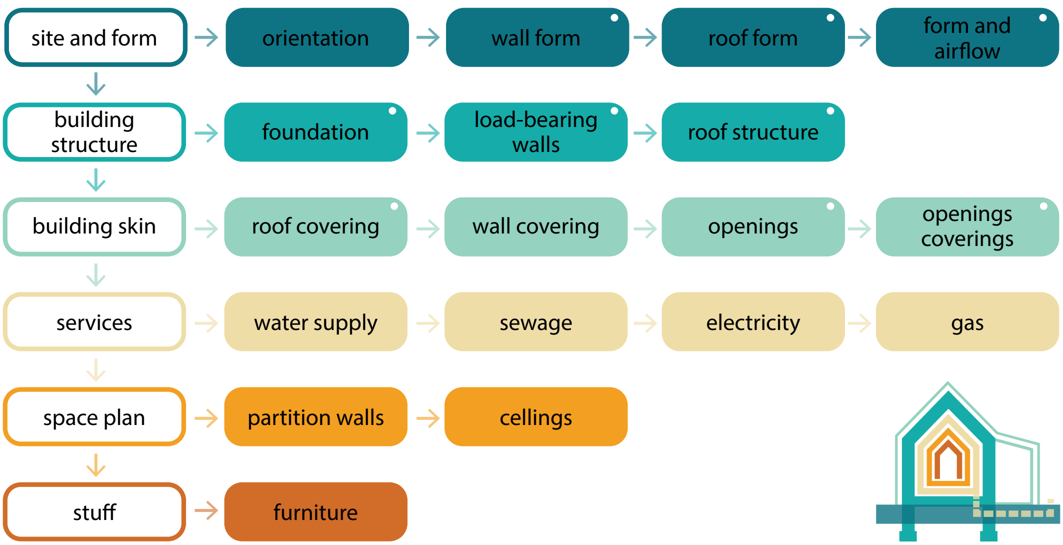

FIG. 5.5 Diagram illustrating the trajectory of housing development and the corresponding sequence of card ranks in the game. Ranks marked with a white dot (upper left corner) were included in card deck prepared for the St. Martin.

This sequencing is critical not just structurally, but **financially**. Early construction phases—like site preparations and the structural core—are often the most costly, yet novice builders may focus instead on visible features like finishes or furniture. This misallocation can leave core elements underfunded, increasing long-term risks such as leaks, cracks, or weather damage.

Drawing on previous experiences with the Housing Flows Cards—where extended playtimes occasionally made sustained engagement more difficult—we streamlined the St. Martin version by including three ranks from each of the first three suits: site and form, building structure, and building skin. These reflect the most critical decisions in early-stage housing design.

By structuring the game around the phased development of a home, we encouraged participants to prioritize essential investments first, deferring non-critical features as resources allowed. This let residents “pre-play” the process, building understanding and supporting more informed decisions.

5.4.2 Game design elements: resources, comfort, and resistance factors

To move beyond engagement and foster **informed decision-making**, it was essential that the game also function as a tool for **conveying critical knowledge**. We recognized the importance of providing clear, accessible information about the **trade-offs and implications of different design choices**. Some design decisions enhance comfort, others improve structural performance or climate resilience—and all of them interact with cost, influencing the overall feasibility of the project.

Architecture is traditionally guided by three core principles: durability, functionality, and aesthetics (Vitruvius 1999). In multi-hazard regions like the Caribbean, designing addressing durability concerns often involves balancing competing risks (Goldwyn, Javernick-Will, and Liel 2022). Strategies that mitigate one hazard can increase vulnerability to another—for example, while concrete is valued for storm resistance, it performs poorly in earthquakes (Goldwyn, Javernick-will, and Liel 2021). Similarly, elevating homes for flood protection may increase seismic risk (Goldwyn, Javernick-Will, and Liel 2022; Murray, Javernick-will, and Elwood 2021). These challenges are compounded by construction practices that neglect critical details like joints and connections, which often fail during disasters (Enajar, Nassef, and El 2023; Prevatt, Dupigny-Giroux, and Masters 2010; Rosowsky 2011).

Aesthetic and status-driven choices also shape housing design, sometimes compromising safety. Preferences for features like large windows (Rosowsky 2011) or coastal views can increase risks, as they often accelerate corrosion and heighten exposure during storms.

Beyond structural concerns, key functional aspects—like thermal comfort and adaptability—are often overlooked early in the design process. While durable materials may enhance resilience, they can reduce comfort; for instance, concrete absorbs heat, driving up cooling costs (Goedert 2008). Passive strategies like porches and eaves can improve comfort but may pose wind-related hazards (Prevatt et al. 2018; Rosowsky 2011). Still, research shows that climate-responsive design can be both cost-effective and livable, reducing long-term maintenance while enhancing everyday quality of life.

To reflect these complexities, we introduced three guiding evaluation categories into the structure of each card (Figure 5.6), addressing cost, functionality, and durability. **Cost**, representing financial impact, ranged from 10 to 100 *johnnies*—a fictional currency inspired by *johnny cakes*, a popular Caribbean dish. This playful, culturally resonant element simulated budgeting and made financial trade-offs more tangible. The other two categories were scored from 1 to 10, with higher scores indicating better performance. **Comfort and adequacy** addressed thermal comfort, livability, and alignment with local climate and culture, while **resistance and performance** focused on structural durability, safety, and environmental responsiveness. Embedded in each card, these categories enabled participants to assess options through a lens that balanced aspiration with practicality.

50 Costs	**8** Comfort & adequacy	**5** Resistance & performance

FIG. 5.6 Gamification elements presented on the bottom of each card, including costs, comfort, and resistance factors.

Based on maximum possible totals, card values varied (Figure 5.7): costs ranged from 290 to 520 johnnies; comfort and adequacy from 41 to 65; and resistance and performance from 44 to 70.5. Each group was given 450 *johnnies* to design a house, introducing real budget constraints and encouraging careful negotiation of priorities.

290-520	41-65	44-70.5
Costs	Comfort & adequacy	Resistance & performance

FIG. 5.7 Ranges of total scores for cost, comfort and adequacy, and resistance and performance.

The card scores were informed by a literature review on resilient and climate-adaptive design, interviews with local architects, and contextual studies. Through a comparative and iterative process, the research team systematically evaluated each option in relation to others, ensuring that values reflected both individual attributes and relative importance across the three categories. Repeated calibration and refinement led to a balanced scoring system designed to help participants understand trade-offs and make informed decisions during the co-design sessions.

For example, the most expensive item—a pile foundation—was valued at 100 *johnnies* (more than 20% of the available budget), while smaller non-structural elements, such as accordion shutters, were priced at just 15 johnnies (around 3% of the budget). In the comfort and adequacy category, high-performing materials like wood and insulation scored well: a wooden roof rated 8, wooden walls 7.5, while uncovered windows received a low score of 2. In resistance and performance, durable materials and structural systems—such as concrete, steel, and helical foundations—scored highest, with 8.5 for helical foundations and 8 for steel walls, despite lower comfort ratings.

By embedding these dimensions in a gamified format, the tool effectively combined engagement with education—deepening participants' understanding of the implications of their choices and fostering a participatory, meaningful co-design process.

5.4.3 Boosters: Climate-adequate and resilient design elements

Building elements affect both **comfort and resilience** in diverse ways, demanding thoughtful and informed decisions. However, early community engagements revealed that many participants were unfamiliar with how specific design choices influence safety, performance, and long-term outcomes—particularly the trade-offs involved. This underscored the need for participatory tools that not only foster collaboration but also build knowledge and confidence in navigating complex design challenges.

To make these considerations more tangible and accessible within the co-design process, we introduced a set of **"design boosters"** into the game. These were presented after participants completed the core card sequence representing the housing development trajectory (Figure 5.8). At this stage, it was essential for participants to pause and reflect on their design decisions, consider the balance of their scores, and evaluate the overall performance of their proposed home.

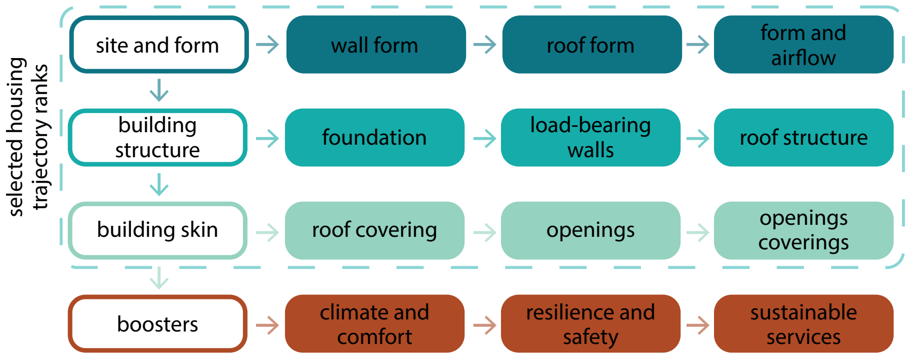

FIG. 5.8 Selected ranks for housing trajectory and booster ranks.

The boosters served as a second layer of engagement, offering participants the **opportunity to revisit and enhance their proposals** with building strategies that support climate responsiveness, hazard resilience, and sustainable services. Designed to address knowledge gaps often present in current housing practices, the boosters introduced essential building concepts in an accessible, engaging format.

Grounded in research on hazard mitigation and **climate-adaptive design**—and visualized through a set of illustrations (Figure 5.9)—each booster presented simple, actionable adaptations tailored to the Caribbean context. Their development was also informed by conversations with local architects and practitioners, ensuring the featured strategies were not only technically sound but also feasible and culturally appropriate.

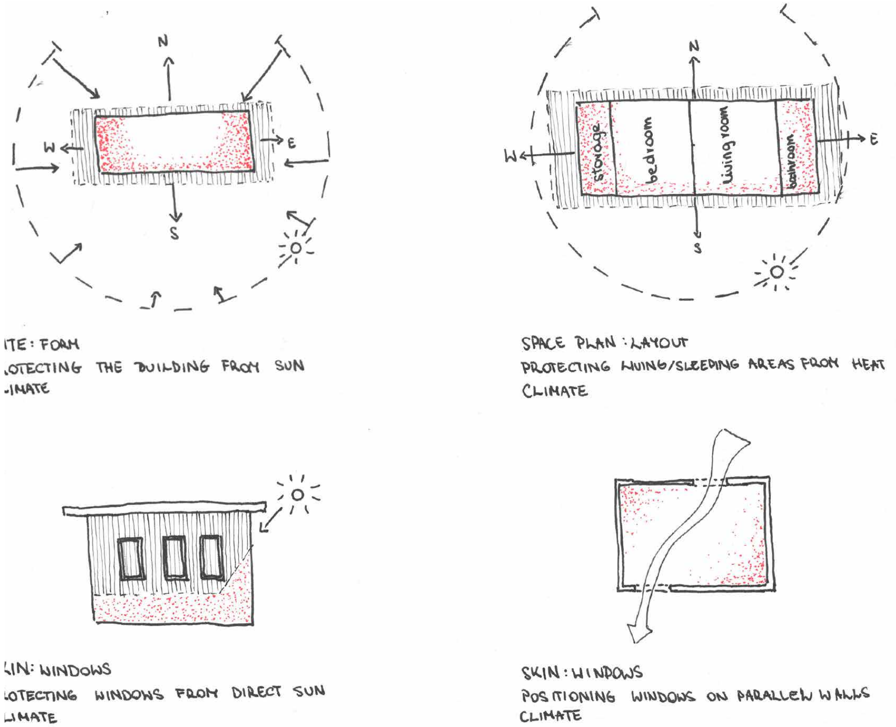

FIG. 5.9 Illustration of possible design boosters related to climate comfort.

By integrating boosters into the gamified structure, the cards evolved from being solely decision-making tools into catalysts for mutual learning and creative exploration. This addition enabled participants to explore alternative approaches, reflect on their implications, and co-create housing solutions that were both grounded in local realities and aspirational in vision.

5.4.4 Cards introduction

This co-design process culminated in the development of the **Designing for a Flow Cards**. The deck was structured around four suits, including the housing trajectory suits and boosters (Figure 5.10). Within each **suit**, three ranks were included to reflect the most critical components of that suit. Each **rank** contained a set of **options**—offering a variety of **material and design choices**—that participants could explore and select from during the game (Figure 5.11).

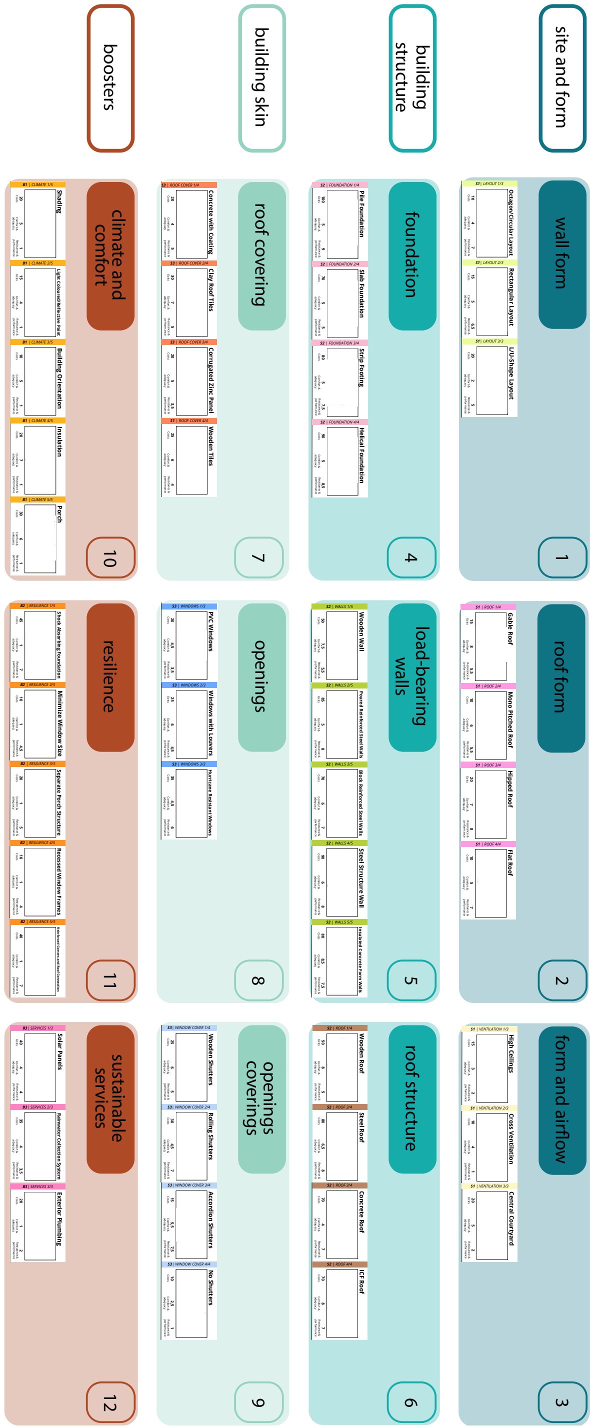

FIG. 5.10 Designing for a Flow card deck used in St. Martin.

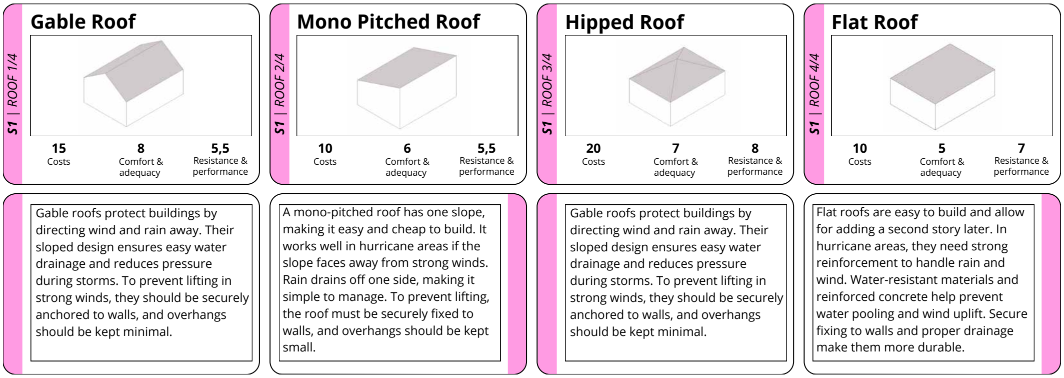

FIG. 5.11 Front and back side of cards representing four options for roof design rank within site planning suit: gable roof, mono pitched roof, hipped roof, and flat roof.

The first suit focused on conceptual design choices, addressing site and form-related decisions such as wall form, roof form, and the relationship between form and airflow. The second suit examined the structural components of the home, with cards dedicated to foundations, load-bearing walls, and roof structure. The third suit addressed the building skin, offering options for roof coverings, types of openings, and coverings for those openings. The final suit introduced design boosters, which provided enhancements across three categories: climate, resilience, and services. These boosters were intended to prompt reflection on context-specific strategies that could strengthen climate adaptability and overall resilience.

By structuring the deck in this way, the cards **guided participants through a step-by-step exploration of housing design**—from foundational decisions to enhancement strategies—encouraging them to consider the implications, trade-offs, and opportunities at each stage. This structure also allowed time for reflection and iterative improvement, particularly through the use of the booster cards.

5.5 Implementation, results, and observations

5.5.1 Implementation and results: workshops and exhibition

To test the Designing for a Flow cards in a participatory setting, we organized three co-design workshops at the University of St. Martin (Figure 5.12). Each session lasted approximately two hours and brought together a diverse group of participants, including students, university staff, community members, and built environment professionals. The goal was to collaboratively generate proposals for student housing on the island—using the card tool both as a vehicle for engagement and as a support tool for co-creative design.

FIG. 5.12 Workshops sessions (A) introduction to the game principles; (B) one of the group taking a decision on which card they will use.

Each session included maximum 5 groups of participants, with group sizes ranging from 3 to 5 people. Our intention was to create mixed teams that encouraged dialogue across different kinds of knowledge—academic, professional, and lived. To kick off, each group was given blank paper, markers, a foam board for the final design, and 450 *Johnnies*, used for in-game transactions.

Four facilitators supported the sessions. One explained the rules, and kept the energy up; two others distributed the cards and collected the currency; and one facilitator tracked scores and outcomes.

The structure of each workshop followed a participatory approach, with sessions organized into four section (Figure 5.13). After a welcome and brief introduction, participants took part in an icebreaker designed to stimulate creativity and personal reflection. With eyes closed, they were invited to imagine their dream home, then sketch it quickly and write down three features they found most important. Each participant then introduced themselves and shared their vision, creating an atmosphere of mutual understanding and curiosity from the outset.

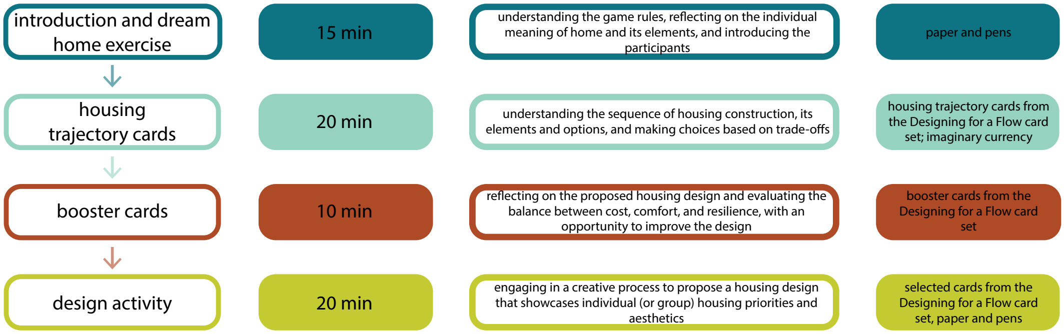

FIG. 5.13 Outline of workshop activities with corresponding durations, objectives, and necessary materials.

We then introduced the game format, highlighting three key factors embedded into the decision-making process: resilience and performance, climate responsiveness, and adequacy. We also explained how the Johnnies currency would simulate the trade-offs involved in real-life budgeting for housing. To spark playful competition, we told participants that the groups from all sessions would be competing for the best overall design—balancing performance and climate scores while spending the least amount of money.

Each round of the game focused on a different design decision, beginning with roof shape. After cards for a given round were distributed, groups had one minute to select their preferred option. Then, we called out all card choices, and groups raised their hands when their choice was announced. To simulate real market dynamics and promote diversity in design, we introduced a bidding mechanism: if more than 3 groups chose the same option, its cost would rise incrementally until no more than 3 groups remained. For example, a hipped roof initially priced at 30 Johnnies would increase in cost if chosen by too many groups, mimicking real-world supply and demand.

FIG. 5.14 Three student housing proposals co-developed during the workshops. The first design scored 58 in comfort, 64.5 in resistance, with a total expenditure of 430 Johnnies. The second achieved 61 in comfort, 63 in resistance, and used 420 Johnnies. The third design scored 55.5 in comfort, 60.5 in resistance, also spending 420 Johnnies.

Facilitators recorded spending and selections, and the game continued through nine rounds, with participants selecting one option per rank. The final rounds featured boosters—optional add-ons like resilience or climate-adequate features that could enhance safety or climate performance, depending on remaining budget.

Following a short break, participants transitioned into the design phase. Using the cards they had selected—along with elements from their dream homes—each group developed a design proposal for student housing (Figure 5.14). This phase also served as an opportunity for creative experimentation, particularly in terms of aesthetic values and personal preferences. Guided by the information on the cards, participants used their creativity to draw their proposed homes. These drawings were presented on foam boards, and each group appointed a representative to deliver a short pitch. The workshop concluded with expressions of thanks to all participants and an invitation to a public exhibition showcasing the resulting proposals the following week.

To conclude the process and deepen community engagement, we organized a public exhibition at a local café (Figure 5.15 A). We invited workshop participants alongside a broader audience of community members and built environment professionals. The exhibition featured the student-led housing proposals developed during the sessions, displayed as part of an open dialogue around resilient and climate-adaptive housing futures.

To further energize participation, we introduced a playful voting system. Two projects were selected for recognition: one based on their performance in the game, and another based on popular support during the exhibition. Each attendee received a small amount of the game currency—*johnnies*—which they could invest in the proposal they valued most. This interactive format encouraged attendees to reflect on their preferences, prioritize values, and engage critically with the design ideas.

Following the voting, we facilitated a community discussion that brought together diverse voices—from students and workshop participants to experts and local residents. The conversation offered space for students to reflect on their design choices and for professionals to contribute insights, fostering a meaningful exchange rooted in mutual learning. The atmosphere was vibrant and emotionally resonant, underscoring the power of collective imagination and the relevance of such discussions in contexts vulnerable to climate and housing challenges.

FIG. 5.15 (A) Exhibition in a local cafe (B) Exhibition space at the university.

After the café session, we relocated the exhibition to a dedicated space within the University of St. Martin (Figure 5.15 B). This installation served as a tangible and lasting outcome of the co-design process—honoring participants' contributions, showcasing the integration of different forms of knowledge, and highlighting the value of collaborative approaches in shaping resilient housing solutions.

5.5.2 Key observations and reflections

The workshops organized around the card set, along with the subsequent exhibition, provided a valuable opportunity to reflect on key observations and consider their broader relevance.

One of the most striking takeaways was the complexity involved in designing housing that meets the varied needs of individuals and households. In a context as culturally diverse as St. Martin, there can be no one-size-fits-all solution. Participants had to navigate multiple competing considerations—balancing safety requirements with climate responsiveness, all while staying within the limits of a family's budget. These inevitable trade-offs became particularly visible during the sessions. Even when groups used similar cards, they arrived at vastly different housing designs. The variability in their priorities and final scores reflected the unique concerns, values, and lived experiences of each group.

This underscored the importance of dialogue and participatory tools that can make these trade-offs visible and negotiable. Tools like the Designing for a Flow card game facilitated this awareness, allowing participants to explore, reflect on, and justify their decisions. It demonstrated how practical, situated knowledge can be productively integrated with theoretical and technical expertise—an essential step toward more inclusive and context-sensitive housing solutions.

Equally important were the interpersonal and power dynamics that unfolded during the co-creation process. While the intention was to create interdisciplinary and intergenerational collaboration by mixing students, community members, and built environment professionals, not all participants engaged equally. Some professionals showed reluctance to fully collaborate with university students, perhaps influenced by perceived hierarchies rooted in local social structures. This dynamic was also observed during the exhibition phase, where experts often took the lead in explaining design outcomes, sometimes overshadowing the contributions of others.

These challenges pointed to the critical role of facilitation in co-design processes. Facilitators were essential in creating space for diverse voices, balancing different forms of knowledge, and encouraging open dialogue. This highlighted the need for intentional, inclusive facilitation strategies in future participatory projects—ensuring that co-design does not replicate existing hierarchies but instead fosters equitable collaboration and mutual learning.

5.6 Conclusion

This research invites a shift in how we think about housing—from a static product to be delivered, to a participatory process co-created by those who live in it. In climate-affected and rapidly urbanizing regions like the Caribbean, conventional models often fail to reflect the cultural, social, and environmental realities of everyday life. Co-design offers a promising alternative by valuing diverse forms of knowledge—technical, lived, and local—and enabling residents to take an active role in shaping their environments. Particularly for communities excluded from both market and social housing systems, participatory approaches can foster more inclusive, context-sensitive solutions while strengthening local capacity, social networks, and climate resilience.

In this research, we explored how co-design can support these aims through a participatory card-based tool titled *Designing for a Flow*. Developed iteratively between 2022 and 2025 on the island of St. Martin, the tool was co-created with residents, architects, students, and built environment professionals. It integrates analytical and projective elements through a set of cards used in workshops focused on designing student housing. The game facilitated a playful yet reflective design process, guiding participants through key stages of housing development—including cost estimation, material choices, and sequencing—while highlighting trade-offs across resources, comfort, and resilience.

Gamification elements—such as a fictional currency ("johnnies") and rating systems for comfort and adequacy, and resistance and performance—sparked creative engagement and collaborative decision-making. Participants were encouraged to think critically about how different choices impact both the individual household and the broader community. "Booster" cards offered additional insights into sustainability and hazard adaptation, serving as both design inspiration and educational prompts.

Through this process, participants generated context-sensitive housing proposals that reflected their priorities, budgets, and lived experiences. The workshops not only led to more grounded and inclusive design outcomes but also fostered knowledge exchange and empowered participants as co-creators of their built environment. Challenges encountered—such as balancing diverse perspectives—offered valuable insights for future iterations.

Although developed for the specific context of St. Martin, *Designing for a Flow* is a flexible and adaptable tool. Its participatory and educational structure makes it applicable in a range of housing contexts—from informal settlements to collective housing initiatives—where co-design can facilitate meaningful engagement and deepen the understanding of housing as a process shaped by, and for, communities.

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6 Conclusion

6.1 Key Findings on Supporting Decision-Making and Adaptability in Self-Organized Housing in Caribbean Contexts

6.1.1 The Role of Circular Design Principles in Enhancing Housing Adaptability

How can circular design principles support the development and adaptation of self-organized housing and inform a design approach that enhances housing adaptability, including to climate-related challenges?

Self-organized housing in the Caribbean, including St. Martin, is typically developed incrementally. Dwellings are often constructed initially as small units and gradually expanded, modified, and repaired in response to changing household needs, available resources, and environmental conditions (Figure 6.1). This **incremental process** distributes construction costs over time while providing flexibility for adaptation. Developments usually occur under financial, administrative, and technical constraints, relying heavily on experiential knowledge and limited professional guidance. In hazard-prone contexts such as St. Martin, frequent exposure to hurricanes and other climate-related risks further intensifies the need for ongoing maintenance, repair, and adaptation.

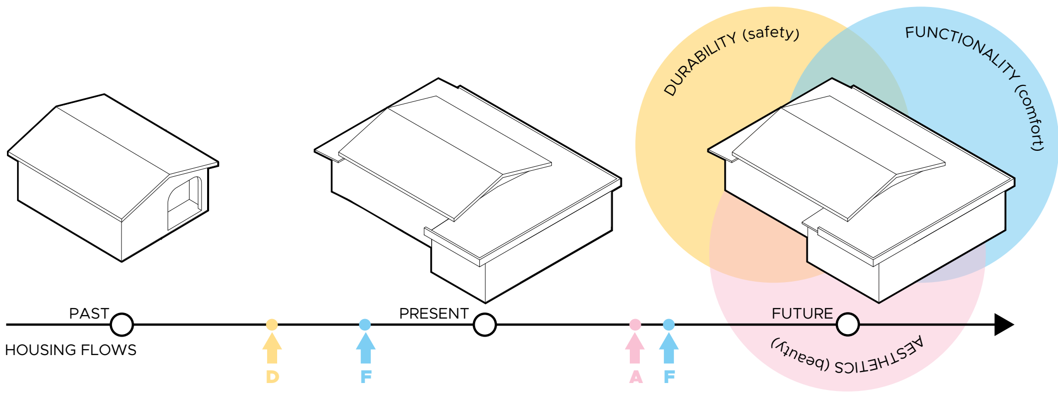

FIG. 6.1 Diagram illustrating conceptualization of incremental development of a house.

These incremental developments underscore the **temporal nature** of self-organized housing, highlighting that houses are processes unfolding over time rather than finished products. Material transformations, spatial adjustments, and evolving knowledge shape their development. Practices such as sharing, repairing, and repurposing materials are widely implemented, often out of necessity. Facilitating these **adaptations** offers practical benefits, including reducing the effort and costs required for modifications and minimizing their impact on other parts of the house. **Circular design principles**—which emphasize extended material lifespans, ease of repair, disassembly, and reuse—can support these adaptations.

The temporal and adaptable nature of self-organized housing aligns with Stewart Brand's concept that buildings **"flow"** through time. Brand's approach of **designing with layers**—comprising site, structure, skin, services, space plan, and stuff—recognizes that different building components change at different rates. By separating these layers physically and conceptually, incremental modifications can be accommodated without compromising overall integrity, thereby enhancing long-term **adaptability** and providing a practical pathway for implementing circular design principles.

Embedding circular principles through Brand's approach—operationalizing repairability, replaceability, and material longevity—makes future adaptations less costly, less disruptive, and can contribute to structural soundness. In hazard-prone regions, this capacity for modification also supports resilience, as buildings must be repeatedly repaired and adjusted in response to environmental risks.

The **Designing for a Flow framework** emerges from the integration of temporal thinking and circular design (Figure 6.2). It acknowledges **residents' agency** in shaping their homes over time and **supports adaptability through layered construction** informed by **circular design principles**. By linking incremental building practices to the housing layers and broader considerations—such as durability, functionality, and aesthetic expression—the framework offers a structured approach to enhancing long-term adaptability and resilience in self-organized housing.

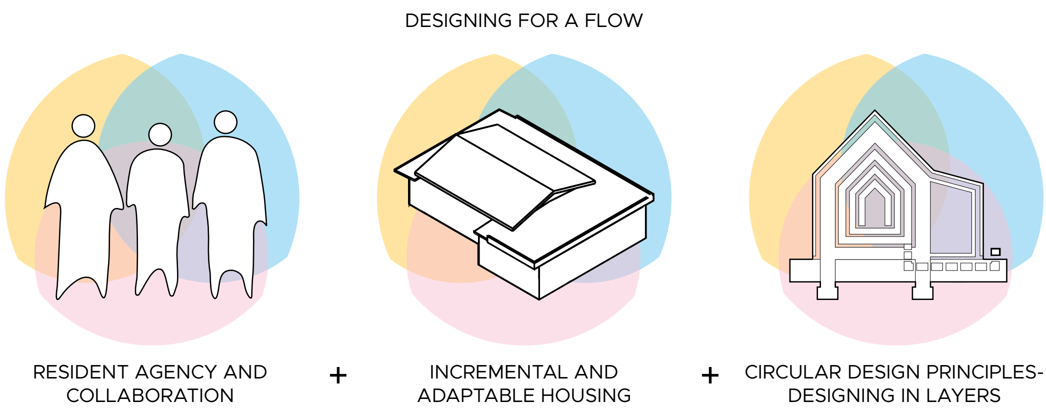

FIG. 6.2 Diagram representing the three main components of Designing for a Flow framework.

In this way, circular design principles inform a design approach that aligns with the temporal realities of self-organized housing and strengthens its capacity to respond to various challenges including climate-related ones.

While the Designing for a Flow framework demonstrates the potential of circular design principles to support the adaptability of self-organized housing, several limitations must be acknowledged. First, translating theoretical concepts such as Brand's layered building approach into incremental construction practices may be challenging in contexts where housing development occurs without long-term planning or technical guidance. Second, the implementation of circular design practices that allow for disassembly, repair, and material separation may require technical knowledge and resources that are not always available in self-organized construction processes. Economic constraints may further limit the adoption of such concepts, as residents often prioritize immediate affordability and material availability over long-term adaptability. In addition, the framework is developed within the specific socio-environmental context of St. Martin, and its application in other settings would require adaptation to different climatic conditions, construction practices, and regulatory and legislative aspects.

6.1.2 Incremental Housing Practices and Adaptations in St. Martin

How do residents of self-organized housing in St. Martin incrementally develop and adapt their homes in response to diverse challenges?

In St. Martin, the prevailing housing form is private, detached, single-family homes, and **self-organized housing** constitutes a significant portion of the stock for lower- and lower-middle-income families. These homes are developed over time, with residents addressing various housing considerations through building activities shaped by financial constraints, climate risks, and evolving household needs. We refer to these ongoing adaptations as housing flows.

Construction often involves joint efforts between residents and building professionals. Residents implement cost-saving strategies such as incremental construction, strategic material choices, and support from family or community networks. The prevalent self-organized homes are built using timber, concrete, combinations of timber and concrete, prefabricated elements, steel frames, or mixed materials. The **diversity in materials and construction methods** produces a range of housing types, forms, and layouts, which in turn influence subsequent adaptations and housing flows (Figure 6.3). Houses are modified to **balance multiple considerations, including durability, functionality, and aesthetic appeal**, through activities such as **additions, repairs, adjustments, and reconfigurations** (Figure 6.4).

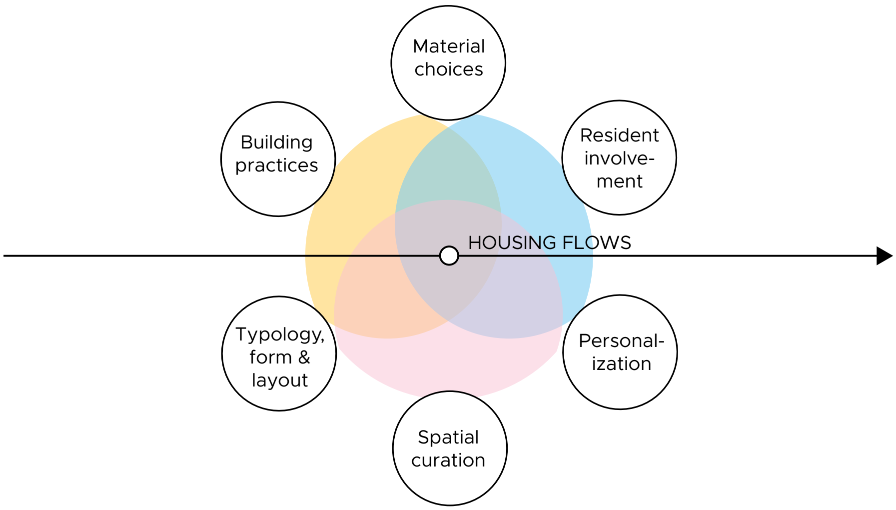

FIG. 6.3 Diagram showing how addressing durability, functionality, and aesthetic appeal influences various aspects of building practices.

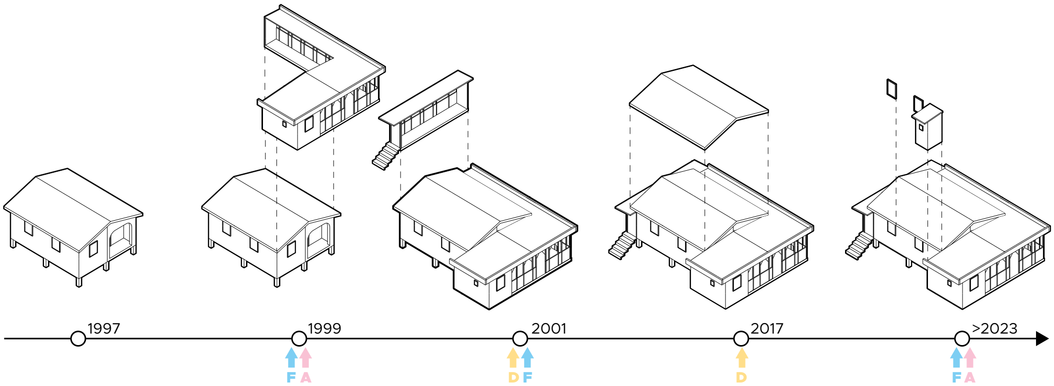

FIG. 6.4 Diagram illustrating housing development and adaptation over time, influenced by activities addressing durability, functionality, and aesthetic appeal.

Durability is addressed through **material choices and structural reinforcements** that respond to St. Martin's exposure to hurricanes, earthquakes, and flooding. Residents commonly strengthen roofs, elevate foundations, and secure key structural components, focusing on the site, structure, and skin layers of their homes. Concrete, valued for strength and storm resistance, requires skilled labor, while timber allows for more flexible repairs or replacements without affecting other structural components.

Functionality emerges through **flexible spatial arrangements** that respond to family growth and changing economic circumstances. Residents reconfigure layouts and extend indoor and outdoor spaces, fostering adaptability in the absence of formal flexible housing options and amid tenure insecurity. Traditional architectural features—such as sloped roofs and shaded outdoor areas—enhance ventilation and comfort in the tropical climate, in contrast to modern flat-roof designs that may increase reliance on air conditioning. Early decisions regarding orientation and circulation have lasting effects on functionality and comfort, while evolving needs for multigenerational living and home-based economic activities further highlight the importance of flexible design.

Aesthetic appeal is central to how residents **experience, maintain, and personalize their homes**. Through painting, ornamentation, gardening, and personal artifacts, residents adapt the skin and stuff layers of their houses, expressing identity, pride, and cultural continuity. These modifications are not purely decorative—they serve as acts of place-making and can provide practical benefits such as improved ventilation and weather protection. The cultural diversity of St. Martin is reflected in these practices.

Facilitating these building activities and housing flows—by building on existing practices and enhancing adaptability—is essential for long-term safety, comfort, and the personalized curation of houses.

Although this research provides insights into how residents of self-organized housing in St. Martin incrementally develop and adapt their homes, several limitations can be identified. First, the analysis is based on a limited number of case studies of houses selected to represent different housing types based on primary construction materials, which may not capture the full diversity of self-organized housing across the island. Second, because incremental housing development unfolds over long periods, the study captures housing adaptations at a particular moment in time and relies largely on retrospective accounts from households rather than long-term observation, which may be influenced by memory bias and the length and depth of the interviews. In addition, the categorization of housing adaptations into durability, functionality, and aesthetic considerations is intended to structure the understanding of complex decision-making processes; however, these considerations often overlap and are also influenced by practical constraints, individual priorities, preferences, and aspirations. These limitations suggest that the findings should be understood as illustrating common tendencies and approaches to incremental construction rather than providing a complete representation of all housing development trajectories in St. Martin.

6.1.3 Supporting Collaboration Between Residents and Building Professionals

How can collaboration between residents and building professionals be supported through a design approach for self-organized housing?

Collaboration between residents and building professionals in self-organized housing can be supported through a design approach that **structures knowledge exchange, facilitates joint decision-making, and bridges technical expertise with lived experienc**e. Residents often undertake incremental adaptations under financial constraints and with limited access to technical guidance. Their decisions are frequently informed by past experiences, informal advice from local builders or neighbours, and observations of seemingly successful housing solutions. While these practices reflect valuable experiential knowledge, they may also result in partial or misunderstood assumptions about structural performance, material behaviour, or hazard resilience. Building professionals, in contrast, possess formal technical knowledge but may lack insight into residents' everyday realities, cultural practices, and evolving priorities.

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A design approach can support collaboration by creating **structured opportunities for dialogue**. Interaction can be organized using the concept of **housing layers**, which separates discussions on design and material choices related to site, structure, skin, services, space plan, and stuff (Figure 6.5). This structure provides a systematic way of addressing different housing components while reflecting the sequence of housing development and highlighting the varying longevity rates of each layer. Building on this concept, the Designing for a Flow approach guides participants through a gradual development process—from site selection and structural decisions to finishing layers—thereby fostering a deeper understanding of the cascading consequences of design choices over time. Decisions regarding foundation type, material selection, or building orientation can thus be discussed in relation to long-term performance and resource allocation across different layers of the house. This sequencing enables residents and professionals to reflect on **the implications of design and material choices** for durability, functionality, affordability, and aesthetic preferences. At the same time, professionals gain insight into residents' priorities, constraints, and decision-making logic, fostering mutual understanding.

Furthermore, visualizing alternative options within each layer helps **structure discussions and makes available choices and potential trade-offs** explicit (Figure 6.6). Such an approach translates design concepts into accessible and tangible formats that residents and other partners can engage with. This can be achieved through visual prompts, such as card-based tools used in participatory sessions, which reveal participants' priorities, preferences, aspirations, and assumptions while supporting more effective communication of complex design information.

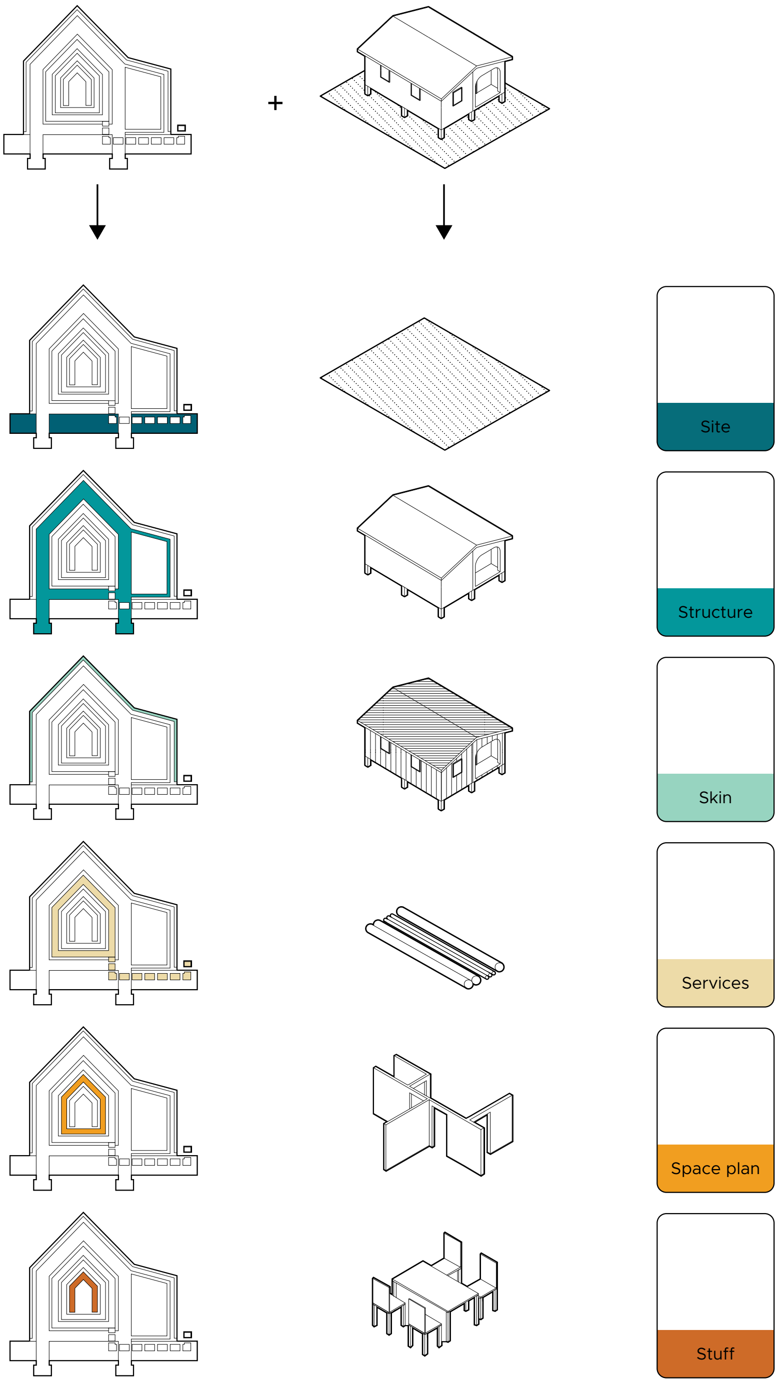

FIG. 6.5 Diagram illustrating housing layers.

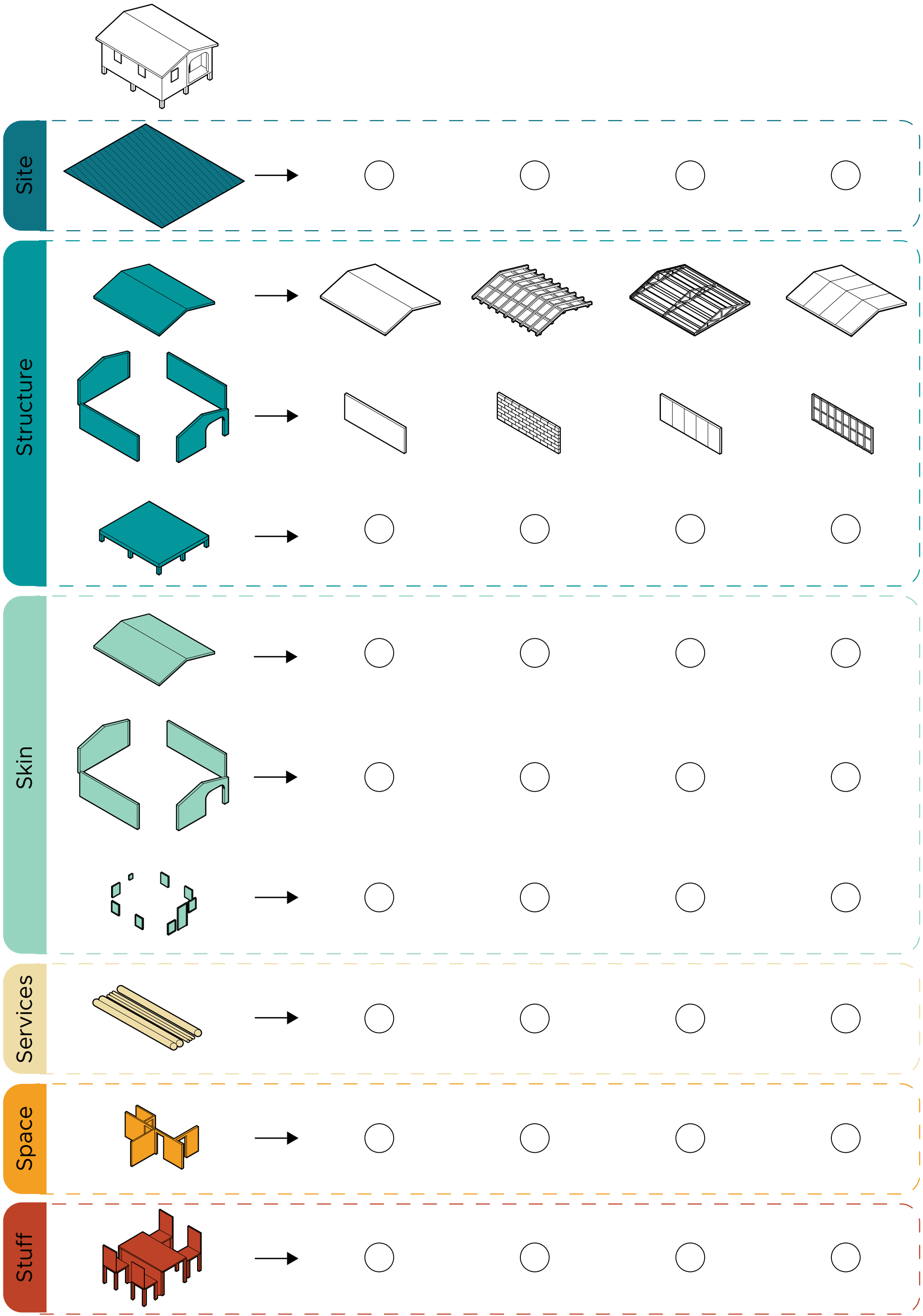

FIG. 6.6 Diagram showing the range of components and options included in each layer.

Collaboration can be further strengthened by integrating **co-creative methods** throughout different stages of housing planning and development. Engaging residents and building professionals in iterative processes of knowledge co-production and co-design can foster continuous knowledge exchange and the joint development of context-sensitive design solutions.

While the proposed design approach demonstrates how collaboration between residents and building professionals can be supported through structured dialogue and visual tools, several limitations persist. First, effective collaboration depends on the availability of building professionals and the willingness of both residents and professionals to engage in participatory processes, which may not always be feasible in incremental self-organized construction. Second, collaborative design activities require time, facilitation, and coordination, whereas housing decisions in self-organized contexts are often made opportunistically in response to available resources. Third, power dynamics and differences in technical knowledge may influence the extent to which residents feel comfortable contributing to design discussions during the collaborative sessions. In addition, while visual tools can support communication and reflection, they cannot fully replace detailed technical and location-specific professional assessments. Finally, the approach was developed and tested within the specific socio-cultural and institutional context of St. Martin, and its application in other settings would require adaptation.

6.1.4 The Contribution of Co-Creative Methods to Decision-Making in Incremental Housing

How can co-creative methods and tools enhance this collaboration and support decision-making during incremental housing development and adaptation?

Co-creative methods and tools enhance collaboration by directly involving residents and building professionals in structured activities where specific design and material choices are discussed, compared, and evaluated. While structured design approaches help organize dialogue, co-creative approaches deepen engagement by making decision-making processes more transparent and enabling shared reflection during incremental housing development.

One method that supports this process is **co-creative citizen science**, which involves participants in generating knowledge that is relevant to the challenges they face, such as housing conditions. In this thesis, co-creative citizen science was implemented to engage residents and building professionals in structured discussions, reflections, and data collection related to housing development and adaptation. **The Housing Flows Cards** operationalize this approach (Figure 6.7). Organized according to housing layers and informed by Caribbean housing studies, the cards function as prompts for discussing choices for different housing layers. During co-creative sessions and workshops, participants selected and compared options, explained their reasoning, and reflected on previous building experiences. This process enabled residents to articulate preferences and constraints, while professionals gained clearer insight into locally grounded construction practices and decision criteria.

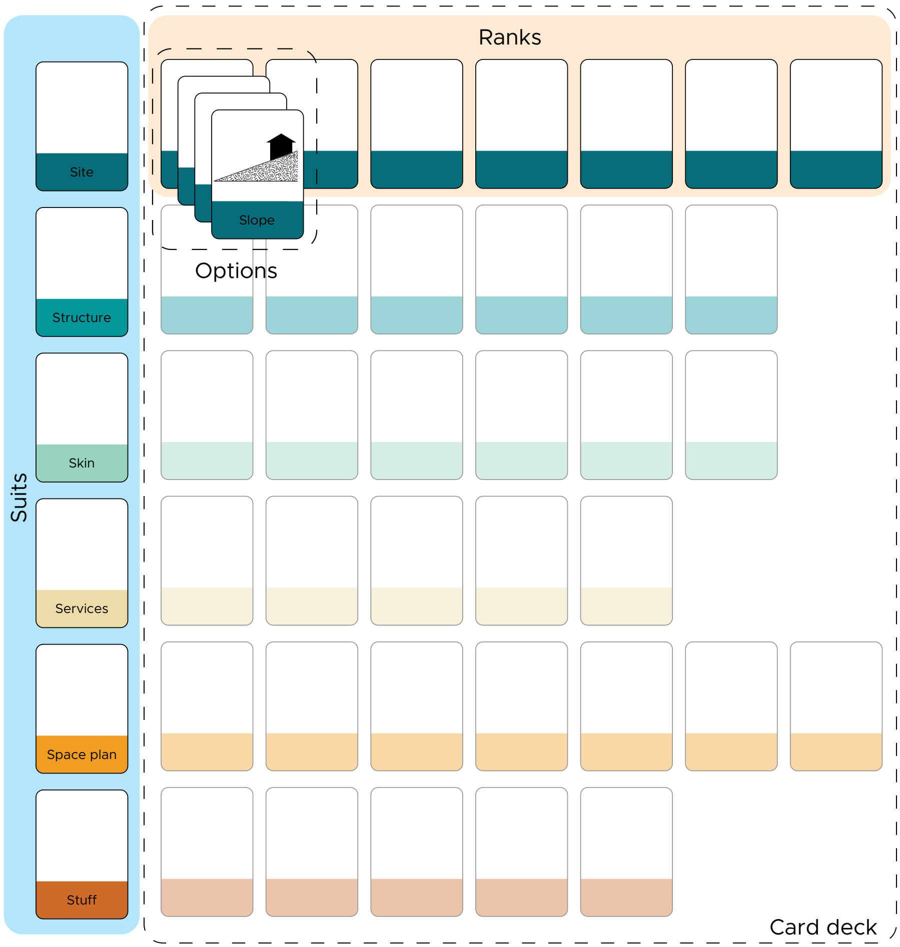

FIG. 6.7 Diagram representing the Housing Flows card deck and its organization into suits, ranks, and options.

Co-design further strengthens collaboration by enabling residents, professionals, and other stakeholders to **jointly develop housing proposals**. Co-design activities support negotiation around specific trade-offs that arise during incremental development, such as allocating limited resources between different design components. **The Designing for a Flow Cards** exemplify this approach (Figure 6.8). Tested in St. Martin, the gamified tool guided participants through co-design sessions following the housing construction sequence. The cards structured the sessions by presenting design and material options alongside cost values and performance indicators related to safety and comfort (Figure 6.9). Participants with different backgrounds worked together to design housing proposals, evaluate financial implications, and assess how choices in one stage influenced subsequent stages (Figure 6.10).

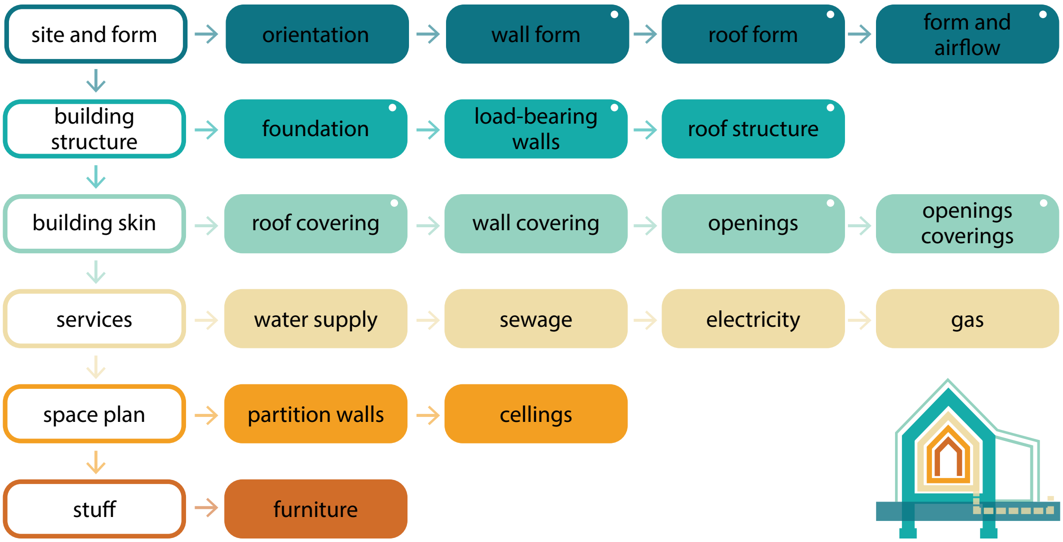

FIG. 6.8 Diagram illustrating the structure of the Designing for a Flow game.

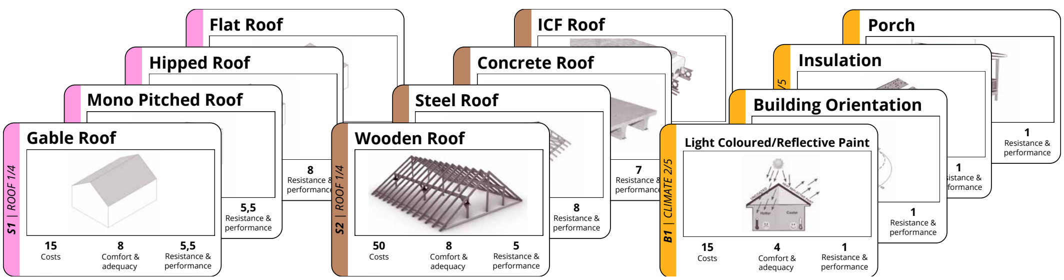

FIG. 6.9 Overview of some of the cards included in the Designing for a Flow game.

FIG. 6.10 Design proposals for St. Martin student housing co-created during the Designing for a Flow workshops.

Overall, co-creative methods and tools can strengthen collaboration by facilitating structured interactions between residents and building professionals that support **knowledge exchange and shared decision-making**. By enabling focused discussions on specific design and material options and examining their practical implications—such as cost, safety, and comfort—these tools contribute to more informed decisions throughout incremental housing development and adaptation.

Although the application of co-creative methods and tools provided valuable insights into collaborative decision-making processes, several limitations should be considered. First, the workshops involved a limited number of participants, and the findings therefore reflect the perspectives of specific partners rather than the full diversity of residents and building professionals in St. Martin. Second, the co-creative sessions were conducted in structured workshop environments that differ from the conditions under which many housing decisions are made during incremental construction. In addition, the card-based tools simplify complex design and material choices and generalize their implications in order to facilitate discussion, which means that they cannot fully represent the technical and site-specific complexities affecting housing development. The effectiveness of these methods also depends strongly on facilitation and participant engagement. Finally, the tools were developed within the context of St. Martin and would require adaptation for use in other regions.

6.1.5 Overall Conclusion: A Design Approach for Enhancing Adaptability in Self-Organized Housing

How can a design approach support decision-making in the development and adaptation of self-organized housing in Caribbean contexts to enhance housing adaptability to diverse challenges?

In Caribbean contexts such as St. Martin, households with limited access to adequate and affordable housing often rely on self-organized construction. These homes are typically **developed incrementally under financial constraints and with limited access to technical expertise**, which can increase vulnerability to hurricanes, flooding, and other climate-related risks. Supporting decision-making in this context requires an approach that acknowledges incremental development while strengthening the ability to adapt housing to various challenges.

This thesis explored how a **design approach** can **enhance adaptability and decision-making in self-organized housing,** drawing on the case of St. Martin. It adopted an interdisciplinary approach informed by housing studies, adaptable and resilient design, and co-creation. Using participatory action research, the study progressed through iterative cycles of planning, action, observation, and reflection. This structure enabled continuous engagement with residents and building professionals while refining both analytical insights and practical tools.

The research was grounded in the understanding that self-organized housing unfolds over time. It examined incremental developments—conceptualized as housing flows—in relation to climate risks, resource constraints, and changing household needs. Building on these observations and on Brand's concept of designing with layers, the study proposed the **Designing for a Flow** approach. This approach conceptualizes housing as a set of layers with different lifespans and functions (site, structure, skin, services, space plan, and stuff), and relates them to specific building activities and housing considerations. Within this approach, housing flows are understood across three interconnected dimensions: **incremental development over time, material modifications, and knowledge exchange**.

To support **decision-making**, the research adapted collaborative methods and tools. **The Housing Flows Cards**, developed as a **co-creative citizen science tool**, facilitated structured discussions between residents and building professionals on specific material and design choices. The cards supported reflection on implications for safety, comfort, and aesthetic preferences, while documenting how decisions are shaped by preferences and constraints.

TOC

Building on this, the Designing for a Flow Cards were developed as a **co-design tool** simulating the sequence of housing development. Tested in St. Martin, the tool brought together residents, students, and building professionals to collaboratively develop housing proposals. By assigning cost values and performance indicators for safety and comfort to different design and material options, the tool enabled participants to evaluate trade-offs and understand how these decisions shape housing outcomes.

These iterative research stages culminated in the Designing for a Flow approach, which provides structured guidance by combining design principles, participatory methods, and practical tools. The approach supports informed decision-making during housing development and adaptation by integrating **circular design principles** with **incremental development** and **fostering collaboration between residents and building professionals**. In Caribbean contexts facing increasing climate risks, this approach provides guidance to support decision-making and enhance adaptability of self-organized housing to diverse and evolving challenges.

While the Designing for a Flow approach demonstrates how circular design principles, participatory methods, and collaborative tools can support decision-making in self-organized housing development and adaptation, several limitations should be acknowledged. First, the approach was developed through a case study in St. Martin, and although the island shares characteristics with other Caribbean contexts, differences in governance systems, construction practices, and climate conditions may require adaptation when applying the approach elsewhere. Second, the research primarily tested the tools and methods through participatory workshops rather than long-term implementation in real housing projects, meaning that their long-term impacts on housing development and adaptation remain to be evaluated. Third, the approach relies on the availability and engagement of multiple stakeholders, which may be constrained by financial, institutional, or time limitations. Finally, broader housing challenges, such as land tenure insecurity and access to financing may limit its overall feasibility and possible impact.

6.2 Contributions and recommendations

6.2.1 Contributions to knowledge

This research contributes to knowledge by developing a design approach (*Designing for a Flow*), participatory tools (*Housing Flows Cards* and *Designing for a Flow Cards*), and a methodological framework that integrates co-creation, circular design principles, and layered housing concepts to support decision-making, adaptability, and resilience in self-organized housing.

The first chapter introduces the *Designing for a Flow* framework, which integrates incremental housing development, circular design strategies, and key housing considerations—durability, functionality, and aesthetics. It advances the understanding of self-organized housing as a temporal and evolving process rather than a finished product. By operationalizing circular design principles—such as repairability, material longevity, disassembly, and reuse—through Brand's layered housing model, the research establishes a theoretical connection between sustainability discourse and incremental self-organized housing practices.

The second chapter deepens empirical understanding of incremental housing development and adaptation processes in St. Martin. It documents building activities addressing safety, comfort, and aesthetic preferences and proposes a material-based typology of self-organized housing in the context. The chapter highlights the importance of gradual modifications in responding to diverse challenges, including climate-related hazards such as hurricanes, thereby contributing to housing studies in hazard-prone Caribbean settings.

The third chapter emphasizes the role of collaboration between residents and building professionals and introduces co-creative citizen science as a methodological contribution to housing research. It demonstrates how resident expertise can be systematically incorporated into design processes. The development of the *Housing Flows Cards* provides a structured participatory method that simultaneously supports dialogue and generates context-specific qualitative data.

The fourth chapter contributes to the field of housing co-design by testing structured design sessions that engage residents and professionals in collaborative housing proposal development. The *Designing for a Flow Cards* simulate the process of housing development, enabling participants to assess trade-offs, understand cascading consequences of decisions, and collectively shape housing proposals.

Together, the thesis extends Brand's layered model by demonstrating how it can be applied within Caribbean self-organized housing to guide incremental adaptations and improve decision-making. It also advances the field of housing studies by extending its usual interdisciplinary scope into a transdisciplinary one, building on the situated and experiential knowledge of partners involved in the research, particularly residents of St. Martin and building professionals. Moreover, it contributes by connecting housing studies with collaborative tools that can serve as instruments for data collection, structured dialogue, and the co-creation of future housing solutions.

Methodologically, it shows how participatory action research can be combined with co-creative design tools to iteratively produce both scholarly knowledge and practical design support in under-researched contexts. In terms of contributions to transdisciplinary research, the study demonstrates how collaboration between academic and non-academic partners can be operationalized in resource-constrained, hazard-prone contexts at the same time accounting for the tensions and challenges of that process.

In the broader academic context, this research engages with discussions on climate mitigation and adaptation in the built environment. By operationalizing circular design principles within incremental housing processes, it explores how material longevity, repair, reuse, and gradual development may reduce resource demand and support more sustainable construction practices. At the same time, by facilitating informed housing adaptations in hazard-prone environments, the approach addresses questions of climate adaptation, particularly in relation to safety, and comfort in self-organized housing.

The research also positions itself in relation to international policy frameworks such as Sustainable Development Goal 11 and the Sendai Framework for Disaster Risk Reduction (2015–2030). It does so by proposing a design approach that aligns with their emphasis on resilience, risk reduction, and inclusive housing processes. In this way, the study offers a context-specific contribution to ongoing discussions on how such global objectives may be interpreted and operationalized in incremental, self-organized housing contexts.

6.2.2 Contributions to society

This research contributes to society by examining how collaboration and structured design support can strengthen incremental housing development in self-organized contexts. It offers locally grounded insights that may inform housing support initiatives led by local authorities, NGOs, and community-based organizations working with self-organized housing.

The study proposes tools and methods developed through iterative research stages involving residents and building professionals. These tools are intended to facilitate dialogue during planning, design, and adaptation processes. By structuring discussions around specific design and material decisions, the approach supports more transparent decision-making and helps residents reflect on safety, comfort, and cost implications of incremental adaptations. The tools developed through this research, principally the co-design cards, are intended to remain accessible beyond the scope of this study. It is envisioned that they will be housed with the University of St. Martin along with a copy of this thesis, providing continued access for local partners, including NGOs, educators, researchers, and government actors involved in housing assistance. This institutional anchoring is intended to support the ongoing use and adaptation of the tools in future housing and disaster recovery projects in the Caribbean.

The transdisciplinary dimension of this research carries particular significance in a context marked by entrenched social hierarchies, structural inequalities, and histories of exclusion and injustice. In St. Martin, as in many Caribbean and post-colonial settings, the knowledge and opinions of residents, particularly those living in self-organized housing, have historically been marginalized in formal planning, design, and policy processes. By actively involving residents as partners in knowledge production and decision-making, this research challenges those dynamics and demonstrates that transdisciplinary approaches can serve not only as methodological choices but as acts of recognition and inclusion. Centering resident expertise and experience is therefore not merely a research strategy but a response to longstanding inequities in who is considered a legitimate contributor to housing knowledge.

The research also seeks to strengthen collaboration between residents and professionals by creating structured formats for knowledge exchange. By making technical and design considerations more accessible and incorporating resident experience into discussions, the approach may help reduce misunderstandings and improve alignment between technical recommendations and self-organized housing developments. In doing so, it aims to contribute to enhancing knowledge and skills in incremental, resilient, and adaptable housing design.

In hazard-prone contexts such as St. Martin, where self-organized housing is exposed to hurricanes, tropical storms, and prolonged heat, the research explores how incremental adaptations can be better informed. The proposed approach supports consideration of durability, ventilation, material performance, and gradual investment over time. By integrating circular design principles—such as repair, maintenance, and material reuse—it also highlights strategies that may help manage long-term costs and resource use without requiring complete rebuilding.

Overall, rather than offering a fixed solution, the research proposes a design approach along with methods and tools that can support residents and professionals in navigating housing adaptation in context challenged by environmental risk and climate-amplified hazards.

6.3 Recommendations and agenda for future research

6.3.1 Recommendations

Based on the findings of this research, several recommendations can be proposed for policy and practice concerning self-organized housing in hazard-prone contexts such as St. Martin and other parts of the Caribbean.

First, incremental housing development should be recognized as a viable and adaptable approach rather than treated as a temporary or inadequate housing solution. Self-organized housing enables households to distribute construction costs over time and respond gradually to changing needs and environmental challenges, including climate-related risks. At the same time, such houses vary widely in materials, layouts, structural quality, and levels of vulnerability, reflecting diverse household circumstances. Policy frameworks and housing support programs could therefore move beyond standardized housing models and instead support gradual upgrading processes, particularly those addressing safety, structural stability, and thermal comfort. Addressing housing challenges in low-income and hazard-prone contexts requires flexible and context-sensitive approaches that acknowledge both the value and the constraints of self-organized housing.

Second, housing support initiatives could integrate circular design principles to facilitate gradual adaptations and more efficient use of materials. Encouraging repair, maintenance, and reuse can help households manage long-term costs while improving performance. Incorporating layered thinking into advisory materials and assistance programs may further strengthen this approach. Distinguishing between long-lasting elements—such as site selection, foundations, and structural systems—and more adaptable components—such as partitions and finishes—can guide early investments toward decisions that are difficult or costly to reverse. Particular attention should be given to roof construction, structural reinforcement, orientation, and ventilation, as these significantly influence long-term safety and thermal comfort in hazard-prone environments.

Third, building and design professionals working in self-organized contexts are encouraged to adopt collaborative and long-term forms of engagement. Instead of delivering fully predetermined design solutions, professionals could provide ongoing decision-support that clarifies trade-offs between cost, safety, and comfort at different stages of development. Methods and tools that structure dialogues may assist in improving mutual understanding and aligning technical recommendations with residents' priorities and financial realities.

Fourth, community organizations and NGOs may consider facilitating collective knowledge-exchange initiatives where residents and building professionals share practical experience related to incremental upgrading, material maintenance, and climate-responsive adaptations. Such initiatives can complement formal technical assistance and strengthen knowledge and skills of residents and local builders.

6.3.2 Directions for future research

The relationship between housing and climate change in St. Martin requires further investigation. This study, together with ongoing scientific research, identifies various challenges, including stronger storms, hurricanes, prolonged heat weaves, socioeconomic inequalities, gentrification pressures, and increasing construction in hillside areas with higher exposure to landslides and runoff. These conditions indicate the need for continued research on housing solutions that address structural safety, thermal comfort, and affordability under changing environmental conditions.

Caribbean islands, similar to other hazard-prone regions, are exposed to multiple environmental risks. Design responses to hurricanes, flooding, heat stress, earthquakes, and landslides may require different technical solutions, and in some cases these solutions may conflict. Further research is needed to document existing adaptation practices, evaluate how specific design interventions perform under multiple hazards, and assess residents' awareness of projected climate risks. Such studies would clarify which housing strategies remain effective under varying environmental conditions.

Additional research could examine the long-term economic implications of self-organized housing that incorporates circular design principles. Comparative analyses of repair, material reuse, and incremental upgrading of structural elements alongside conventional rebuilding approaches could provide clearer insight into costs over time and financial feasibility for low-income households.

While this thesis applies the concept of designing with layers, circular design principles, and co-creative methods conceptually, further testing in built projects would strengthen understanding of their practical implementation. Future studies could document housing cases that already incorporate such strategies, or implement the Designing for a Flow approach in ongoing development projects to evaluate its applicability. Applying the approach in other Caribbean islands would allow examination of how differences in regulation, hazard exposure, material supply, and socio-economic conditions influence its use. Comparative research across islands, and between formal and self-organized housing contexts, could clarify which elements of the approach require contextual adaptation.

The card-based tools developed in this research could be further refined or adapted into digital or hybrid formats. Future studies could assess whether digital simulations improve accessibility, support sustained engagement, or influence decision-making processes among residents and professionals, and to what extent such tools support informed decision-making and housing adaptability.

This research also identified challenges related to participation and collaboration. Further investigation could examine how power relations, trust-building, and negotiation processes affect co-creative housing design. Such research would contribute to a more detailed understanding of the conditions under which collaborative approaches function effectively.

Finally, further work is needed to examine how incremental and collaborative design approaches could be incorporated into housing policy and planning instruments. Research focusing on institutional procedures, regulatory constraints, and implementation mechanisms would clarify how such methods can operate within existing governance structures in St. Martin and similar contexts.

6.3.3 Reflection and discussion

6.3.4 Self-organized housing, adaptability, and resilience

This research highlights adaptability as a key characteristic of housing for lower- and middle-income households in hazard-prone contexts such as St. Martin. Unlike formal affordable housing supply programs that typically deliver complete units with limited opportunities for modification, self-organized housing develops through extensions, repairs, and modifications led by residents. These incremental processes allow households to respond to changing financial capacities, evolving needs, and environmental pressures, making such housing particularly relevant in contexts characterized by uncertainty and increasing climate risks. The results of the affordable housing development analysis in St. Martin conducted in this research align with design approaches that support self-organized housing processes, as advocated by scholars such as Turner, Crane, and Abrams, which emphasize incremental and resident-led housing development over standardized housing units.

Moreover, the research also revealed the significant diversity within self-organized housing, contributing to the understanding that the category of self-organized units comprises a large variety of homes, and that these differences also affect adaptation needs and possibilities. The research uses the term self-organized housing rather than self-built or auto-constructed housing, reflecting findings from housing studies showing that many houses are often developed by joint efforts of local builders and residents, who typically take the initiative, negotiate key construction decisions, and often participate in the building process to varying degrees depending on their circumstances and abilities.

Self-organized housing types vary widely in terms of materials, construction methods, spatial layouts, and development timelines. Even within the relatively small context of St. Martin, these differences result in varying paces and scales of material deterioration, maintenance needs, and opportunities for future adaptations. This diversity challenges the possibility of developing standardized design solutions and instead highlights the importance of adaptable design approaches that can accommodate different housing trajectories.

The research also connected the concept of adaptability with resilience, understood as the capacity of homes to withstand environmental risks and recover or be rebuilt after a hazard, which can be facilitated through design approaches that ease or support such practices. Yet, in scientific discourse, resilience is a contested term because it has become an institutionalized buzzword in strategic planning, often framed as an individual trait or responsibility while ignoring wider structural factors. It is important to acknowledge that housing adaptability and resilience are strongly shaped by broader socio-economic and institutional conditions. Factors such as land tenure arrangements, access to construction materials, labour markets, regulatory frameworks, and cultural norms influence how and when houses are modified, repaired, or rebuilt, therefore affecting these capacities.

This research explored enhancing adaptability through circular design principles based on Brand's concept of designing with layers, which emphasizes the separation of building components according to their lifespan and function. In principle, such an approach facilitates repair, replacement, and incremental modification while reducing material waste. However, the findings indicate that translating these principles into practice remains challenging. Implementing layered construction requires technical skills, planning capacity, and awareness among the partners involved in the building process—conditions that are not always present in self-organized housing contexts. Moreover, decisions about modifications are often made in response to available resources and immediate needs, and the implementation of circular design principles in actual construction requires adequate planning and execution, as well as technical expertise and forward-looking planning, which are often limited during adaptations driven by urgency. While this research draws on circular design principles, it primarily addresses those related to material longevity, repair, and adaptability rather than the full spectrum of circular economy strategies such as material recovery systems or closing material loops. Additionally, in hazard-prone contexts, priorities related to durability and safety may further conflict with certain circular design principles such as design for disassembly.

In such contexts, the adaptability of self-organized housing reflects both opportunity and constraint. On one hand, the ability to modify and expand houses over time enables residents to gradually improve their living conditions. On the other hand, these processes are often shaped by restricted resources, limited construction knowledge, and variable material quality, which may lead to suboptimal construction outcomes and higher long-term maintenance demands. Enhancing adaptability therefore requires not only design flexibility but also improved support for decision-making regarding construction practices.

Collaboration and Support of the Decision-Making Process

While self-organized housing offers important advantages—including the distribution of construction costs over time, resident agency in shaping living spaces, and the ability to adapt gradually to changing conditions—it should not be considered a universal solution to the limited supply of affordable housing. These aspects reflect both the resourcefulness of residents in the absence of formal housing support and the significant responsibilities associated with housing development, particularly when limited technical knowledge and financial resources influence design and material choices.

In this context, the roles of building professionals and residents become particularly important. Professional expertise in spatial design, construction techniques, and climate-responsive strategies can significantly influence housing performance in terms of safety, comfort, and long-term durability. Yet, when professional expertise is not connected to the varied and often specific needs of residents, houses risk becoming dysfunctional or poorly suited to their users. At the same time, residents and local builders can contribute valuable experiential knowledge shaped by practical construction experience and previous hazard events. Although this experiential knowledge is crucial to consider and to incorporate into housing planning, it can also be influenced by particular biases, preferences based on isolated experiences, or observational copying of building practices without a full understanding of their technical implications, as noted by scholars studying housing cases in other islands, such as Puerto Rico.

These different forms of knowledge can therefore be seen as complementary, suggesting that assisted self-organized housing development benefits from collaboration between residents and technical experts. In this research, the proposed design approach aims to support such collaboration by involving diverse partners in housing development processes and enabling the integration of different forms of expertise and knowledge among actors who often already interact in practice.

However, achieving meaningful collaboration is not always straightforward in the context of affordable housing supply, particularly in hazard-prone regions such as the Caribbean. Institutional procedures and regulatory frameworks are typically organized around standardized construction processes and fixed timelines, which are easier to manage administratively but often do not align with the incremental and evolving nature of self-organized housing that allows for adaptation and responsiveness to individual household needs.

Addressing the broader challenges of affordable housing provision therefore requires not only collaborative design approaches but also shifts in the perspectives of governmental actors and decision-makers responsible for shaping housing policies and development strategies. In addition, existing power relations—including the continuing influence of colonial governance structures in Caribbean contexts—can further shape how housing development processes are organized and whose knowledge is recognized.

These conditions highlight the importance of design approaches that support collaboration and joint decision-making throughout the housing development process, rather than focusing solely on the initial construction stages or relying exclusively on either residents or building professionals to drive housing development.

In this research, co-creative methods and tools were explored as potential ways to support collaboration between residents and building professionals. Visual and interactive tools, such as card-based prompts, helped structure discussions by presenting alternative design and material options in a tangible format. By making trade-offs visible, these tools supported reflection on the implications of different choices and facilitated dialogue between residents, researchers, and building professionals.

Within this process, co-design sessions were organized to engage diverse actors in collaborative design activities aimed at developing negotiated outcomes. The developed tool was intended to support these interactions, while its gamified format aimed to enhance engagement and make the activities more accessible and enjoyable for participants.

However, the findings also demonstrate several limitations of such approaches. In self-organized housing contexts, residents ultimately retain control over design and material choices. As a result, increased awareness of technical implications does not necessarily lead to outcomes that would be considered optimal from a technical perspective. Decisions remain strongly shaped by financial constraints, personal preferences, social influences, and the practical realities of construction.

The co-design sessions also revealed social and professional barriers to collaboration. Some participants from the building sector were hesitant to discuss design choices with residents or to participate in mixed groups, suggesting that existing professional boundaries and power relations may influence collaborative processes. In addition, the design outcomes generated during the sessions cannot be considered fully developed architectural proposals or a substitute for professional design assistance.

TOC

A further limitation concerns the gap between collaborative design activities and actual construction processes. The translation of ideas developed during workshops into building practice is influenced by various external factors, including financial constraints, material availability, technical expertise, and changing household priorities.

Engaging residents in design discussions therefore requires more than the provision of participatory tools. Effective collaboration depends on trust, clear communication, willingness to participate, and sensitivity to the constraints faced by different actors. The research thus underscores that co-creation is not simply a methodological choice but an ongoing process of negotiation and facilitation that recognizes residents' experiential expertise as a legitimate form of knowledge in housing development while also acknowledging the practical limits of participatory design processes.

Environmental Hazards and Climate Adaptations

Strengthening adaptability and supporting informed decision-making in self-organized housing offers a potentially practical pathway for addressing climate-related challenges over time. Incremental housing development provides opportunities for residents to gradually improve safety and comfort conditions through modifications, particularly when supported by access to technical and design knowledge and appropriate guidance.

However, the research also demonstrates that climate adaptation cannot be addressed through standardized design solutions, particularly in multi-hazard environments such as St. Martin and other Caribbean islands. Design solutions that mitigate one type of risk may conflict with solutions addressing another. For example, structural measures intended to increase hurricane resistance may influence ventilation and thermal comfort, while design responses to heat or rainfall may interact differently with structural requirements. As a result, climate-responsive design involves negotiating trade-offs rather than implementing singular solutions.

Local environmental conditions further complicate this process. Houses located on steep slopes, in flood-prone lowlands, or in coastal areas exposed to erosion and storm surges face different risks and therefore require different adaptation and mitigation priorities. Standardized design solutions or guidance cannot fully account for these location-specific vulnerabilities.

In this context, the Housing Flows Cards function less as prescriptive technical or design solutions and more as tools that support awareness and dialogue about potential risks and design implications. By visualizing trade-offs and encouraging discussion, they contribute to broader understanding of climate-related considerations in housing development rather than providing standardized design solutions.

At the same time, housing decisions are not determined solely by risk considerations. Socio-economic conditions, aesthetic preferences, and cultural aspirations continue to shape design and material choices. Climate adaptation therefore becomes one consideration among many competing priorities within housing decision-making.

Transferability and Research Process

Although *Designing for a Flow* provides a conceptual framework that integrates circular design principles with collaborative methods, it should not be interpreted as a universal solution applicable across contexts without modification. While the underlying approach may be transferable, the specific tools developed in this research—such as the cards representing material and design options—are grounded in observation of the realities of St. Martin. Applying the approach elsewhere would require adaptation to different environmental risks, construction practices, material availability, and cultural aspects.

The research also revealed practical challenges associated with interdisciplinary and transdisciplinary approaches. Integrating perspectives from housing studies, circular design, and collaborative methods required ongoing negotiation between different conceptual frameworks, terminologies, and methodological choices. Working with partners from diverse backgrounds further highlighted differences in knowledge systems, professional roles, and priorities.

Such processes demanded significant time for coordination and preparation, while structural constraints—including project timelines, funding structures, and academic requirements—often affected the continuity of engagement. These challenges underscore the importance of reflexive research practices when conducting collaborative research, particularly if the researcher comes from outside of the studied context.

Overall, the research demonstrates that strengthening housing adaptability in St. Martin requires not only innovative design approaches and collaborative tools but also sustained attention to the broader social, institutional, and environmental conditions that shape housing development.

Curriculum vitae

Aga Kuś

Linkedin: https://www.linkedin.com/in/a-kus/
Orcid: https://orcid.org/0009-0009-7002-0297

Biography

Aga Kuś is an architect and researcher at Delft University of Technology (TU Delft), where she also completed her PhD. Her work brings together engineering and social science to address challenges in the built environment, with a focus on climate adaptation, disaster risk, and housing inequality. Working across disciplines, she combines collaborative research methods, circular economy principles, and resilient design strategies to create solutions that are technically informed while remaining closely connected to the realities of the communities they are meant to support.

She holds a Master of Science in Architecture (*cum laude*) and a Bachelor of Science in Architecture from TU Delft and Wrocław University of Science and Technology (WUST) respectively, with an Erasmus exchange at the Polytechnic University of Turin focused on sustainable architecture. Prior to her doctoral studies, A. Kuś gained professional experience in architectural practice in Italy and Poland, and worked on a research project at WUST addressing improving air quality and reducing emissions from residential heating.

Her doctoral research was conducted as part of the NWO-funded project *Island(er)s at the Helm* and affiliated with TU Delft and the Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV). It resulted in the development of ***Designing for a Flow***, a co-creative housing design approach operationalizing circular design principles and encompassing participatory methods and card-based tools tailored to hazard-prone Caribbean contexts. This work was supported by the TU Delft Global Fellowship and conducted in close collaboration with the University of St. Martin and local communities. Her research has been published in Q1 peer-reviewed journals and presented at international conferences. She has also engaged with broader audiences through newspaper, radio, and television media.

Supported by an NWO KIEM MV grant, she is currently working as a researcher at TU Delft on the ***ToolGETHER*** project, which builds on the findings of her doctoral thesis. Continuing her collaboration with communities in the Caribbean, the project brings together industry, public-sector, and academic stakeholders to develop a digital tool that supports engagement and trust in housing environments.

Education

2022 - 2026 **Doctoral Researcher in Architecture (PhD)**
Delft University of Technology (TU Delft), the Netherlands

2019 - 2021 **Master of Science in Architecture (MSc)**
Delft University of Technology (TU Delft), the Netherlands,
(cum laude graduate)

2017 - 2018 **Erasmus+ Program, Master program in Sustainable Architecture**
Polytechnic University of Turin (PoliTO), Italy

2015 – 2019 **Bachelor of Science in Architecture (BSc)**
Wrocław University of Science and Technology (WUST), Poland

Experience

Jan 2022 – July 2026 **Doctoral Researcher in Architecture**
Delft University of Technology (TU Delft), the Netherlands;
Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV), Leiden, the Netherlands
University of St. Martin (USM) Philipsburg, Sint Maarten
Published in Q1 peer-reviewed journals, organised stakeholder workshops with academic, institutional, and community partners, led and supervised a three-month student project (15 ECTS), and communicated findings through international conferences and media interviews including radio, newspaper, and television.

Nov 2020 – Sep 2021 **Project Manager**
'BEST Connections' Tree Competition' (BCTC), TU Delft, the Netherlands
Initiated an engeneering competition on steel connections at TU Delft, securing institutional and industry partnerships including funding and in-kind support, and managing concept design, logistics, budgeting, promotion, and execution — resulting in multi-faculty attendance and media coverage.

Jul 2020 – Jul 2021

President

BEST Delft (Board of European Students of Technology), TU Delft, the Netherlands

Led and represented a team of 40+ international, multidisciplinary students. Coordinated with university representatives, student councils, and external partners to secure resources and alignment with organisational goals. Organised professional and academic development opportunities for students through trainings, events, and educational and social programmes.

Mar – May 2019

Research Assistant

Wrocław University of Science and Technology, Poland

Worked on the government-funded “Zimno-Ciepło” project focused on improving air quality. Supported data collection and analysis from 48,000+ buildings, integrating existing datasets with structured resident surveys, and investigated alternative heating solutions to inform a city-wide strategy for more sustainable energy practices.

Feb – Aug 2018

Junior Architect

TRA Architecture Studio, Turin, Italy

Developed conceptual design from urban scale to architectural detail, including sustainable energy, regeneration, and transportation strategies for the requalification of Palmaria, a former military island. Prepared technical drawings, models, and visuals, collaborating with environmental experts, investors, and municipal authorities.

Jul-Sep 2017

Architecture Apprenticeship

RS+ Architecture Studio, Tychy, Poland

Worked on conceptual and executive projects for single-family houses and landscape architecture, producing 3D models, technical documentation, visuals, and cost estimates. Gained practical experience in design development, client communication, BIM software, and project lifecycle management.

Workshops and Public Engagement

Designing for a Flow: Co-design of Resilient and Adaptable Housing

Delft University of Technology (TU Delft), the Netherlands, September 2025
University of St. Martin, (USM) Philipsburg, Sint Maarten January 2025
Organised co-design workshops for students, residents, architects, and other stakeholders using a card-based tool to develop resilient housing proposals, with the St. Martin edition concluding in a public exhibition at an art café.

Housing Flows: Balancing Safety, Comfort, and Aesthetics in Housing

University of St. Martin, (USM) Philipsburg, Sint Maarten May 2024
Ecovision, Willemstad, Curaçao, June 2024
Sobremesa, Kralendijk, Bonaire, June 2024
Organised workshops and co-creative sessions for residents, community members, built environment professionals, and developers, supporting informed decision-making around key housing considerations in hazard-prone contexts.

ProtoLAB: Design-and-build Workshop

Wrocław University of Science and Technology (WUST), Poland, July 2022, 2024, and 2025
Guided students across several editions of an international design-and-build workshop, in which participants used bio-based materials such as paper to design and prototype full-scale structures, including pavilions.

Skills and interest

Project & Stakeholder Management

workshop facilitation and organization, interdisciplinary coordination, community engagement, stakeholder mapping

Design & Facilitation Tools

co-design methods, card-based tools, visual facilitation, scenario building, prototyping

Research Skills

academic writing, ethnography, qualitative research, participatory action research, visual and narrative methods

Professional Training

leadership, team dynamics, facilitation, change management, public speaking, conflict management.

Software

Adobe Creative: Photoshop, Illustrator, InDesign
Design software: AutoCAD, Revit, Google Sketch-Up, Rhino and Grasshopper
Google Suite: Word, Ppt, Excel

Languages

Polish (native speaker)
English (professional)
Spanish (professional)
Italian (limited professional)

Interests

drawing, hiking, travelling, dancing, swimming, reading, socializing.

List of Publications

Peer-reviewed articles

Kuś, A., Mota, N., van Bueren, E., Carmona Báez, A., & Asselbergs, T. (2024). Designing for a Flow: Navigating Temporalities in Housing Considerations in Low-Income and Hazard-Prone Caribbean Contexts. *Buildings*, *14*(2). https://doi.org/10.3390/buildings14020327

Kuś, A., Mota, N., Van Bueren, E., & Carmona Báez, A. (2025). Narratives of Caribbean housing flows: step-by-step development and changes in self-organized homes in St. Martin. Archnet-IJAR: International Journal of Architectural Research. https://doi.org/10.1108/ARCH-11-2024-0481

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26#15

Designing for a Flow

Co-creative Approach to Adaptable and Resilient Housing

Aga Kuś

This research investigates how adaptability and decision-making in self-organized housing can be supported in hazard-prone Caribbean contexts, with a focus on St. Martin. Where low-income households face barriers to formal housing, self-organized housing becomes a primary means of shelter access. While offering flexibility, such housing often develops under constraints that compromise structural safety, climate comfort, and long-term functionality — challenges intensified by climate change. Assisted self-organized housing approaches offer a way to improve these conditions, yet typically focus on initial construction, providing limited guidance for long-term adaptation. This research addresses this gap by developing Designing for a Flow — a structured guidance integrating circular design principles and co-creative methods to enhance adaptability and resilience in incremental housing processes. Conceptualizing housing as a dynamic process, the approach facilitates "flows" through three interrelated dimensions. Development flow addresses incremental construction and adaptation; material flow supports easy repair and replacement of building elements; and knowledge flow enables collaborative decision-making between residents and professionals. The study adopts a transdisciplinary Participatory Action Research approach within a single-case study in St. Martin, through which collaborative tools — including the Housing Flows Cards and the Designing for a Flow co-design tool — were developed and tested. The findings advance assisted self-organized housing by strengthening adaptability and collaborative decision-making, offering transferable insights for resilient housing development in other climate-affected contexts.

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