The Cost of Improving Vulnerable Housing

Recommendations for Investments in Housing Resilience from an Analysis of Global Project Data

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Cover photo: Reconstruction work in Sint Maarten in 2021, to repair damage from Hurricane Irma and strengthen the home to withstand future hazards.

Abstract

Following the implementation and development of hundreds of home improvement designs from Asia, the Pacific, Latin America and the Caribbean, data was compiled and analyzed to understand the cost of home improvement and how spending is allocated across different kinds of interventions, specifically Structural Condition Repairs, Habitability Upgrades, Disaster Mitigation Measures and Finishings and Growth. Cost data was compared across different building typologies, hazards, contexts and structural performance objectives, and overall costs compared with the relative cost of new construction. The data highlights many reasons why preventatively improving vulnerable housing for health and safety before the next disaster is not only crucial but a smart, cost-effective investment, including compared to the alternative of building new housing.

Acknowledgments

This study was carried out by Build Change team members. Build Change is grateful to the many homeowners, donors and partners globally over the past decade who have helped to make it possible.

Executive Summary

The issue of vulnerable housing requires urgent action and massive investment. By 2030, three billion people—about 40% of the world's population—will be living without adequate housing.[1] Inadequate or vulnerable housing is disproportionately inhabited by the poor, putting those who are already vulnerable most at risk when earthquakes, windstorms, floods and pandemics strike. Investment in better, safer housing must be prioritized if we are to protect people and assets against future crises.

However, most people do not need a new home, but a more resilient home, and the majority of homes can be made safer using relatively simple, inexpensive solutions that already exist: for example, improving sanitation, lighting, ventilation and meal preparation facilities in a house can make a home healthier to live in, while strengthening the walls or improving the connections from the roof to the foundations can make the house safer in earthquakes and windstorms. Investing in upgrading existing housing is an efficient, effective way to reduce housing vulnerability, while enabling people to remain in the homes and communities they already live in. At the same time, home improvement programs can also provide families with opportunities for growth (e.g., through home expansion). This combination of benefits makes home improvement an optimal response to the qualitative housing deficit observed in most countries today.

One of the common barriers to homeowners, governments, funders and others who could invest in improving vulnerable housing is a lack of information or misunderstanding about the associated costs. This home improvement cost study was undertaken by Build Change in order to share key information and trends about the costs of improving vulnerable housing to make it more resilient.[2] It is based on detailed design and cost information[3] representing 1,484 home improvement designs in fourteen countries over an eight-year period (2013–2020), across a range of contexts and programs in Asia, the Pacific, Latin America and the Caribbean.

Key Findings and Recommendations

Improving vulnerable housing is a cost-effective strategy to reduce the qualitative housing deficit, especially when compared to new construction.

On average across the data analyzed, the cost of improving vulnerable housing was 23% of the average cost of building new housing in the same locations. The average total cost of home improvement was $133/m^2, with the majority of total costs falling below $100/m^2. The average cost of new construction in the corresponding locations across the data analyzed was $588/m^2.[4]

✔ *Investments in improving existing housing should be prioritized as a cost-effective means to*

[1] UN-Habitat, "Housing," accessed July 15, 2021, https://unhabitat.org/topic/housing

[2] Resilient housing is defined as being disaster resistant, healthy and secure, locally appropriate, sustainable, affordable, a financial asset, adaptable and scalable. Refer to *The Build Change Guide to Resilient Housing* (Build Change, 2021) for more information.

[3] Cost information used are the direct construction costs for materials and labor including structural, non-structural and other work, either estimated or actual.

[4] All costs stated are in US Dollars.

address the gap in the global supply of adequate housing as well as to combat increasing threats due to climate change.

In many cases, investments in improving vulnerable housing can be further leveraged to safely densify housing and cost-effectively create new housing units.

Overall, the cost of improvements that included upgrading the house to safely receive an additional story in the future were on average 35% of the average cost of building a new house of the same size in the same locations. In cases where the ground floor of a house was improved and a second floor was added as part of the work, the average cost for preparing for and adding the new space (per square meter of new space) was less than the average cost of new construction of the same size and in the same location, when the additional costs of land and site development for new construction were considered. ✔ *Investments in improving and expanding vulnerable housing should be prioritized as a cost-effective means to support densification and address the gap in the global supply of adequate housing, particularly in urban areas.*

Home improvement investments address multiple challenges: Homes can be made more resistant to disasters, while supporting other goals linked to increased household resilience.

For the purpose of this analysis, all home improvement spending was assigned to one of the following categories: i) Structural Condition Repairs, ii) Habitability Upgrades, iii) Disaster Mitigation Measures and iv) Finishings and Growth. All the sample designs in this study started with disaster mitigation as the initial and predominant objective. However, while almost 60% of spending was on Disaster Mitigation Measures, on average more than 40% of spending was in the other three categories. ✔ *There is demand from homeowners for a range of interventions beyond disaster mitigation, and investments in these other categories should be accounted for when increasing the resilience of housing against disasters.*

Improving housing before—rather than after—a disaster, is a smarter, more cost-effective investment.

Taking preventative action to improve housing is essential to mitigate losses in disasters, but it also enables the same investment to go further than it would in a post-disaster context. Construction costs to improve vulnerable housing were about 1.6 times lower in a Prevention context than in a Post-Disaster context, on average. The amount spent specifically on structural repairs was almost six times less before a disaster than after. For a post-hurricane housing recovery project in Sint Maarten, an average added investment of 30% helped to ensure the entire house was more disaster resistant, instead of only repairing the severely damaged roofs. ✔ *Investments in improving vulnerable housing before a disaster are more cost efficient, and enable more of the investment to be directed toward non-structural and forward-looking interventions, rather than repairs. In post-disaster settings, investments should go beyond repairing damage, to make preventative home improvements that will protect the investment against future threats, for a low additional cost.*

The cost of improving housing varies greatly depending on the level of performance that is targeted.

The targeted level of performance for the design interventions included in this study varied, from minor improvements that would reduce risk in the next disaster ("Risk Reduction"), to life safety upgrades for the hazard level specified in the building code ("Life Safety"), to life safety upgrades plus preparing for and/or building a vertical expansion ("Life Safety + (Future) Vertical Expansion"). If we consider only countries where examples from all three performance targets were available, on average, Life Safety interventions cost 17% more than Risk Reduction interventions, but 55% less than interventions for Life Safety + (Future) Vertical Expansion.✔ *Plan improvement goals to fit the level of investment available (through grant, loan or other financial incentives).*

Home improvement can be tailored according to the available level of investment.

A range of performance targets and costs for home improvement supports greater flexibility with regard to funding and affordability. In the Philippines, incremental Risk Reduction improvements (average cost of approximately $\$72/m^2$) were found to be affordable to clients of microfinance institutions who are primarily in the low to lower-middle income level brackets. However, for more significant interventions, or to reach even lower income brackets, subsidies or grants for the homeowner are needed to make the improvement affordable. ✔ *Ensure that needed subsidies or grants can be provided to low-income and poor households for improvement that might not otherwise be affordable.*

Relative to the corresponding costs of new construction, there was no significant difference in overall costs when improvements were designed for both earthquakes and high wind versus only earthquakes.

In locations exposed to both seismic hazard and high wind, home improvement costs were on average 2.8 times higher than those in locations only exposed to seismic hazard. However, the cost of new construction in the locations exposed to both seismic hazard and high wind were approximately three times higher than those in locations only exposed to seismic hazard. This indicates that the apparent cost increase for making homes resilient against multiple hazards, rather than against a single hazard, is likely due to the generally higher cost of construction for the markets in those locations. Relative to new construction costs, preventative improvements for resilience against multiple hazards were the most cost efficient (20% of the cost of new construction, on average), while post-disaster improvements for resilience against multiple hazards were the most expensive (29% of the cost of new construction, on average). ✔ *Housing improvement programs and interventions should take advantage of the high efficiencies of mitigating against multiple hazards to ensure that all applicable hazards are addressed when making improvements to reduce disaster risk. Further, investments to improve the safety of housing should be made before a disaster, especially in locations exposed to multiple hazards, due to the relatively high increased cost of improvement after a disaster.*

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Acronyms and Abbreviations

(F)VE	(future) vertical expansion
LS	life safety
LWR	lightweight roof
m^2	square meters
MFI	microfinance institution
RC	reinforced concrete
RR	risk reduction
VE	vertical expansion

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1. Introduction

Wherever possible, Build Change advocates for making improvements to vulnerable housing—"home improvement"—rather than building new homes, in order to save lives and prevent housing loss caused by disasters, and improve people's quality of life. Our experience designing and implementing home improvement[5] interventions across the world has shown that most housing can be strengthened to better withstand future threats using relatively inexpensive, simple solutions that already exist: improving sanitation, lighting, ventilation and meal preparation facilities in a house can make it healthier and safer to live in, while strengthening the walls or improving the connections from the roof to the foundation can make the house safer in earthquakes and windstorms.[6]

When compared to new construction, upgrading existing housing in such ways is less expensive and has a lower environmental impact while avoiding a range of undesirable consequences (such as the permanent relocation of families and the need for new infrastructure). At the same time, housing vulnerability reduction measures can be a gateway to wider home improvement measures that enhance people's quality of life and may provide families with opportunities for growth, for example, through expansion that can allow for a home business or rental income. This combination of benefits makes home improvement an optimal response to the qualitative housing deficit, including structural vulnerability of housing to disasters, observed in most countries today.

To support these assertions, a cost study performed by Build Change has analyzed data obtained from designing home improvement interventions for 1,484 homes in fourteen countries over an eight-year period (2013–2020). The study was motivated by a desire to i) contribute to the limited data available with regard to the cost of upgrading homes, ii) obtain greater insight into the different kinds of home improvement spending, and iii) drive investment toward home improvement.

The study had three principle objectives:

- To understand where spending is directed, and how it is distributed, across different kinds of home improvement interventions (Structural Condition Repairs, Habitability Upgrades, Disaster Mitigation Measures, Finishings and Growth);[7]
- To understand how these costs compare across different contexts (Prevention/Post-Disaster), building typologies (timber, unreinforced masonry, confined masonry), hazards (earthquake,

[5] "Home improvement" is used in this study as an umbrella term for any changes made to a house with the objective to improve the safety and living conditions of those who live there. This may include, but is not limited to, repairs, structural changes, habitability upgrades, measures to mitigate the impacts of disasters, and expansion of the home.
[6] For a detailed guide to designing and implementing home improvement programs, refer to *The Build Change Guide to Resilient Housing: An Essential Handbook for Governments and Practitioners. Denver, CO: Build Change, 2021.*
[7] Spending analysis was of direct construction costs only. See 2.1 for more details.

earthquake + high wind), performance targets (Risk Reduction, Life Safety, and Life Safety + (Future) Vertical Expansion), and locations;

- To determine the cost-effectiveness of home improvement relative to new construction.

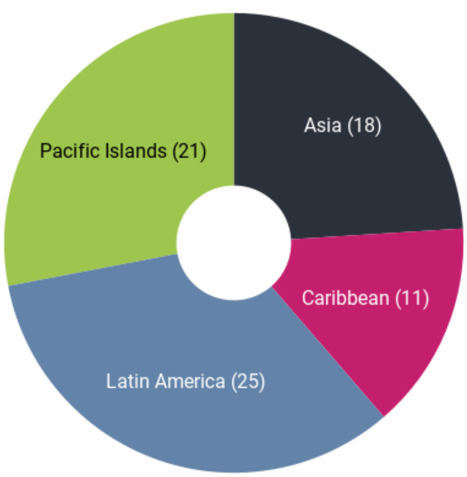
This paper begins by briefly outlining the approach that was used for the study, followed by a summary of key findings and recommendations that can be used to optimize investments in more resilient housing.

2. Approach

2.1 Dataset

Build Change drew upon a dataset of 1,484 designs from Asia, the Caribbean, Latin America and the Pacific Islands. Approximately 300 sample designs were determined to be representative of the full dataset and were grouped into 75 different design groups (see 2.1.1). The dataset covers fourteen different countries across four regions: Indonesia, Nepal and the Philippines (Asia); The Commonwealth of Dominica, Haiti and Sint Maarten (Caribbean); Colombia, Guatemala and Mexico (Latin America); and Cook Islands, Samoa, Solomon Islands, Tonga and Vanuatu (Pacific Islands) (Figure 1). Representative samples in each design group were averaged across the group, and each design group was weighted equally across the dataset.

FIGURE 1 *Number of Design Groups by Region*



SOURCE: BUILD CHANGE

The retrofit designs sampled and studied had been created in response to an assessment of structural and architectural deficiencies, and included input on preferences from homeowners.[8] Each retrofit design solution included building plans or a scope of work, details, bills of quantity and cost estimates (or actual construction costs when available).

The cost data analyzed as part of this study includes only the direct labor and materials construction costs of home improvement, including structural, non-structural and other construction costs, like demolition, when applicable. Non-construction direct costs, such as

[8] The designs developed were for houses that were screened through some process and determined to be suitable for retrofit. Not every house is suitable for retrofitting. For example, houses located on sites that are exposed to hazards such as storm surge, tsunami or landslide risk, require solutions other than reducing the vulnerability of the building in order to reduce the risk to the home. Additionally, temporary or makeshift houses are better candidates for new construction replacement than for retrofit, especially considering the homeowners' likely preference for it.

technical assistance, permit fees, etc., or indirect costs, such as relocation costs or financing costs are not included.[9]

The data for this study was collected over eight years (2013–2020), and all costs were adjusted for inflation to 2020 (see Appendix 1).

2.1.1 Design Groups

The sample designs were grouped into 75 design groups (Table 1) based on shared key characteristics such as location, building typology, performance target, hazards considered and context. A brief explanation of these key characteristics is provided below. Sample designs within the same design group were averaged to get an overall representative set of costs for each group.

- **Location:** One of the fourteen countries listed above, in some cases further refined by region or city.
- **Building type description:** Designs were grouped by building typology, which was defined by parameters such as the number of stories, the type of roof, the construction materials and the structural system of the existing building. The majority of building types included were masonry or timber, one- and two-story houses. See Appendix 2 for more detailed examples.
- **Performance target:** The level or standard to which the building was retrofitted to improve disaster resistance. This comprised
  - Risk Reduction: Bespoke changes to mitigate risk through reducing vulnerability that do not otherwise target a specific level of performance.
  - Life Safety: A full retrofit to enable the building to meet the required hazard intensity levels, as defined by relevant building codes.
  - Life Safety + (Future) Vertical Expansion: A retrofit that includes the provision for a second story (built concurrently or in the future).
- **Hazards considered:** The designs studied considered either earthquake hazard, high-wind hazard, or both, depending on the applicable hazards for each location.
- **Context:** For designs that were developed following a disaster in that location, the context was considered "Post Disaster," while for designs developed for locations that had not previously, or recently, been affected by a disaster, the context was considered "Prevention".

[9] For more information on the direct and indirect costs of structural retrofitting, see Juan F. Fung et al., "The Total Costs of Seismic Retrofits: State of the Art", *Earthquake Spectra*, (May 2021).

TABLE 1 Dataset by Region

LOCATION	NO. OF SAMPLE DESIGNS REPRESENTED	NO. OF DESIGN GROUPS
Asia	321	18
Caribbean	940	11
Latin America	202	25
Pacific Islands	21	21
Total	**1,484**	**75**

SOURCE: BUILD CHANGE

2.1.2 Cost Categories

The direct construction costs for each of the sample designs were divided into four cost categories, relating to the type of work to be carried out. These categories were determined based on Build Change's experience of home improvement spending, and defined as follows:

- Structural Condition Repairs
- Habitability Upgrades
- Disaster Mitigation Measures
- Finishings and Growth

Table 2 provides examples of action items for each cost category.

Cost categories were used in order to differentiate and compare costs for different kinds of interventions, and to provide more detailed understanding as to what extent the addition of disaster risk reduction measures impacts the overall cost of home improvement work.

In cases where a work item could be considered to apply to more than one category (for example, a newly rendered wall in cement plaster is both more hygienic, more structurally stable and more aesthetically desirable to the homeowner in many cases), the costs associated with the work were allocated to only one category, as defined by the examples provided in Table 2.

TABLE 2 Cost Category Descriptions and Examples

<table>
<tr><th>COST CATEGORY</th><th>DESCRIPTION</th><th colspan="2">EXAMPLE ACTIONS</th></tr>
<tr><td>Structural Condition Repairs</td><td>Items that require repair or replacement due to damage from past events, insects, deterioration, etc.</td><td colspan="2">Repair wall or foundation wall
Replace damaged wall
Replace damaged slab
Replace damaged roofing
Replace damaged framing or timber elements</td></tr>
<tr><td>Habitability Upgrades</td><td>Items that are required to meet basic health and safety standards.</td><td colspan="2">Improve lighting and ventilation
Improve security
Improve kitchen
Improve electricity
Improve water and sanitation
Improve accessibility and egress
Improve drainage
Fix leaking roof
Improve fire safety
Improve space distribution — add walls</td></tr>
<tr><td rowspan="5">Disaster Mitigation Measures</td><td rowspan="5">Items that are specifically added to help mitigate risk of building collapse or other life-threatening hazards in the event of an earthquake or windstorm.</td><td>Foundations</td><td>New foundation
Wall to foundation connections</td></tr>
<tr><td>Walls</td><td>New wall or sheathing/bracing
New column or post
New opening reinforcement
Infill of openings
Reinforced overlays
Strongbacks
New ring beam or top plate
Gable wall replacement or bracing</td></tr>
<tr><td>Floors</td><td>Diaphragm slab strips
Connection of walls to floor</td></tr>
<tr><td>Roof</td><td>Wind bracing
Strengthen or add roof framing or connections</td></tr>
<tr><td>Building envelope</td><td>Wind protection for openings</td></tr>
<tr><td>Finishings and Growth</td><td>Items desired by the homeowner, often forward-looking in their use of the house.</td><td colspan="2">Horizontal and vertical expansions
Conversions to more permanent construction materials
New slab roof to replace light roof
Finish/plaster masonry walls
Ceiling
Painting</td></tr>
</table>

SOURCE: BUILD CHANGE

3. Key Findings and Recommendations

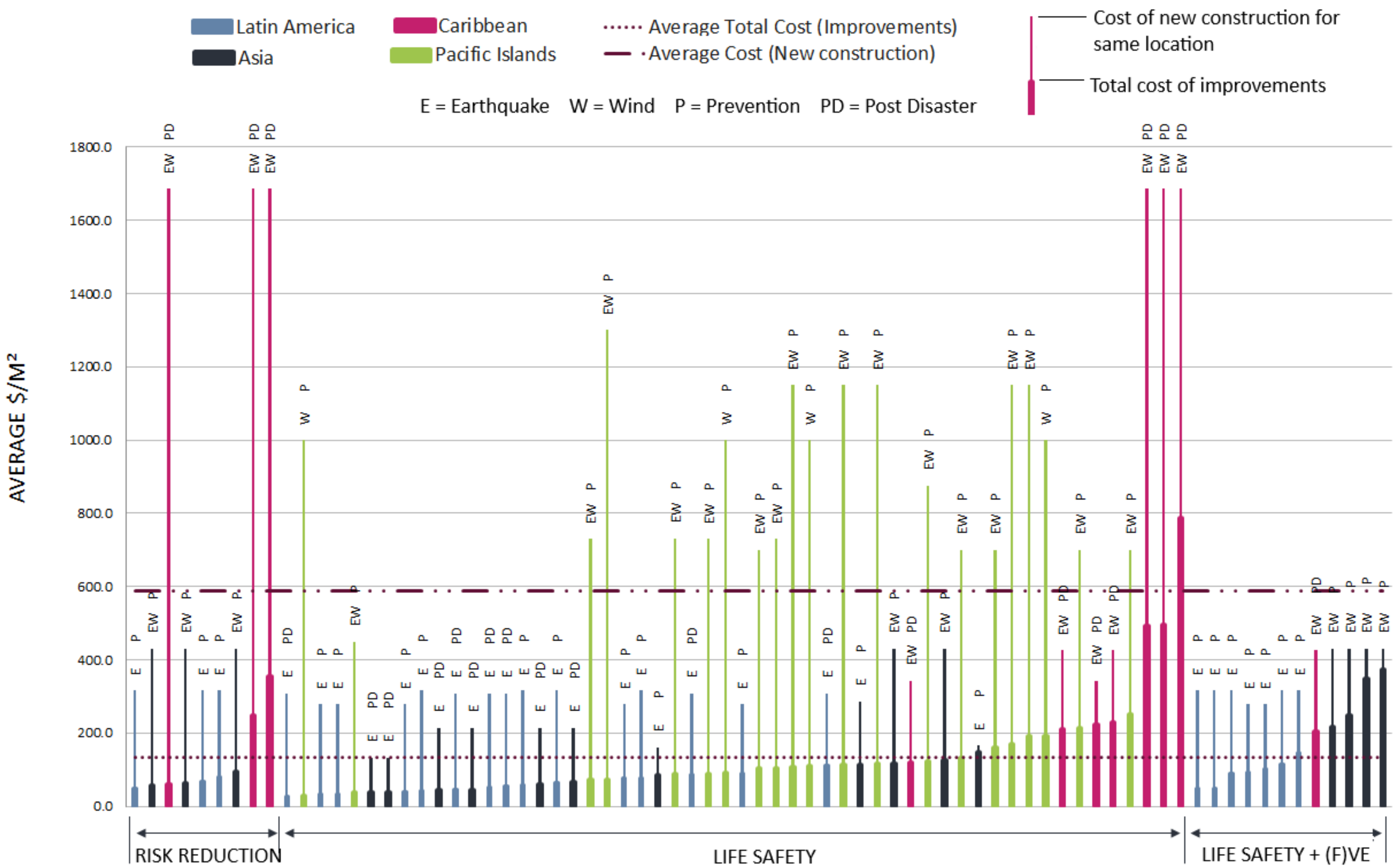
3.1 Improving vulnerable housing is a cost-effective strategy to reduce the increasing qualitative housing deficit, especially when compared to new construction.

On average across the data analyzed, the cost of improving vulnerable housing was only 23% of the average cost of building new housing of the same size in the same locations.[10] The average cost of improvement for all design groups was $133/m^2$ and the average total cost of new construction for all design groups was $588/m^2$ (see Figure 2).

Looking at the frequency distribution of the costs by design group (Figure 3), more than half of the design groups had a total cost below $100/m^2$. Additionally, although there were some outlier groups, for 90% of the design groups the total cost of improvement was below $250/m^2$.

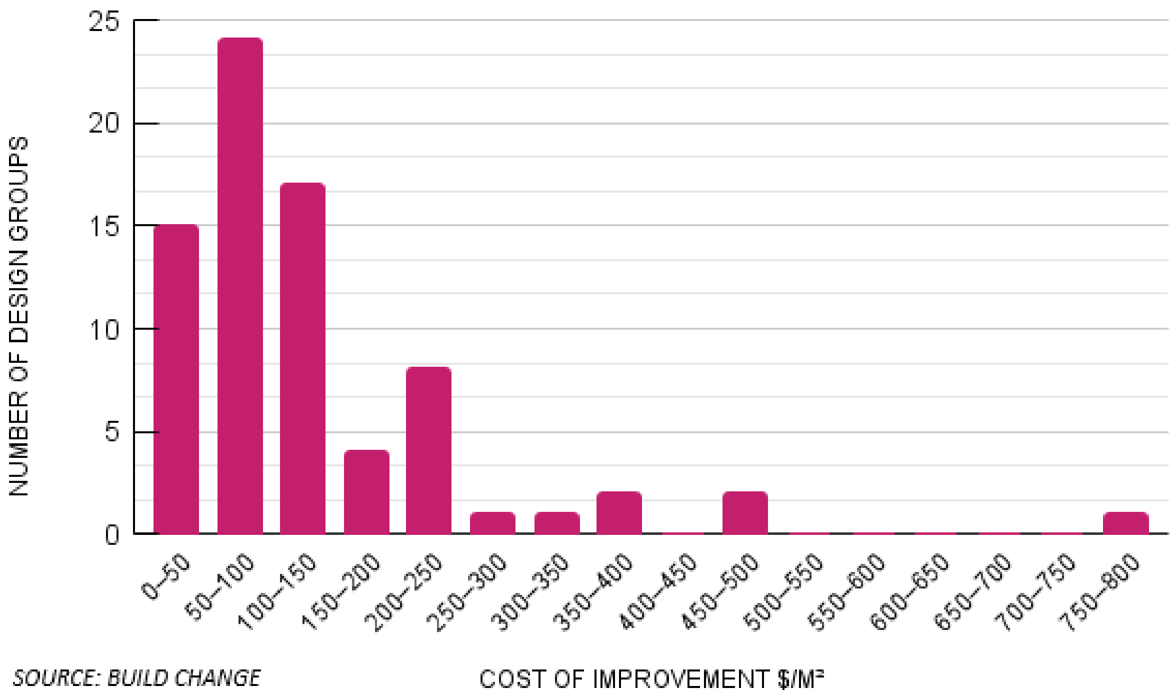
[10] Cost of new housing construction considers only the direct costs of construction (materials and labor), it does not include costs such as land and site development nor does it consider indirect costs. In most cases, a representative new construction cost for each country adjusted to 2020 US Dollars was used for comparison.

FIGURE 2 Total Cost of Improvement and New Construction by Design Group



SOURCE: BUILD CHANGE

FIGURE 3 *Frequency Distribution of Total Cost of Improvement by Design Group*



SOURCE: BUILD CHANGE

Design groups that targeted Life Safety performance for the seismic and/or high-wind hazard levels specified in the applicable building code have a similar performance target to new construction. This is because in most countries, new construction is required to comply with building codes, which typically target Life Safety for the code-prescribed hazard levels. When only design groups targeting Life Safety performance are considered, improving existing housing is even more cost effective, costing on average 21% of the average cost of new construction (Table 3). In other words, **constructing new housing is almost five times more expensive than improving existing housing for essentially an equivalent level of disaster resistance**. Considering the variable intensities, frequencies and geographies of hydrometeorological hazards (such as windstorms) due to climate change, improving vulnerable housing to resist those hazards is a viable solution for addressing the increasing risk to those who live there.

✔ Investments in improving existing housing should be prioritized as a cost-effective means to address the gap in the global supply of adequate housing as well as to combat increasing threats due to climate change.

TABLE 3 Improvement Cost by Performance Target Compared to New Construction Cost

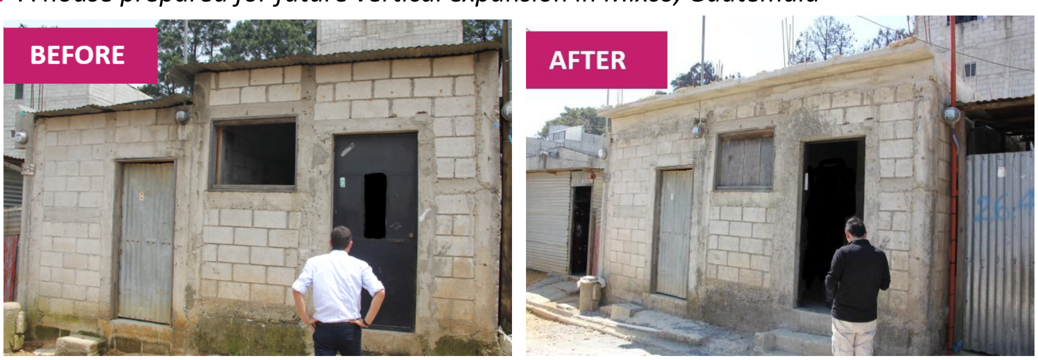
IMPROVEMENT PERFORMANCE TARGET	IMPROVEMENT COST[11] $\$/M^2$	IMPROVEMENT COST[12] AS A % OF NEW CONSTRUCTION COST
Risk Reduction	$119	15%
Life Safety	$128	21%
Life Safety + (Future) Vertical Expansion[13]	$169	47% 35% (future expansion)[14] 69% (expansion included)

SOURCE: BUILD CHANGE

3.2 In many cases, improving vulnerable housing can be further leveraged to safely densify housing and cost-effectively create new housing units.

Overall, improvements that included upgrading a house to safely receive a future vertical expansion were on average 35% of the average cost of building a new house of the same size in the same locations (Table 3). These improvements might include work on the existing house, such as replacing a lightweight roof with a slab roof that can support a future second level, or increasing the strength of the ground floor to account for increased lateral loads due to the future vertical expansion. Figure 4 shows a house in Guatemala which was improved to support a future second story, and included the construction of a roof slab.

FIGURE 4 A house prepared for future vertical expansion in Mixco, Guatemala



SOURCE: BUILD CHANGE WITH PROJECT CONCERN INTERNATIONAL, 2014

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[11] Average total cost over the design groups for the specific performance target

[12] Average total cost over the design groups for the specified performance target divided by the average cost of new construction for the same design groups

[13] Includes both cases where the ground floor was prepared for a future vertical expansion as well as cases in which the ground floor was prepared and the vertical expansion was also built.

[14] Considers only the area built; for example, for future expansion provisions the area of the existing house is considered in calculating the cost per square meter, and for expansion included, the area of the existing house plus the area of expansion are considered.

In sample designs where the house was improved on the ground floor and then a second floor was also added as part of the work, the average additional cost associated with preparing for and adding the new space to the existing one-story house was $\$418/m^2$ of new space (beyond the cost of Life Safety improvements at the ground floor of $\$122/m^2$ of existing ground floor space), which was essentially equal to the average cost of new construction for the same size as the new second floor space of $\$416/m^2$ for the same locations. However, this new construction cost does not account for the cost of land and site development that would likely need to be added to the cost of a new house, thereby making improvement plus expansion less expensive overall when compared to new development. There are also social and environmental benefits to safely densifying strategic urban areas instead of developing new sites, which consume more land and are often outside of established communities. Figure 5 shows a house in Port-au-Prince, Haiti which was improved at the ground floor (to Life Safety level) and vertically expanded.

FIGURE 5 *Improved and expanded house in Port-au-Prince, Haiti*

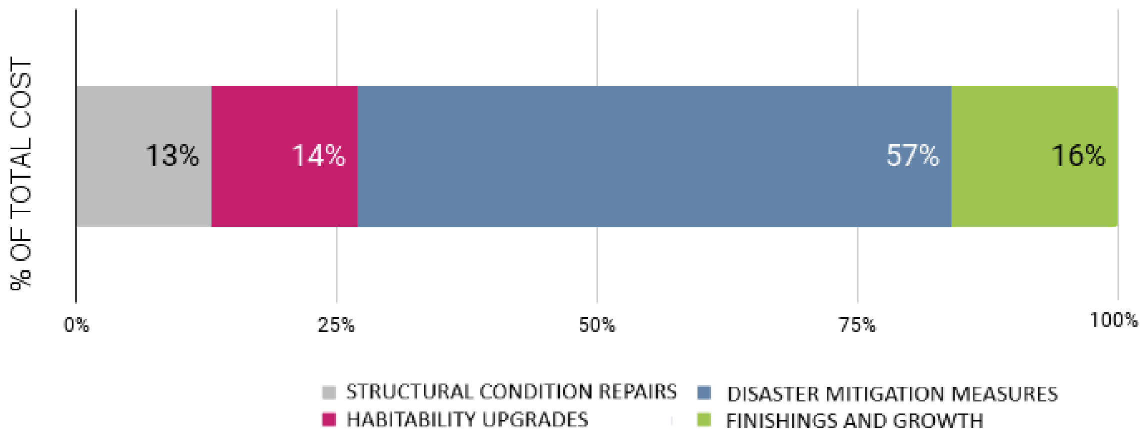
SOURCE: BUILD CHANGE, GLOBAL COMMUNITIES FOR THE AMERICAN RED CROSS AND MINISTRY OF PUBLIC WORKS AND TRANSPORTATION, 2015

✔ Investments in improving and expanding vulnerable housing should be prioritized as a cost-effective means to support densification and address the gap in the global supply of adequate housing, particularly in urban areas.

3.3 Home improvement investments address multiple challenges: Homes can be made more resistant to disasters, while supporting other goals linked to increased household resilience.

The starting point for all the designs included in this study was disaster mitigation and/or recovery. However, from studying overall spending across all design groups for the four cost categories (Table 2) it was observed that, while almost 60% of all home improvement spending was on Disaster Mitigation Measures, more than 40% of spending was in the remaining three categories combined (Structural Condition Repairs, Habitability Upgrades, Finishings and Growth) (Figure 6).

FIGURE 6 *Average Cost of Improvement by Cost Category*



SOURCE: BUILD CHANGE

While it may not have been the initial priority, work relating to non-Disaster Mitigation Measures was carried out for various reasons, primarily due to it being required—either to address a damaged condition or to meet basic health and habitability standards—or in order to meet the needs and demands of homeowners, such as in the case of expansion or finishing works. Our experience has consistently shown work in these other cost categories to be a critical component of home improvement work, and this is reflected in the high amount of spending in these categories overall. Whereas the need for Disaster Mitigation Measures may not always be evident to or prioritized by a homeowner, the opportunity to add another bedroom, improve the layout of the kitchen or increase security (for example) is often a more effective incentive to invest in home improvement. These changes can then be integrated with disaster mitigation improvements to reduce the structural vulnerability of a home.

✔ There is demand from homeowners for a range of interventions beyond disaster mitigation, and investments in these other categories should be accounted for when increasing the resilience of housing against disasters.

3.4 Improving housing before—rather than after—a disaster, is a smarter, more cost-effective investment.

Of the 75 design groups, 23 were in the Post-Disaster context and 52 were in the Prevention context (Table 4). Investing in mitigation measures for private buildings, like housing, has a 4:1 benefit-cost ratio.[15] Taking preventative action to improve housing is essential to mitigate losses in disasters, but it also enables the same investment to go further than it would in a post-disaster context. Overall, construction costs to improve existing housing were about 1.6 times lower, on average, in a Prevention

[15] National Institute of Building Sciences, Multi-Hazard Mitigation Council, *Natural Hazard Mitigation Saves: 2019 Report*, (Washington, D.C.: National Institute of Building Sciences, 2019).

context than in a Post-Disaster context, and the amount spent on structural condition repairs was almost six times less before a disaster than after.

TABLE 4 Dataset by Region and Context

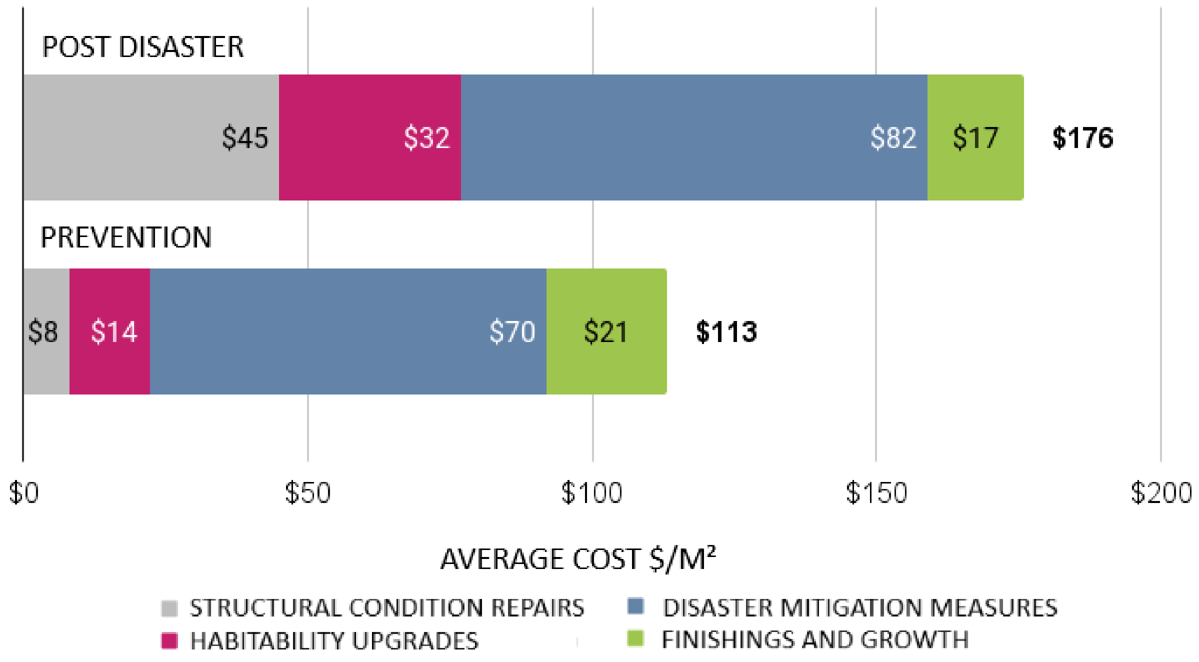
	NO. OF DESIGN GROUPS	
LOCATION	**POST DISASTER**	**PREVENTION**
Asia	6	12
Caribbean	11	0
Latin America	6	19
Pacific Islands	0	21
Total	**23**	**52**

SOURCE: BUILD CHANGE

Figure 7 shows the average total cost of improvement for the Post-Disaster design groups was $176/m^2, whereas for the Prevention design groups this was only $113/m^2. With the exception of Finishings and Growth, costs increased in every category in the Post-Disaster context, with the cost of Structural Condition Repairs increasing by 5.9 times ($8/m^2 for Prevention and $45/m^2 for Post Disaster). Box 1 explores the costs associated with repairing and retrofitting existing damaged houses, depending on the level of damage present in houses affected by a strong hurricane in Sint Maarten. It should be noted that the cost increases observed across almost all categories in the Post-Disaster context are likely to also reflect the rise in labor wage rates, material prices, equipment costs and contractor profit that can result from demand surge following disasters.[16]

[16] See Anna H. Olsen and Keith A. Porter, "What We Know About Demand Surge: Brief Summary", *Natural Hazards Review*, May 2011, 62–71.

FIGURE 7 Cost Comparison for Post-Disaster and Prevention Contexts



SOURCE: BUILD CHANGE

Box 1: Costs of Roof Repairs vs. Replacements in Sint Maarten

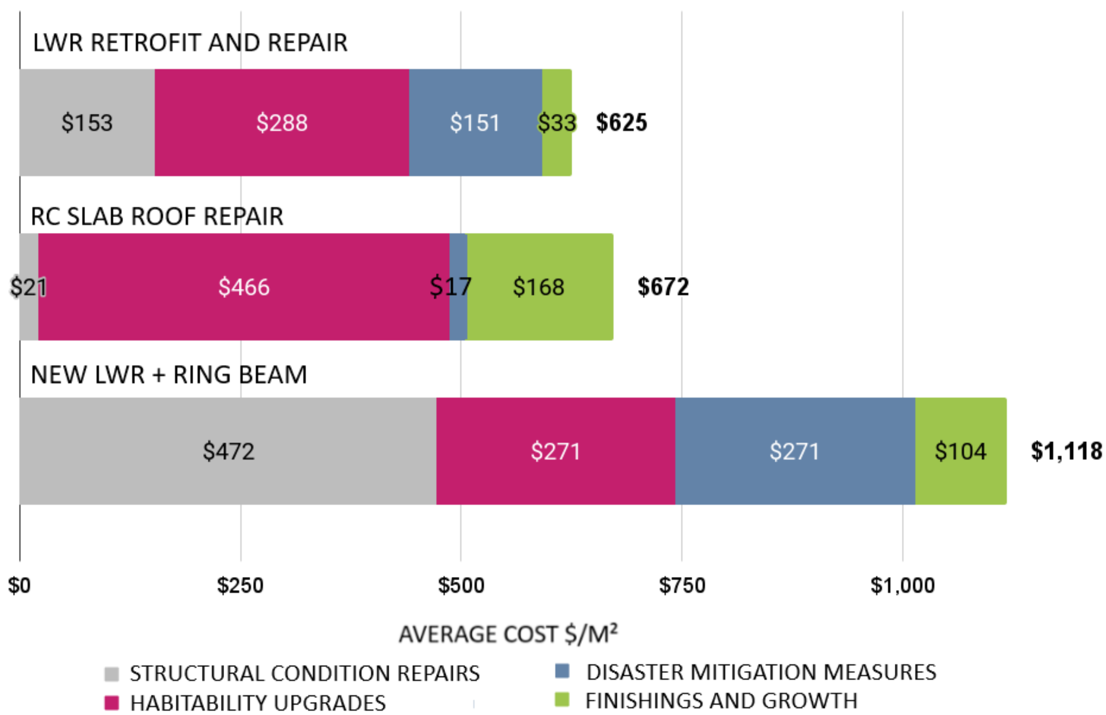
The six design groups studied from Sint Maarten are in the Post-Disaster context, following damage suffered in 2017 by Category-5 Hurricane Irma. Build Change worked with the Government of Sint Maarten and their National Recovery Program Bureau, who led the repair and reconstruction of affected housing. Most of the houses were one-story, partially-confined or unreinforced masonry with light-framed sloped roofs, although some had reinforced concrete flat slab roofs. The program supported three types of roof interventions:

- **Lightweight roof (LWR) retrofit and repair**: For houses with a lightweight roof made of timber framing in which the roof was repaired and strengthened. These had a lower level of damage to the existing elements.
- **Reinforced concrete (RC) slab roof repair**: For houses with a reinforced concrete slab roof in which the roof was repaired. These had a lower level of damage and deterioration.
- **New LWR + ring beam**: For houses with a lightweight roof made of timber framing in which the entire roof was replaced. These had a high level of damage to the existing elements, including badly deteriorated reinforced concrete roofs which were replaced with a new lightweight roof.

The damages to the existing light-framed roofs were typically due to the hurricane-force winds and debris impacts, whereas the badly damaged or deteriorated existing RC slabs were typically due to poor initial construction practices and maintenance of the slab that led to water intrusion and accelerated corrosion of the embedded reinforcing bars.

Figure 8 compares the average costs by category for houses with a Life Safety performance target, for each of the three roof interventions described above.

Figure 8 *Average Costs by Roof Intervention Type, for Life Safety Performance Target (Sint Maarten)*



SOURCE: BUILD CHANGE

Overall, when the roof could be repaired, the total cost of improving the house was about 40% lower (average of $625 and $672, for LWR and RC slab repair cases, respectively) than the average total cost for houses requiring roof replacement ($1,118). This further highlights that preventing damage—both by ensuring the structure can withstand the applicable loads and by starting with quality construction materials and practices—ultimately saves money in the next disaster by avoiding having to replace and rebuild structures.[17]

[17] In the case of RC slab roof repair, the relatively high cost of Habitability Upgrades reflects the high cost of addressing leaks in the roof with specialized waterproofing systems for RC slabs.

For the new LWR + ring beam interventions, the roof reconstruction is categorized as Structural Condition Repair, as this work addresses the high level of damage to the roof. In these cases, the cost of additional Disaster Mitigation Measures is only 24% of the total cost of all improvement work, or an extra investment of approximately 30%. This additional cost is low considering such work can help mitigate against other threats, like earthquakes, and better protect the investment in the new roof and all other work undertaken to increase the building's resilience against future windstorms.

The higher costs associated with Finishings and Growth in the Prevention context (as seen in Figure 7) is reflective of both push factors (which discourage spending on Finishings and Growth) and pull factors (which encourage spending on Finishings and Growth). These can typically be explained as follows:

Push factors (in Post-Disaster contexts):

- Finishings and Growth are of lower priority as families rebuild homes to repair damage after a disaster;
- Spending on Finishings and Growth may be unaffordable after families have spent on essential Structural Condition Repairs;
- Spending on Finishings and Growth is made less affordable by the demand surge typically experienced after a disaster, and therefore is not prioritized.

Pull factors (in Prevention contexts)

- Families have more money to spend on Finishings and Growth without the cost burden of structural repairs that disasters bring;
- Spending on Finishings and Growth is often what motivates families to improve their homes in the first instance (as these needs may have a more immediate or obvious impact on day-to-day life), and can act as a gateway to encourage families to make disaster mitigation improvements at the same time;
- Costs are lower (they are not inflated by demand surge, as they would be following a disaster)—this leaves more money for less urgent changes that are nonetheless desired and of benefit to homeowners.

✔ Investments in improving vulnerable housing before a disaster are more cost efficient, and enable more of the investment to be directed toward non-structural and forward-looking interventions, rather than repairs. In post-disaster settings, investments should go beyond repairing damage, to make preventative home improvements that will protect the investment against future threats, for a low additional cost.

3.5 The cost of improving existing housing varies greatly depending on the level of performance that is targeted.

The performance targets of the design interventions included in this study varied (due to budget and program constraints), from minor improvements that would reduce risk in the next disaster ("Risk Reduction"), to life safety upgrades for the hazard level specified in the building code ("Life Safety"), to life safety upgrades plus preparing for and/or building an additional story ("Life Safety + (Future) Vertical Expansion").

Table 5 summarizes the dataset for the different performance targets.

TABLE 5 Dataset by Region and Performance Target

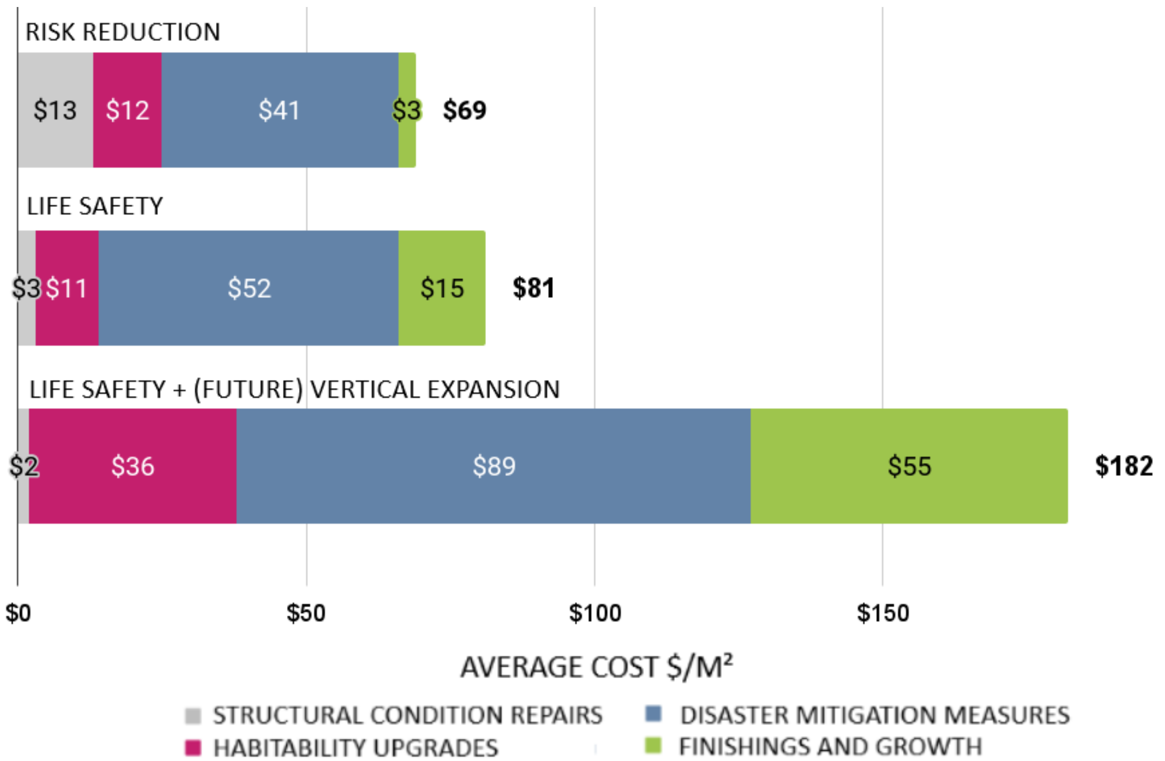
	NO. OF DESIGN GROUPS		
LOCATION	**RISK REDUCTION**	**LIFE SAFETY**	**LIFE SAFETY + (FUTURE) VERTICAL EXPANSION**
Asia	3	11	4
Caribbean	3	7	1
Latin America	3	15	7
Pacific Islands	-	21	-
Total	**9**	**54**	**12**

SOURCE: BUILD CHANGE

These different levels of interventions have varying costs, as shown previously in Table 3. Figure 9 is compiled considering a subset of data from the only two countries where design groups from all three categories were available (Colombia and the Philippines). Figure 9 shows that the average total cost of improvement targeting Risk Reduction was about 85% of the average cost of interventions targeting Life Safety, while the interventions that provided an opportunity for, or actual, vertical expansion were on average over two times more expensive than the Life Safety targeted interventions without provisions for vertical expansion.

✔ Plan improvement goals to fit the level of investment available (through grants, loans or other financial incentives).

FIGURE 9 Comparison of Performance Targets Across the Same Locations



SOURCE: BUILD CHANGE

3.6 Home improvement can be tailored according to the available level of investment.

In the Philippines, while the average total cost of home improvement work ($183/m^2) is unaffordable for most low- and lower-middle income families, incremental improvements targeting Risk Reduction are more affordable. Build Change has been working with microfinance institutions (MFIs) in the Philippines to help them tailor home improvement loans into incremental packages with lower costs that can be repaid over shorter time frames by their clients. However, for more significant interventions, or to reach even lower income brackets, subsidies or grants for the homeowner are needed to make the improvement affordable (Box 2).

Box 2: Affordable Housing Improvements in the Philippines Through Incremental Risk Reduction Improvements

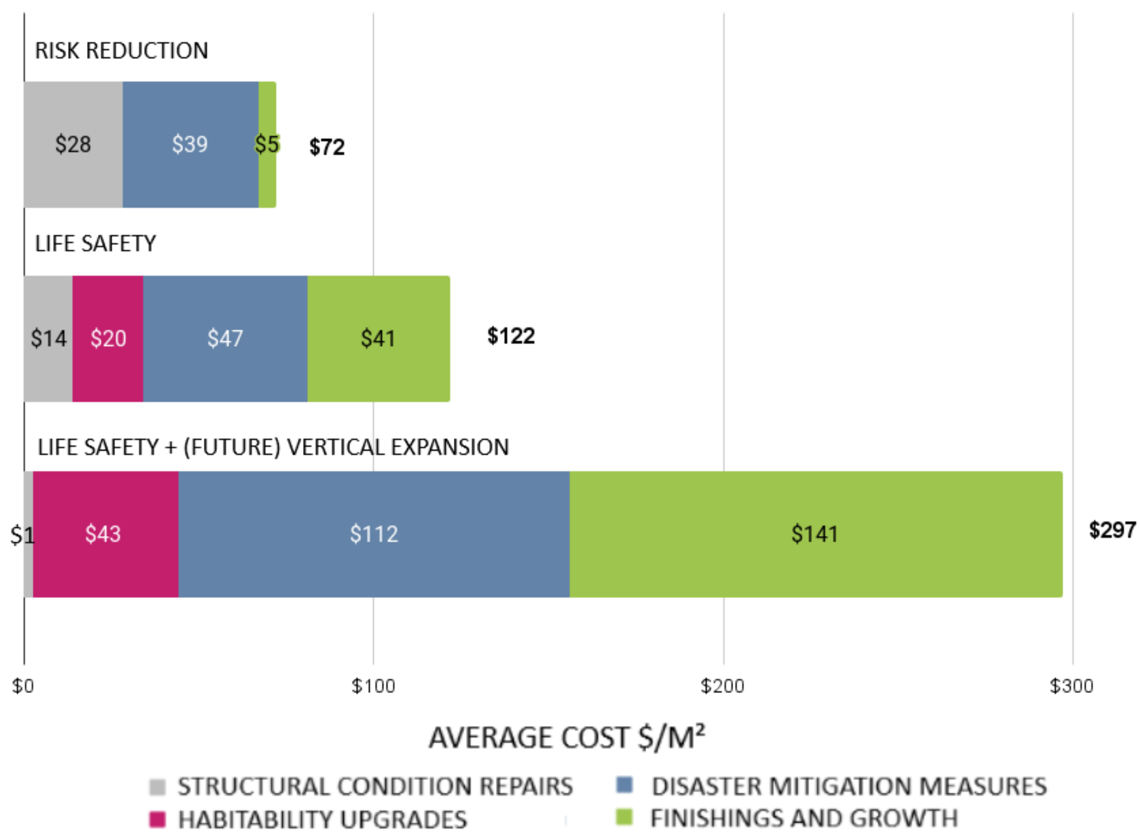
Across all design groups in the Philippines, the average total cost of improving vulnerable houses was $183/m^2. Table 6 provides a breakdown of the average total costs by performance target. A more detailed cost comparison showing categorized spending for each performance target can be seen in Figure 10.

TABLE 6 Average Total Cost of Improvement by Performance Target (Philippines)

PERFORMANCE TARGET	IMPROVEMENT COST ($/M²)	NO. OF DESIGN GROUPS
Risk Reduction	$72	3
Life Safety	$122	2
Life Safety + (Future) Vertical Expansion	$297	4
Total	**$183**	**9**

SOURCE: BUILD CHANGE

FIGURE 10 Categorized Cost Comparison Based on Performance Target (Philippines)



SOURCE: BUILD CHANGE

Based on the average cost of improvement per square meter, and the average house size ($50m^2$) across all design groups, the average total cost of improvement for a home in the Philippines is $9,150. This cost was then examined alongside income and poverty data from the Philippine Statistics Authority to determine its affordability for households of different income levels.

Table 7 summarizes the affordability of a home improvement loan based on the average cost of improvement for a home in the Philippines ($9,150) for each income bracket, considering annual repayments for loans of different amortization periods. Income bracket "A" is highest, while income bracket "D" and beyond are below the poverty threshold, meaning that these families cannot afford to fulfill even basic needs. The calculations show that homeowners in income bracket B can afford loans awarded on a minimum 3-year amortization basis, while homeowners in income bracket C typically require much longer, practically unfeasible, repayment terms.

TABLE 7 *Affordability of Home Improvement Loans Based on the Average Total Cost of Improvement (Philippines)*

INCOME BRACKET	ANNUAL INCOME LEVELS (PHP)	ANNUAL AVERAGE INCOME (US$)	POVERTY THRESHOLD (US$/YR)	ANNUAL DISPOSABLE INCOME FOR LOAN REPAYMENT (US$/YR)	COST OF IMPROVE-MENTS (US$)	LOAN REPAYMENT TERM TO MAKE AFFORDABLE (YEARS)
D	60,000 – 99,999	1660	2574	-914	9150	NEVER
C	100,000 – 249,999	3380	2574	806	9150	>100
B	250,000 – 499,999	6980	2574	4406	9150	3
A	500,000 and over	17300	2574	14726	9150	1

SOURCE: BUILD CHANGE

On the other hand, if the home improvement work focuses on Risk Reduction only, the average total cost is around $3,600 for a 50 m^2 house (approximately 17% of the cost of new construction). Table 8 shows that this level of home improvement is more affordable to income brackets A and B for a 1-year loan and income bracket C for a 7-year loan.

TABLE 8 *Affordability of Home Improvement Loans for Risk Reduction Home Improvement (Philippines)*

INCOME BRACKET	ANNUAL INCOME LEVELS (PHP)	ANNUAL AVERAGE INCOME (US$)	POVERTY THRESHOLD (US$/YR)	ANNUAL DISPOSABLE INCOME FOR LOAN REPAYMENT (US$/YR)	COST OF IMPROVE-MENTS (US$)	LOAN REPAYMENT TERM TO MAKE AFFORDABLE (YEARS)
D	60,000 – 99,999	1660	2574	-914	3600	NEVER
C	100,000 – 249,999	3380	2574	806	3600	7
B	250,000 – 499,999	6980	2574	4406	3600	1
A	500,000 and over	17300	2574	14726	3600	1

SOURCE: BUILD CHANGE

Build Change works with MFIs to help them provide incremental home improvement loan packages with lower costs that can be repaid over shorter time frames by their clients, including for income bracket C households. Most MFIs whose clients are in the low and lower-middle income brackets prefer shorter loan repayment terms, of approximately 1–3 years. This work is helping to bridge the gap between the estimated 15.6 million vulnerable housing units in the Philippines and the estimated 8.6 million of these units that can be supported by MFIs.[18] However, the MFIs still need enhanced access to more appropriate wholesale funds in order to provide low- and middle-income households with the financing required. Additionally, in the Philippines—as for the rest of the world—financial support in the form of subsidies or grants is required to make home improvement affordable to those families living at and below the poverty threshold.

✔ Ensure that needed subsidies or grants can be provided to low-income and poor households for improvement that might not otherwise be affordable.

3.7 Relative to the corresponding costs of new construction, there was no significant increase in overall costs when improvements were designed for both earthquakes and high wind versus only earthquakes; both cases were on average about one-quarter the cost of new construction for the corresponding locations.

Of the 75 design groups, 34 were designed for seismic hazard only, four for high-wind hazard only and 37 for both seismic and high-wind hazard (Table 9). Given the limited availability of wind-only data, this study focused on data for seismic hazard and seismic + high-wind hazard only.

TABLE 9 *Dataset by Region and Hazard*

	NO. OF DESIGN GROUPS		
LOCATION	**SEISMIC**	**WIND**	**SEISMIC + WIND**
Asia	9	-	9
Caribbean	-	-	11
Latin America	25	-	-
Pacific Islands	-	4	17
Total	**34**	**4**	**37**

SOURCE: BUILD CHANGE

As shown in Table 10, in locations exposed to both seismic hazard and high wind, home improvement costs were on average 2.8 times higher than those in locations only exposed to seismic hazard. However, the cost of new construction in the locations exposed to both seismic hazard and high wind were

[18] Build Change, *Disaster Resiliency in Housing in the Philippines: A Market Study of Residential Retrofit Financing*. Denver, CO: Build Change, 2019.

approximately three times higher than those in locations only exposed to seismic hazard. This indicates that the apparent cost increase for making vulnerable homes resilient against multiple hazards, rather than against a single hazard, is likely due to the generally higher cost of construction for the markets in those locations.

TABLE 10 *Cost Comparison by Hazard*

	SEISMIC	SEISMIC + HIGH WIND	(SEISMIC + WIND)/ SEISMIC
Average total cost of improvement ($/m^2)	$70	$195	2.8
Average cost of Disaster Mitigation Measures ($/m^2)	$47	$92	2.0
Average cost of new construction ($/m$^{2)}$	$275	$820	3.0
% cost of new construction	25%	24%	1.0

SOURCE: BUILD CHANGE

Relative to new construction costs, preventative improvement for resilience against multiple hazards was the most cost effective (20% of the cost of new construction, on average), while post-disaster improvement for resilience against multiple hazards was the most expensive (29% of the cost of new construction, on average). For design groups that targeted Life Safety performance, the overall costs were lower but still consistent across hazards considered, relative to the cost of new construction (Table 11).

TABLE 11 *Average Cost of Home Improvement as a Percentage of New Construction Costs by Context, Performance Target and Hazard*

	SEISMIC	SEISMIC + HIGH WIND
Post Disaster: RR, LS and LS + (F)VE	22%	29%
Prevention: RR, LS and LS + (F)VE	27%	20%
Post Disaster and Prevention: LS	23%	22%

SOURCE: BUILD CHANGE

✔ Home improvement programs and interventions should take advantage of the high efficiencies of mitigating against multiple hazards to ensure that all applicable hazards are addressed when making improvements to reduce disaster risk. Further, investments to improve the safety of housing should be made before a disaster, especially in locations exposed to multiple hazards, due to the relatively high increased cost of improvement after a disaster.

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Appendix 1

The data for this study was collected over eight years (2013–2020). In order to ensure cost data was comparable across this period, the rate of inflation for each year in each country was taken into account.

For each sample design, an average rate of inflation was calculated based on the average yearly inflation rate from the year and location in which the data was generated, upto 2020. This average rate multiplied by the number of years was used as a factor to adjust older information to make it comparable to more recent data from other countries. Table A1 presents the average yearly inflation rates used for each country.

TABLE A1 *Inflation Rates Applied from 2013 to 2019*

	2013	2014	2015	2016	2017	2018	2019
Colombia		2.90%	4.99%	7.51%	4.31%	3.24%	3.52%
Guatemala			3.70%	3.75%	4.43%	4.45%	2.39%
Haiti	6.78%	3.94%	7.52%	13.38%	14.74%	12.89%	17.35%
Indonesia			6.36%	3.53%	3.81%	3.29%	2.82%
Mexico			3.64%	4.90%	6.04%	2.82%	2.72%
Nepal			7.21%	9.93%	4.45%	4.15%	4.64%
Philippines			0.67%	1.25%	2.85%	5.21%	2.48%
Sint Maarten						2.1%	2.1%

INFLATION DATA FROM MACROTRENDS.NET

Appendix 2

The primary existing building types referenced in this study were one and two-story masonry or timber houses. Table A2 below provides more details and examples on these building types.

TABLE A2 Building Structural Type Descriptions

BUILDING STRUCTURAL TYPE	DESCRIPTION	EXAMPLE
Unreinforced masonry: Concrete block	Unreinforced masonry houses built from concrete blocks, with cement and sand mortar.	 An unreinforced masonry concrete block house in Haiti. *SOURCE: BUILD CHANGE*
Unreinforced masonry: Fired brick	Unreinforced masonry houses built from fired clay bricks, with cement and sand mortar.	 An unreinforced masonry fired brick house in Indonesia. *SOURCE: BUILD CHANGE*

BUILDING STRUCTURAL TYPE	DESCRIPTION	EXAMPLE
Unreinforced masonry: Horizontal perforated clay block	Unreinforced masonry houses built from horizontal perforated clay blocks, with cement and sand mortar.	 An unreinforced masonry horizontal perforated clay block house in Colombia. *SOURCE: BUILD CHANGE*
Unreinforced masonry: Stone and mud-mortar	Unreinforced masonry houses built from stone masonry, with mud mortar and a timber floor.	 An unreinforced masonry stone and mud-mortar house in Nepal. *SOURCE: BUILD CHANGE*
Confined masonry: Concrete block	Confined masonry houses built from concrete blocks, with cement and sand mortar.	 A confined masonry concrete block house in Guatemala. *SOURCE: BUILD CHANGE*

BUILDING STRUCTURAL TYPE	DESCRIPTION	EXAMPLE
Confined masonry: Fired brick	Confined masonry houses built from fired bricks, with cement and sand mortar.	 A confined masonry fired brick house in Indonesia. *SOURCE: BUILD CHANGE*
Timber	Timber-framed houses with timber-panel or other lighter-weight cladding.	 A timber house in Dominica. *SOURCE: BUILD CHANGE*
Timber with masonry skirt	Timber-framed house with timber-panel or other lighter-weight cladding, with masonry for the lower half of the wall.	 A timber house with masonry skirt in Indonesia. *SOURCE: BUILD CHANGE*

SOURCE: BUILD CHANGE