Housing and resilience: Case studies from the Cook Islands

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Abstract

The Pacific Islands is widely known as being highly vulnerable to climate change impacts. In addition to long-term impacts such as sea level rise, current impacts such as tropical cyclones wreak havoc and the housing sector is often most severely affected. There is therefore a critical need for assessing the resilience of housing in the region. In response to that need, an evaluation tool for assessing housing resilience was developed. The analytical framework of the tool consists of five main factors - Inputs, Output, Result, Impacts & Effects, and External Factors – and the tool was tested in the Cook Islands. Two housing case studies implemented and/or facilitated by Australia-based agencies on two different island locations were examined: On Aitutaki, it was a reconstruction project built after Cyclone Pat in 2010; in Mangaia, it was a program for strengthening roofing against cyclones. It was found that in different ways both the projects had improved the resilience of the beneficiary communities. However a number of challenges were also evident in meeting the wider needs of the beneficiaries and long-term sustainability. The sustainability of these interventions, and indeed that of the islands facing severe resource constraints and rapid demographic and environmental change, posed serious questions. The study allowed confirming the importance of the evaluation tool in the global context of climate change and consequent widespread disaster occurrence, and the devastating impact on the housing sector. In that respect, while there are obvious implications for other Pacific islands, the findings of the study offer wider global lessons for the multiplicity of agencies engaged in housing reconstruction, disaster risk reduction and development.

Keywords: Climate change, Cook Islands, Cyclones, Evaluation tool, Housing, Resilience.

1. Background

This paper is concerned with the importance of housing resilience in the face of increasingly intense and frequent disasters linked to climate change in the Pacific region, and the potential for post-disaster reconstruction to enable resilience. It is derived from a research project entitled *Scoping study: shelter and disaster risk reduction in the Asia-Pacific region* (Charlesworth and Ahmed 2012) undertaken for the Australian Shelter Reference Group (SRG). Housing is usually the most valuable asset for many people and experiences widespread devastation in disasters. Loss of housing exposes people to the weather – rain, snow, heat, etc – thus compounding the impacts of the disaster and often affecting communities over a long term. Therefore the need for housing that is resilient, to safeguard people from such disaster impacts. However, commonly, the need for disaster-resilient housing assumes significance, tragically, after a disaster. Most guidelines and initiatives for safer housing have arisen after major disasters (for example, ERRA 2006; NHDA 2005) and in many post-disaster recovery programs maximum resources and priority is allocated to shelter and infrastructure reconstruction compared to other sectors (Lang 2008). Thus during reconstruction there is the opportunity to understand and thereby address and overcome the underlying vulnerabilities that had previously prevented building resilient housing, and the risks that threaten the durability and sustainability of housing. Building housing back to a standard that is less vulnerable to future hazards can contribute to reduced disaster risks in the long term. Reconstructed or rehabilitated housing built with avoidance of future risk in mind will prove more resilient and sustainable.

A literature review on the broad theme of housing and disaster risk reduction indicated the importance of a long-term framework when evaluating housing projects and the necessity of exploring the link between housing and livelihoods when reviewing the outcomes of a housing project (for example, see Feinstein International Center 2011; Lyons et al. 2010). Thus the need was evident for looking at both physical and social aspects of shelter within a sustainable shelter systems framework. Limited literature on permanent housing was found and most literature on housing and disasters was found to be concerned with temporary or transitional housing, such as the *Shelter Projects* publications (see for example the 2012 edition by UN-Habitat and IFRC); there were very few publications on permanent housing in Asia, and hardly any in the Pacific. The book *Beyond Shelter* (Aquilino 2011) was thus unique in that it assembles a number of leading housing practices. Given the very limited literature on shelter and disaster resilience in the Pacific, the work of Emergency Architects in the Solomon Islands presented in the book is noteworthy, as well as the beneficiary-driven shelter projects there of the Australian Red Cross.

A key outcome of the scoping study was the development of an evaluation tool encompassing a range of physical and social dimensions for understanding and assessing housing resilience. A review of evaluation frameworks pointed that disaster risk reduction (DRR) evaluation frameworks (see for example Twigg 2007) offer a holistic perspective and offer potential for adapting to the evaluation of disaster-resilient housing. The log frame approach is most widely used in the development field (see for example AusAID 2005), but it allows conducting evaluations only within the framework of an ongoing project. However, an approach derived from the log frame for evaluating post-disaster reconstruction was found useful (Lizarralde 2002); this adapted framework in the form of a housing evaluation tool is discussed in this paper. As housing includes intrinsic design and technical factors in relation to resilience (see for example Hunnarshaala Foundation 2006), they were incorporated into the evaluation framework presented here. The tool consisted of three main sequential stages – Pre-Assessment, Assessment and Consolidation – with each stage including a set of guided activities (see Fig. 1). An Analytical Framework consisting of five main factors – Inputs, Output, Result, Impacts & Effects, and External Factors – established through the literature review, was adopted in the evaluation tool (see Table 1).

The tool was tested in actual housing projects in two countries in the Asia-Pacific region – the Cook Islands and Sri Lanka. While the evaluation tool and the Sri Lankan case studies have been discussed elsewhere (Ahmed and Charlesworth 2014; Ahmed and Charlesworth 2015), this paper focuses on the case studies in the Cook Islands, highlighting the opportunities and challenges in the Pacific, a region highly vulnerable to climate change.

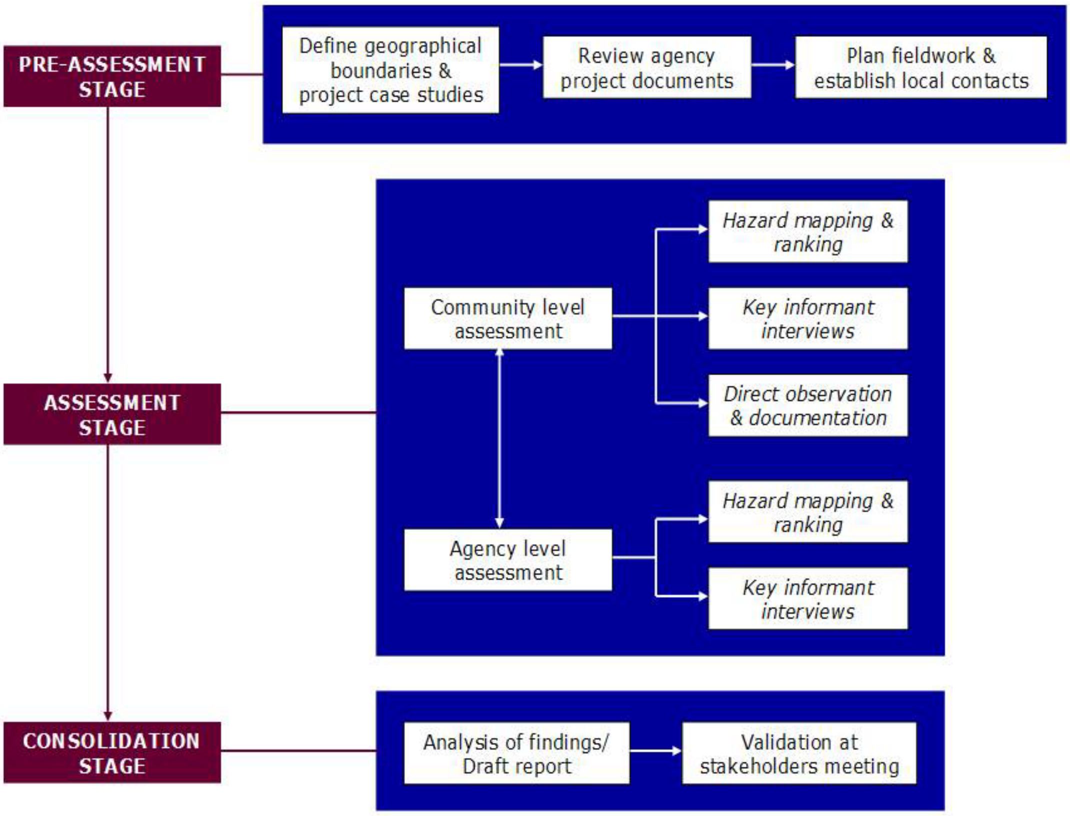

Figure 1: Stages and activities of the evaluation tool

Table 1. Analytical framework of the evaluation tool (adapted from Lizarralde 2002).

Factors	Definition	Aspects	Key questions
a) Inputs	Human, material and financial resources required to incorporate resilience in shelter	Efficiency	• Were the local and external resources optimised (cost-effectiveness)? • Was the community specifically engaged in design/construction? • Was there a dedicated skills transfer/training component?
b) Output	Articulation of resilience options before applying it	Results	• Were the resilience options realised?
		Timing	• Were they available at the right time?
		Quality	• Are the resilience options 'good' in the local context?
c) Result	Direct consequence for the beneficiary of applying the resilience options	Pertinence	• Were the resilience options available to the most vulnerable people?
		Acceptability	• Did the local community use the resilience options? • Were they pre-determined/required, or optional? • Were they replicated outside the project? • Are they easy to maintain?
d) Impacts & Effects	Indirect or later consequences for the beneficiary of using resilience options (or the situation originating from the project)	Strategy	• Did the resilience options correspond to the needs of the community?
		Scope	• What proportion of vulnerable people was covered?
		Ultimate objective	• Did the project reduce the disaster risks of the community? • Do the community/ households feel a greater sense of security?
e) External Factors	Factors beyond the control of the implementing agency.	External aspects	• How did the context and environment affect the results of the project?

2. Disasters and housing in the Cook Islands

Countries in the Pacific region are among the most vulnerable in the world to climate change impacts, presenting tremendous challenges to the housing sector (World Bank and SOPAC 2009; World Bank 2013). In addition to exposure to coastal hazards because of the islands' locations, vulnerability is compounded by low socio-economic development throughout the region. A number of disasters affect Pacific Island countries, among which cyclones are by far the most significant; among all the hazards, an estimated 50% risk is posed by cyclones (World Bank 2013).

Out of twenty countries in the world that experience the highest disaster losses, eight are Pacific island countries including the Cook Islands (World Bank 2013). The group of small islands comprising the Cook Islands is highly exposed to cyclones. Part of a long history of cyclones, Cyclone Pat hit Aitutaki Island in February 2010 with a wind speed of nearly 200 kilometres per hour and caused extensive devastation. Out of 762 buildings on the island, 388 were damaged or destroyed and 90% of housing was impacted. Most of the damage was evident in the roof structure (MOIP 2010). All the islands of the Cook Islands, such as Mangaia Island, are at risk. A number of cyclones battered Mangaia in 2005, including the most devastating Cyclone Meena. Islanders are aware of the risk and have a local practice of tying down metal sheet roofs during the cyclone season (January-April).

3. Basis of selection of case studies

Two case study housing projects in the Cook Islands were selected through extensive consultation with SRG member agencies. The projects were led by Australia-based members of the SRG, which offered their projects for test assessments using the evaluation tool. One of the projects was a housing reconstruction project on Aitutaki island implemented after Cyclone Pat, designed and led by Emergency Architects Australia (EEA). The other was a housing disaster risk reduction (DRR) project led by Partner Housing Australasia (PHA) in Mangaia island. Both the projects incorporated disaster resilience features and hence were considered suitable for assessment to understand the extent resilience had been achieved. The projects were however different in scope and nature, and therefore allowed gaining a broader insight.

4. Case study 1: Housing reconstruction, Emergency Architects Australia (EAA)

This project was funded by the New Zealand government through NZAID. Post-cyclone damage-and-needs assessment was undertaken by the Cook Islands Ministry of Infrastructure & Planning (MOIP), Rarotonga, in partnership with the Aitutaki Island Council. Key decision-making and guidance was provided by a Recovery Committee consisting of key government agencies in Rarotonga. However, the local level implementation and management was conducted by the island council. The design of the new housing was prepared by EAA, with periodic supervision provided by an EAA architect. Thus the project relied on a range of stakeholders, which had a bearing on its effectiveness.

4.1. Key housing features

There were four categories in the post-cyclone housing reconstruction program. Cat 1 and Cat 2 consisted of repairing minor structural and other damages; Cat 3 involved building a new roof over houses that had lost their roofs, but were otherwise undamaged; and Cat 4 consisted of constructing new houses to replace completely destroyed houses. The study focused largely on Cat 4 housing. Firstly Cat 1 and 2 were implemented, followed by Cat 3 and finally Cat 4 over one year (July 2010 – July 2011).

Two house designs were built: 1-bedroom type for households with less than 5 residents and 2-bedroom type for larger households. 66 houses were built, out of which 33 were of the 1-bedroom type and 33 of the 2-bedroom type. The cost of the 1-bedroom type was NZ$26,000 and the 2-bedroom type NZ$34,000 including labour costs.

Figure 2: A 2-bedroom house in the Aitutaki project

4.2. Main findings

4.2.1. Inputs: Resources for incorporating resilience

Beneficiary selection was based on assessment by MOIP, with support from the Island Council. The Rarotonga-based Recovery Committee ruled that only households that were living in the houses during the cyclone would be eligible for reconstruction support, even if they were tenants; thus absentee landlords were not compensated. Households that were poor and vulnerable, but whose houses were not damaged or destroyed did not receive reconstruction support. This led to various grievances.

There was minimal or no consultation with beneficiaries. After the designs were done, they were shown to the affected communities and most of them accepted the designs in order to be able to get free houses. During construction, some households made changes, for which they had to bear any extra costs incurred. The houses were expected to be painted and floor finishes (tiles, linoleum, etc) to be provided later by the beneficiaries, which some of them had done or were in the process of doing with their own funds.

4.2.2. Output: Articulation of resilience options

The Cat 4 houses were built to resist future cyclones. Some of the main resilience features included: strong foundations with heavily reinforced footings (6 rebars of 20mm diameter), reinforced concrete block posts (4 rebars of 16mm diameter with stirrups of 10mm @ 300mm spacing), double wall plates (6”x2” each), strong timber rafters (8”x2” instead of the commonly used 4”x2” or 6”x2”), purlins (4”x2” instead of the usual 3”x2”) and wall studs (6”x2”), metal straps to connect roof framing members, thick corrugated iron (CI) roofing sheets (0.45mm) screwed onto the frame and a roof pitch more than 30^o to prevent lift-off by wind. The main focus was on building a strong roof, the element most affected by cyclones. The wet areas – bathroom and kitchen - had external walls of concrete block to prevent quick deterioration and requiring less maintenance, adding to the resilience of the house.

All interview respondents agreed that the houses were strong and would withstand future cyclones. Indeed, some of them mentioned that they were “over-designed”. Most respondents agreed that the construction quality and materials were good, and adequate supervision was provided. However in some houses finishing was reported deficient with gaps in the ceiling, window louvres not matching in colour and other such shortcomings.

All the sites were compacted to prevent settlement and adequate infrastructure and services were provided. Although flooding was generally not common, localised water-logging occurred due to low elevation of some of the sites. In such instances, some households paid the extra cost of increasing the plinth height by one layer of concrete block during the construction process.

4.2.3. Result: Direct consequences of application of resilience options

It was not clear to what extent the resilience features included in the project were being replicated locally. In one house where an extension had been added, it was found that some features such as connecting straps were used, largely because one of the household members was a construction worker and involved in the shelter reconstruction where he learnt the strengthening technique. On the other hand, in a new house being built, it was reported that there were hardly any resilience features. Houses more than 15 square metres required a building permit and to follow wind-resistant building codes. However the codes had not been upgraded to the wind speed level of Cyclone Pat, and also enforcement in implementation by Island Council building inspectors was found to be lacking.
In general, most commodities in the Cook Islands were imported from New Zealand, as were the building materials and products used in the reconstruction program. This made the commodities expensive and there was also an embodied energy cost due to transport. Therefore any repair, maintenance or extension of the houses would require imported and hence expensive materials, not available locally.

There were unanimous reports that the houses were too small. The 1-bedroom type had a small bedroom of 2.65 x 2.85 metres and in the 2-bedroom type, bedrooms were smaller - 2.65 x 2.65 metres. Large extended households were common and alternative arrangements had to be made, such as sleeping outside in makeshift structures or in the living room. Nonetheless the houses were designed for ease of extension, having exposed rafters under the eaves to which new roof frames could be attached. Many households were found to have built extensions or planning to. However it was uncertain if the extensions would be as resilient to cyclones as the original house; only a shallow roof pitch could be maintained in the extended parts, and also it seemed unlikely that most households would be willing to spend money on and have access to products and skilled workers to apply resilient building techniques.

A number of households mentioned that they did not like having the bathroom inside the house, especially next to the kitchen. Some of them had arranged during construction to avoid building the bathroom inside, some had moved the kitchen to an extended structure at the back and most were planning to build extensions and move the bathroom and kitchen. Firstly, this pertained to the local culture. Secondly, because of the small house sizes, not having a bathroom and/or kitchen inside allowed more space inside the house; for example, one household with 11 residents was found to have converted the area originally allocated for a kitchen into a small bedroom.

4.2.4. Impacts & Effects: Indirect/Later consequences of application of resilience options

In the earlier stages (Cat 1 and 2) building teams were brought in from Rarotonga, but subsequently 18 local builder teams were engaged and local construction workers employed and trained on the job. Even workers who built their own house were paid, hence contributing to the local economy. It was not clear to what extent local builders and workers were trained in building resilient houses, though there was some evidence of that, for example in the new extension to a house mentioned above, where some resilience features were applied.

The new houses provided a sense of security to the beneficiaries and they felt that they were better protected from future cyclones. Even in Cat 1, 2 and 3, repairs and roof replacements were reported to be of high standard and had therefore contributed to the disaster resilience of the wider community on the island.

4.2.5. External Factors: Beyond control of implementing agency

Because the project was managed and implemented largely by MOIP from Rarotonga, although in partnership with the Aitutaki Island Council, the local people did not feel entirely empowered. The design of houses and decision-making process was external and the locals felt left out. The Island Council office did not even have a set of the design drawings. In this sense, the project was somewhat top-down. The Mayor of Aitutaki at that time was unpopular in his own village (Amuri) and it was alleged that he intentionally overlooked people who deserved a new house, even though some of them were needy and vulnerable.

5. Case study 2: Disaster risk reduction (DRR) of housing, Partner Housing Australasia (PHA)

This project was funded and designed by PHA in partnership with the Australian Red Cross. The Cook Islands Red Cross was the local partner and the project was implemented through the Mangaia Red Cross Chapter. The project consisted of implementing a system of tying down metal sheet roofing to prevent displacement by storms and cyclones. It started in July 2012 in one of the three villages – Tamarua – in Mangaia Island. All of the 30 occupied houses in the village were planned to be strengthened, and there were plans to subsequently extend the project to the other two villages (Oneroa and Ivirua), thereby building resilience throughout the island.

5.1. Key housing features

Recognition of the prevalent cyclone risk led to this DRR project. Based on the local practice of tying down metal sheet roofs, a more systematic approach to roof anchoring was implemented. Households were provided good quality nylon (polypropylene) ropes (12mm diameter) to tie down roofs to anchor points.

Figure 3: A house with the roof anchoring system.

The terrain being rocky, where strong and deeply embedded rocks were available on site, the anchors consisted of galvanised iron 'eyebolts' (with a threaded end

25mm long) fixed into the rocks. A hole was first drilled into the rock and the pointed and threaded end of the eyebolt then placed in the hole, which was then filled with fast-setting adhesive cement. The ‘eye’ or ring protruding from the rock could then be used for tying the rope holding the roofing sheet in place. Where suitable rocks were not present on site, a reinforced concrete footing having a base of 450 x 450 x 400mm with a cylindrical shaft (100mm diameter, 600mm high) was used as the anchor. A 12mm diameter steel rebar was curved and attached to the base reinforcement, acting as reinforcement for the shaft with the curved end protruding from the top of the shaft to serve as a ring to tie ropes.

5.2. Main findings

5.2.1. Inputs: Resources for incorporating resilience

There was significant migration of young people from Mangaia to the capital, Rarotonga, and New Zealand for employment opportunities. Tamarua village was found particularly vulnerable in a Vulnerability & Capacity Assessment in 2011 by the Red Cross because of the high prevalence of elderly-headed households and few able-bodied persons. Only 30 houses were occupied in the village and the owners of most other houses had migrated. The village was also somewhat isolated from the main part of the island. Therefore it was chosen to begin the DRR roof anchoring project here.

A representative from Red Cross, Rarotonga, visited the village together with Island Councillors and community meetings were held in a local church. The project was introduced to the community and reportedly all of them agreed that it was a good idea.

The cost of roof anchoring for each house was roughly NZ$200 including labour. Some of the beneficiaries helped the construction workers, or provided them lunch or snacks, and in some cases supplied materials such as old chains or shackles as an alternative to the eyebolts or curved rebars. An engineer from PHA trained a local builder and a construction worker. After gaining experience, the trained builder was expected to train and supervise workers in subsequent stages of the project when implemented in the other villages.

5.2.2. Output: Articulation of resilience options

This was the first time this type of resilience feature was applied on this island. Although there was a tradition of tying down roofs, the ropes were tied to trees or nearby heavy objects. If the tree was uprooted in a storm, it could fall and damage the house. Thus the new roof anchoring system could be expected to contribute better to resilience.

The materials provided through the project and the construction was reported to be of good quality. However progress was slow as only two workers were involved. Additionally not having good transport affected their work as the village was somewhat remote and about a 40-minute drive from the main village; there was no public transport on the island and roads were not paved, making transport of materials a critical issue.

5.2.3. Result: Direct consequences of application of resilience options

Nylon ropes being used in the project were more durable than ropes made of organic materials. However they would deteriorate in the sun within a few years, if left on the roof. Therefore households had been instructed to use them only in the cyclone season and store them inside the house during the rest of the year. Fixing and tying the ropes is a laborious task and it was not clear how household without able-bodied persons would be able to manage. Nonetheless there was a tradition of mutual help within the island communities and the elderly people would possibly be able to get some help from other community members.

The galvanised eyebolts were weather-resistant, but the curved steel rebars will rust and weaken by corrosion in the salty atmosphere. There was no provision in the project for coating them with corrosion-resistant paint or a greasy substance. The roof anchoring was expected to resist up to Category 3 cyclones (118-159 kilometres/hour wind speed) evidence of which can only be found after an actual cyclone.

5.2.4. Impacts & Effects: Indirect/Later consequences of application of resilience options

This was a small-scale project and hence only a couple of local construction workers were trained. Nonetheless over the long-term this could be expected to build further capacity with the support of these trained workers. However, as typical of the Cook Islands, all the building materials had to be brought from New Zealand or elsewhere. This might be a barrier to extensive replication and long-term maintenance.

The project addressed a key vulnerable part of the house. Although the whole structure was not strengthened and only a part of the roof was made secure, it still improved the resilience of houses to some extent. As one interview respondent commented: “It’s better than nothing.”

5.2.5. External Factors: Beyond control of implementing agency

Reliance on imported building materials and outside suppliers led to some uncertainty. For example, it proved difficult to get timely delivery of the eyebolts causing delay to the project. Subsequently the anchor design was modified, replacing the originally planned eyebolts with the curved rebar design. Materials such as steel rebars and cement were imported, but more easily available in local markets, especially in Rarotonga, compared to unusual products such as eyebolts.

6. Overview of findings

In the EAA-led project in Aitutaki, the quality of construction and building materials were of high standard, and the houses incorporated resilience features to resist cyclones, the main hazard there. However, houses being small required extensions for large households, often built without professional support. It is uncertain if such extensions would be as resilient as the original house, in which case the occupants and household belongings would be vulnerable to future cyclones.

In the PHA-led project in Mangaia, the system of roof anchoring introduced in the project provided better resilience to cyclones, addressing a key vulnerable part of the house. Although the whole structure was not strengthened and only a part of the roof was made secure, it still improved the resilience of houses to some extent. However, reliance on imported materials might affect sustainability and long-term resilience.

Thus both the projects were found to have reduced disaster risk to varying levels, and had contributed to their respective beneficiaries' resilience. By reducing vulnerability, they had led to an improvement of previous living conditions. However, despite the overall positive findings some challenges became evident when testing the housing evaluation tool, especially with regard to the **Result** factor concerning housing design issues. The one-size-fits-all approach followed in the Aitutaki project, given the diversity of beneficiary households, resulted in the obvious problem of lack of space for large households and too much space for small ones. Other challenges as noted above, such as the lack of acceptance of indoor toilets, mismatch of colours of window louvers and gaps in ceilings were due to the bearing of the **Inputs** factor on the **Result**: Although the houses were designed and built professionally, there was no community consultation and participation in those processes, hence the challenges arose. The Mangaia project also indicated weakness in the **Result**, where there was no specific strategy for managing the labour-intensive roof-anchoring system in a community with a significant proportion of elderly residents.

The other factor that was found to have played a problematic role was **External Factors**. The lack of ownership by local authorities in Aitutaki because of the externally driven implementation, and in Mangaia, the reliance on imported building products, both undermined the long-term sustainability of the projects and the well-intentioned efforts of the implementing agencies.

7. Conclusion

The evaluation tool was designed to capture a wide range of issues relating to housing and disaster resilience. Because it is comprehensive, it allows examining different types of projects, as indicated from the two different case studies from the Cook Islands. Not all the issues included in the tool would be relevant for all projects, and some issues might be more important according to specific projects. To prove relevant to organisations, it would need to be adapted to the particular context and project while adhering to its structure and processes. The advantage of being comprehensive, as found in the field, is that it provided a menu of issues that allowed selecting those most relevant to the project being studied.

The evaluation tool that allowed arriving at the above findings and conclusion has been found productive in a variety of contexts and projects and would therefore serve as a useful resource for agencies interested in evaluating whether and how resilience has been achieved in their housing projects. It is being recommended that such evaluations using purpose-built tools should be a standard procedure, given the widespread and global occurrence of disasters, their devastating impact on the housing sector and the multiplicity of housing reconstruction and DRR projects by humanitarian agencies.

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