

Resilient housing policies: A framework for evaluation

**Prof Paula Jarzabkowski¹, Dr Katie Meissner¹, Neil Taylor¹
and Dr Tyler Riordan¹ (with assistance from Rosie Gallagher¹)**

1. The University of Queensland Business School, Queensland





Version	Release history	Date
1.0	Initial release of document	21/01/2025
1.1	Minor corrections to sections 1.1, 3.2 and Appendix G	11/02/2025



Australian Government

Natural Hazards Research Australia receives grant funding from the Australian Government.

© Natural Hazards Research Australia, 2025

We acknowledge the Traditional Custodians across all the lands on which we live and work, and we pay our respects to Elders both past, present and emerging. We recognise that these lands and waters have always been places of teaching, research and learning.

All material in this document, except as identified below, is licensed under the Creative Commons Attribution-Non-Commercial 4.0 International Licence.

Material not licensed under the Creative Commons licence:

- Natural Hazards Research Australia logo
- Australian Government logo
- Any other logo
- All photographs
- All figures and graphics

All rights are reserved in content not licenced under the Creative Commons licence. Permission must be sought from the copyright owner to use this material.



Disclaimer:

The University of Queensland and Natural Hazards Research Australia advise that the information contained in this publication/material comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in all circumstances. No reliance or actions must therefore be made on the information contained in this publication/material without seeking prior expert professional, scientific and/or technical advice. To the extent permitted by law, The University of Queensland and Natural Hazards Research Australia (including its employees and consultants) exclude all liability and responsibility for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication/material (in part or in whole) and any information, material, omission, error or inaccuracy contained in it. The University of Queensland and Natural Hazards Research Australia (including its employees and consultants) make no representation or warranty as to the accuracy, completeness, or reliability of information contained in the publication/material. The information contained in the publication/material is only current at the date of publication. The University of Queensland and Natural Hazards Research Australia (including its employees and consultants) accept no responsibility to update any person regarding any inaccuracy, omission or change in information in the publication/material or other information made available to a person in connection with the publication/material. By accessing the publication/material you are confirming you have understood and accept the disclaimer as outlined above.

Publisher:

Natural Hazards Research Australia

ISBN: 978-1-923057-17-3

Report number: 37.2025

January 2025

Cover: Image by bilanol / Adobe Stock. Used under institutional educational licence



Table of contents

Acknowledgements	3
Executive summary	4
List of abbreviations	6
1. Introduction	7
1.1 Selecting resilience programs	7
1.2 A framework for evaluating resilience programs	8
2. Enabling policy mechanisms	10
2.1 Continuing policy	11
2.2 Government-based insurance scheme	11
3. Trade-offs in program delivery	13
3.1 Trade-off one: Collective or individual approach	13
3.2 Trade-off two: Eligibility and equity	15
4. Mobilisation	18
4.1 Incentives	18
4.2 Support to access the program	19
5. Evaluating outcomes of a resilience program	21
6. Summary: Future considerations	23
Appendices - Resilience Program Summaries	25
A. Grantham Relocation Policy (Australia)	25
B. Christchurch Residential Red Zone (New Zealand)	27
C. Restore Louisiana Homeowner Assistance Program (USA)	29
D. The State of New Jersey: Superstorm Sandy (USA)	31
E. Flood Re Build Back Better (UK)	33
F. The State of North Carolina: 1990s hurricane and storm response (USA)	34
G. Brisbane City Council's Flood Resilient Homes Program (Australia)	36
References	37



Acknowledgements

The Resilient Homes Fund is a jointly funded initiative delivered through Commonwealth-State Disaster Recovery Funding Arrangements (DRFA).

This research project is funded by Natural Hazards Research Australia and the Queensland Reconstruction Authority.

We thank our partners, the Queensland Government, the Department of Housing and Public Works, The University of Melbourne and participating insurance companies, IAG and RACQ, for their collaboration in this research project.

The views and opinions expressed in this report are those of the authors and do not necessarily reflect the views or positions of funders or partners.



Executive summary

The purpose of this report is to understand how selected resilience programs unfold (within their own physical, financial, social and emotional constraints), gather lessons learned and expand the body of knowledge around post-program resilience. This report is the first in a series of work packages in the Evaluating the Resilient Homes Fund research project.

This report reviews seven selected programs from which to draw comparative themes that can be applied to evaluating the Resilient Homes Fund in Australia. The following were selected because of their relevance to some of the key issues for Australian flood resilience programs:

- a) Grantham Relocation Policy (Australia)
- b) Brisbane: Flood Resilient Homes Program (Australia)
- c) Christchurch Residential Red Zone (New Zealand)
- d) Flood Re's Build Back Better (UK)
- e) The State of North Carolina: 1990s hurricane and storm response (USA)
- f) The State of New Jersey: Superstorm Sandy (USA)
- g) Restore Louisiana Homeowner Assistance Program (USA)

While these programs are all similar in that homeowner participation has been voluntary, they differ in several ways, including diversity of population; housing stock; presenting conditions of hazard; and scale and complexity.

The programs were analysed from the perspective of policy design and delivery rather than specific structural or hazard features to develop a framework for evaluating the key enablers and trade-offs involved in implementing government-sponsored resilience programs. The framework facilitates the development of the following *interlinked indicators for evaluating outcomes*:

1. **Evaluating measures taken against relevant criteria**
A key outcome is evaluating how many properties were made more resilient to the identified hazard. These interventions alone will not indicate successful outcomes unless measured against future hazards. Therefore, maintaining data provides an opportunity to enable evaluation against relevant criteria.
2. **Establishing a basis for future enabling policy mechanisms**
Any specific resilience program is likely to be one in a series of government interventions to improve the resilience of housing stock, communities and regions. Hence, the outcome of any specific intervention should be understood as cumulatively feeding into subsequent programs. Careful collection and maintenance of data and knowledge is critical to enable the (re)activation of a future resilience policy.
3. **Shifting from post-disaster recovery to pre-disaster mitigation**
Most cases were implemented in a post-disaster phase, during which the ability to mobilise people to engage in the program is complexified by the disaster itself. A shift to pre-disaster mitigation provides time to test resilience materials and to work with property owners on using those materials. Consistent with the second outcome of establishing enabling mechanisms, the data and knowledge developed during recovery is useful in shifting the resilience program toward a pre-disaster mitigation phase – concurrently facilitating societal resilience.
4. **Establishing a multi-dimensional approach to resilience outcomes**
Due to variations in properties, population and demographics and trade-offs in collective or individual approaches, eligibility and equity criteria, there is no 'one size fits all' or 'best' approach for resilience



programs. Some homeowners will need longer and more targeted support to develop resilience than others. Therefore, a multi-dimensional approach to resilience that transcends solely physical changes to properties is needed to support people with physical, financial, emotional and social dimensions of resilience.

In conclusion, we propose eight future considerations for designing and implementing resilience programs.

1. *Continuing policy* examples of how continuing policy can support a timely and expanded response to a new disaster are insightful in developing a cumulative approach to disaster resilience.
2. *Open access to insurance data* where a government-based insurance scheme was in place, this supported access to data and knowledge and provided an initial set of procedures and funding for rolling out the resilience programs in our cases.
3. *Consider collective approaches* where there is strong data from which to identify the target population.
4. *Consider individual approaches* when the target population is varied and hard to identify.
5. *Broad eligibility criteria* based on exposure to hazards rather than any socioeconomic or demographic characteristics can be considered when there is an aim to increase the baseline of resilience within a region and ensure equality of access to a program.
6. *Equity criteria* can make eligibility more targeted towards the needs of those who might otherwise struggle to access a resilience program.
7. *Incentives* may mobilise populations to either move out of high-risk locations or improve their current home's resilience to weather events.
8. *Support* should be embedded in program design and made available to homeowners in a manner that accommodates vulnerabilities and limitations in access to the Internet, email and mobile phones.



List of abbreviations

AMI	Area Median Income (USA)
BBB	Build Back Better (UK)
CDBG-DR	Community Development Block Grant Disaster Recovery Program (USA)
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DFIRM	Digital Flood Insurance Rate Map (USA)
EQC	Earthquake Commission (New Zealand)
FEMA	Federal Emergency Management Agency (USA)
FIRM	Flood Insurance Rate Map (USA)
FRHP	Flood Resilient Homes Program (Australia)
FRM	Fund for Restoration of Large Multi-Family Housing Program (USA)
HMGP	Hazard Mitigation Grant Program (USA)
HRP	Homeowner Resettlement Program (USA)
HUD	Department of Housing and Urban Development (USA)
LVRC	Lockyer Valley Regional Council (Australia)
PFR	Property Flood Resilience (UK)
QRA	Queensland Reconstruction Authority (Australia)
RHF	Resilient Homes Fund (Australia)
RLHAP	Restore Louisiana Homeowner Assistance Program (USA)
RREM	Reconstruction, Rehabilitation, Elevation and Mitigation Program (USA)
SARF	State Acquisition and Relocation Fund (USA)



1. Introduction

The purpose of this report is to understand how selected resilience programs unfold within their own physical, financial, social and emotional constraints, gather lessons learned and expand the body of knowledge around post-program resilience. Many government-sponsored resilience programs are implemented in the aftermath of a devastating disaster. During this period, homeowners are traumatised because homes have strong financial, social and emotional meaning in people's lives. Implementing a program during this time of intense distress is challenging and we recognise the remarkable effort of all involved. Hence, there is no 'one size fits all' retreat or resilience program. Instead, every program should be considered within the context in which it is developed and implemented, where multiple, complex outcomes are likely rather than a singular view of success or otherwise (Ajibade et al., 2022).

1.1 Selecting resilience programs

This report is not an exhaustive review of all resilience programs but a review of seven selected programs from which we can draw comparative themes that can be applied to evaluating Resilient Homes Fund (RHF) programs in Australia. Programs were selected because of their relevance to some of the key issues for Australian flood resilience programs. That is, they address the impact of the flood (storm surge, riverine, hurricane or overland flow) on a sizeable population through a complex array of buy-back, retrofit and home-raising sub-programs, for example, programs in Louisiana, North Carolina and New Jersey. In addition, we included two programs because they have relevance to some of the policy issues facing Australia: a smaller-scale relocation program in Grantham, a rural Queensland town that was partially relocated following devastating flood events and Christchurch as an example of a large-scale buy-back in a concentrated area following a series of catastrophic earthquakes.

These programs are all similar in that homeowner participation has been voluntary; however, the programs differ in several ways. For example, the programs vary in:

- a) diversity of population,
- b) housing stock,
- c) presenting conditions of hazard and
- d) scale and complexity.

Persistent tension between helping distressed homeowners to recover rapidly post-disaster whilst also giving them time to make decisions about their homes is a consistent theme across all programs. While most of the selected programs were developed and implemented during immediate disaster recovery, adding to this tension, two programs, Brisbane's Flood Resilient Homes Program and the Flood Re's Build Back Better program, were initiated in the pre-disaster mitigation phase in anticipation of future flood events.

We analysed the selected programs from the perspective of policy design and delivery rather than specific structural or hazard features. To do so, we collected a combination of academic and grey literature to identify variations in the structure and delivery of each program that facilitate or constrain its implementation. Table 1 details the programs selected for analysis, which serve as the basis for the evaluative framework developed in this report. Summaries of each case are also included in the appendix.

**Table 1 Resilient housing policies by country**

Program name	Year	Status	Weather event	Program type	Scale
Brisbane: Flood Resilient Homes Program (Australia)	2018	Completed	Flood	Retrofit	199 homes participated in this small selective pilot program
Christchurch Residential Red Zone (New Zealand)	2011	Completed	Earthquake	Buy-back	7,900 buy-backs completed (98% of 8060 eligible homes)
Flood Re's Build Back Better (UK)	2022	Ongoing	Flood	Retrofit	No data available.
The State of North Carolina: 1990s hurricane and storm response (USA)	1999	Completed	Flood	Buy-back and raising	Purchased or relocated more than 5,000 homes Raised 1,000 homes
The State of New Jersey: Superstorm Sandy (USA)	2012	Some streams are ongoing	Flood	Buy-back, retrofit and raising	Data on the number of retrofit homes is unclear Incentive to stay for 18,500 homes Purchased 770 properties Repaired 5,299 multi-family homes
Restore Louisiana Homeowner Assistance Program (USA)	2023	Ongoing	Flood	Buy-back, retrofit and raising	39,100 applicants 23,700 eligible homes \$380 million delivered to 4,846 homes

1.2 A framework for evaluating resilience programs

Drawing from these seven case studies, this report develops a framework for evaluating the key enablers and trade-offs involved in implementing government-sponsored resilience programs. Such programs typically seek to improve homeowner resilience against hazardous events by removing properties away from the presenting hazard (e.g., flood, cyclone, earthquake) through relocation or buy-back, or improving the hazard resilience of existing housing stock through some form of reconstruction (e.g. raising above flood levels or installing roof tie downs and cyclone shutters).

Enabling policy mechanism

Implementing resilience programs requires i) extensive knowledge of housing stock and its exposure to specified hazards, ii) access to data on affected individuals and iii) clear procedures for identifying and mobilising the target population for the program. These requirements are exacerbated when a program is large-scale, complex, has significant diversity in housing stock and population and/or is being rolled out at speed to cope with post-disaster recovery. Compared with starting anew, they are most easily met when an existing policy mechanism enables access to knowledge, data and procedures for identifying the target population. In analysing the cases for this report, we found two key types of enabling policy mechanisms: i) a



continuing disaster resilience program that can be easily activated and ii) a government-based insurance program.

Trade-offs

No resilience program is optimal for all the multiple stakeholders involved. People's homes are a key physical and financial asset and an emotional and social investment and these homes are located in communities that are also affected by the program. Therefore, the implementation of resilience programs can be overshadowed by the very real consequences of disaster and associated psychosocial effects on property owners, communities and the authorities implementing them. As such, the implementation of resilience programs involves a series of trade-offs. Trade-offs are defined as 'compromise situations when a sacrifice is made in one area to obtain benefits in another' (Byggeth & Hochschorner, 2006, p. 1420). These trade-offs mean that any resilience program will never be considered universally successful but will bring variable benefits and detriments to stakeholders. In our analysis of the cases for this report, we found two key, interlinked trade-offs between: i) collective and individual approaches to working with the target population and ii) eligibility and equity of access to the program.

Mobilisation and ongoing outcomes

Taken together, these features of any program will affect the processes for mobilising the target population and the outcomes that can be achieved. Importantly, any specific resilience program is usually one government intervention in a longer-term experience of hazards and government policies aimed at addressing the ongoing resilience of the population. Hence, any program needs to be considered in terms of its specific outcomes and also how those outcomes contribute to the ongoing disaster resilience process.

Evaluative framework

We have drawn these key points of our analysis of the seven cases into an evaluative framework, Figure 1, that we use to structure the sections in this report. We conclude by using the framework to develop a checklist of considerations for those implementing resilience programs.

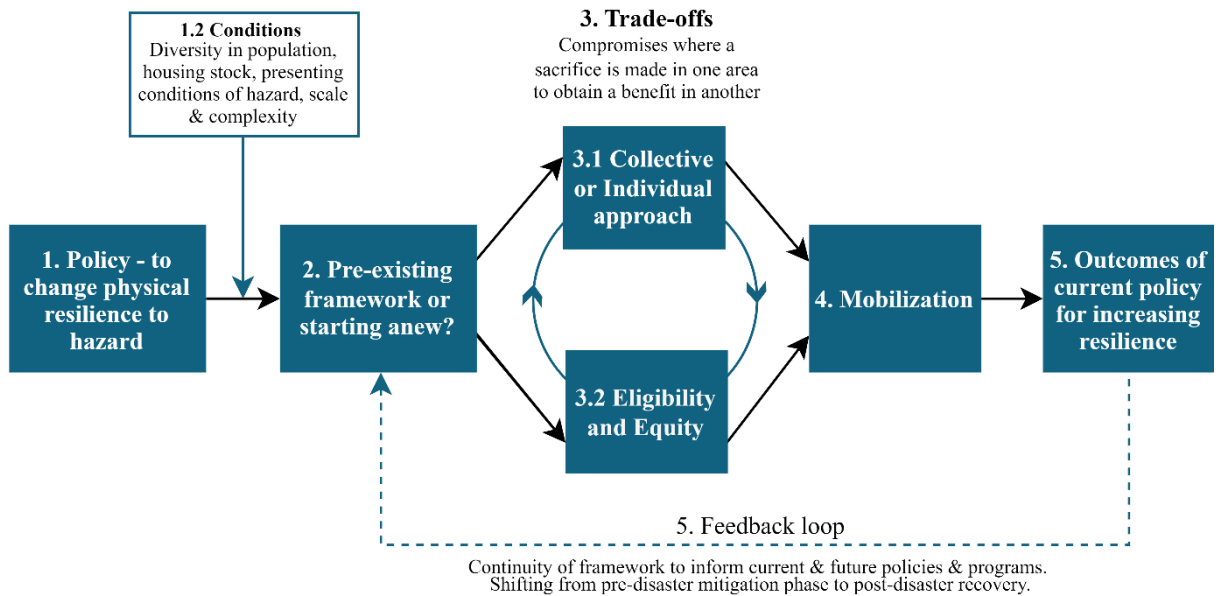


Figure 1 Evaluative Framework

(numbers in the diagram correspond to sections of the report).

2. Enabling policy mechanisms

An enabling policy mechanism, as opposed to starting anew, is key to the smooth rollout of a resilience program. An enabling mechanism provides data to support the identification of hazard-affected houses and individuals, knowledge about the target population and procedures for mobilising that target population to access the program. This provision of data, knowledge and procedures is critical, particularly given that many such programs are large-scale and complex, have significant diversity in housing stock and population and are being rolled out at speed to cope with post-disaster recovery. For example, in 2011, Hurricane Sandy damaged 346,000 homes in New Jersey and a subsequent \$4 billion in funding was rolled out across 12 resilience programs for those homeowners.

Starting anew without clear access to data, knowledge and procedures during such times significantly delays the ability to establish and roll out a policy. While data and knowledge may reside in different levels of government and in different agencies, the ability to pull these together, combined with the fact that these household and resident-level data can be sensitive or confidential to move between agencies, will generate delays in setting up the program. Such delays constrain the ability to reach people who are often in recovery mode and need rapid support to make decisions about what to do with their properties in the aftermath of a disaster.

In our cases, we found two key forms of enabling policy mechanisms: continuing disaster resilience programs that could be easily (re)activated and government-based disaster insurance schemes, which already contained data on disaster-affected properties and residents. Below, we provide examples of how these two types of enabling policy mechanisms worked to support the rollout of resilience programs in our cases. Importantly, these mechanisms underpinned some of the trade-off decisions discussed in Section 3.



2.1 Continuing policy

A continuing policy, based on resilience responses to some prior disaster or as a mitigation program in anticipation of disaster that is either ongoing or has had sufficient funding for the database to be maintained and easily accessible by the relevant agencies has many benefits. First, it can provide a basis for identifying the target population of those houses and residents affected by the hazard. For example, New Jersey's Blue Acres program targeted clusters of homes that, once bought back, would create 'green sinks' to protect the broader area from flood and storm surges based on prior events and hazard maps. Second, at least some of the resilience measures to be taken in terms of types of material and their use in particular houses are established and costed. For example, the Department for Environment Food and Rural Affairs (DEFRA) had already piloted resilient flood materials for homes in high flood zones in the UK. The database on these homes and materials was maintained and was easily accessible between agencies as Flood Re began to roll out its Build Back Better program to make homes more flood resilient. Third, a pre-existing program supports longer-term rollout as policies typically morph into multiple programs. For example, the New Jersey response to 2011 Hurricane Sandy proliferated into 12 different programs, with interagency handovers between programs supported by the continuing development of a database.

Despite these benefits of continuing disaster resilience policies that can be easily (re)activated, databases and evidence from prior resilience programs do not seem to be routinely maintained. Rather, they may eventuate because one program is already ongoing when a new disaster strikes. For example, a resilience program employing buy-back and raising in North Carolina was implemented after Hurricane Fran in 1996. The program was used again three years later after Hurricane Floyd, at which point, the program was further expanded to include infrastructure development and flood mapping.

Future consideration 1: Continuing policy

The above examples of how continuing policy can support a timely and expanded response to a new disaster are insightful in developing a cumulative approach to disaster resilience. Continuing programs mean changes to housing stock for a target population at one time can be carried forward to evaluate the longer-term implications of prior programs and support progressive upgrading of housing stock and incremental support for individuals and communities exposed to hazards. Therefore, the completion of any specific disaster resilience program provides an opportunity to develop and maintain a robust database within relevant government agencies that can be easily accessed for subsequent policies.

2.2 Government-based insurance scheme

A government-based insurance scheme is a government-legislated insurance or reinsurance scheme that provides disaster insurance where it would otherwise be unavailable or unaffordable in the private sector, usually due to the location's high risk of damage and loss from extreme weather or other hazards. For example, Flood Re is a government-legislated reinsurance scheme in the UK to ensure that houses at high risk of flood can obtain affordable insurance. Such schemes are usually not-for-profit and vary significantly in how they provide insurance and their explicit links to resilience programs (Jarzabkowski et al., 2023). However, our analysis shows they have two key features as an enabling mechanism for resilience programs.



First, government insurance schemes have access to household-level data, including details of the property, the hazard and the probable value of the home for all houses insured within the scheme. As these are also the properties most likely to be affected by a hazard and included in a resilience program, there is valuable overlap with the data for identification of and some knowledge about, the target population. Because these data already reside within a centralised, usually federal or state-based, government insurance agency, they can be repurposed to the resilience program without the many barriers involved when data are owned by commercial organisations or scattered amongst different levels of government and agencies.

Second, government insurance schemes support the procedural rollout of the program, because affected households that are insured by the scheme can be directly contacted without needing to register for the program. Furthermore, the insured value and any claims payout on the damaged property are known by those rolling out the resilience program, supporting home assessment procedures for the resilience program and providing funds to supplement the program funding. A third point, which we will discuss under mobilisation, is the use of government insurance as an incentive for people to engage with the resilience program (Section 4).

The Toka Tū Ake Earthquake Commission (EQC) in New Zealand (NZ) is a key example of how government insurance schemes serve as an enabling mechanism for resilience programs. As a mandatory scheme, some 90% of the NZ population have earthquake insurance through the EQC. Following the sequence of earthquakes in Christchurch in 2010/2011, the government knew what housing stock was in the hazard zone and had immediate access to homeowner data. This data supported government decisions to roll out a large-scale, concentrated buy-back of some 7,900 properties in the hazard zone. Government funding for the buy-back program was also supplemented through EQC insurance payments to those with affected homes targeted for buy-back. In other examples, Flood Re in the UK can identify flood-prone homes that would benefit from a retrofit with flood-resilient materials and provide funding through local councils and private sector insurers to support such retrofits.

Future consideration 2. Open access to insurance data

Where a government-based insurance scheme was in place, this supported access to data and knowledge and provided an initial set of procedures and funding for rolling out the resilience programs in our cases. We, therefore, identify an opportunity for those countries with a government insurance scheme to consider, in advance of a disaster, how they might use their ownership of the insurance risk on hazard-exposed homes to activate a resilience program after a disaster. Where no government insurance scheme is in place, open access to insurance data could serve at least some similar purposes for data, knowledge and home assessment procedures. However, evidence suggests that the commercial and confidential nature of such data, when it sits within the private sector, constitutes significant barriers to its use for the purposes of resilience programs (Sheehan et al., 2023).



3. Trade-offs in program delivery

Implementing a resilience program involves a series of trade-offs, in which benefits in some areas of the program constitute detriments in others. These trade-offs are usually dictated by the terms of the resilience policy, which program implementors must then negotiate as they roll out that policy. Given people's deep physical, financial, emotional and social investment in their homes and social investment in their communities, these trade-offs mean that any resilience program will never be considered successful by all stakeholders. In our analysis of the cases for this report, we found that the policies for resilience programs comprise two key trade-offs between: i) collective and individual approaches to working with the target population and ii) eligibility and equity of access to the program. These trade-offs are both interlinked and partially shaped by the presence of an enabling mechanism at the outset of a program.

3.1 Trade-off one: Collective or individual approach

One key trade-off involves whether assessment decisions about the resilience measures to implement are made at a collective level, such as a community or suburb, or at an individual, property-by-property level. Each approach comes with benefits and constraints and reveals tensions between the need to effect change to many properties in a timely and consistent manner while also giving individuals time and autonomy over their engagement with a program that will affect their home, way of living and even, potentially, their livelihood. We now explain the benefits of each approach, noting that each also comprises the detriments of not taking the opposite approach.

Collective approaches are easier to implement where an enabling mechanism is already in place to identify the collective target population. They involve policies such as zoning a whole area for a specific intervention, such as buy-back, or mandatory program features that are then rolled out consistently to all of the target population. Collective approaches, such as the zoning of an area, have three key benefits. First, they can increase the consistency and, hence, the potential speed of implementing the specific resilience measures to be taken. For example, in Christchurch, areas with extensive and widespread damage that would be expensive, protracted and uncertain to repair were zoned red, meaning the entire area was targeted for voluntary buy-back. This consistent approach to buy-back, based on zone, negated the need for individual property assessments in terms of which might remain and which would be bought back. Christchurch's Residential Red Zone program, involving buy-back decisions made at a collective (suburb) level, meant that whole suburbs were deemed a 'red zone' and subsequently eligible for buy-back. While the program was voluntary, 98% of offers were accepted, resulting in 7,900 completed buy-backs. Without individual assessment of homes, the program was able to manage thousands of affected homes within approximately five years. This collective approach to assessing homes offset the program's size in successfully completing a major buy-back scheme.

Second, such collective schemes can facilitate whole community engagement in a response, which can be of value where small or tightly cohesive communities can be addressed simultaneously. The 2011 Grantham Relocation Policy offers an example of multi-level government collaboration to collectively relocate flood-affected residents in a small rural community, moving the community to a nearby new development site above the flood zone. In the interest of fairness, a ballot system was developed to allocate blocks of land in the new



development, which was (mostly) accepted by the community. Grantham residents were allocated a similar sized piece of land on which they could either build a new house or relocate their old home. Within 11 months of the flood event, building had begun on homes in the new development site. Grantham's collective approach was implemented through collaborative relationships and political will, the immediate availability of suitable, lower-risk land, a small population and the recent shared traumatic flood experience of a close-knit community; many residents were willing to move in the immediate aftermath of the flood. This community cohesion and commonality of experience was understood to be a contingent factor in facilitating relocation in Grantham as a largely community-wide outcome (Sipe & Vella, 2014).

Third, collective assessment allows whole parcels of land to be rezoned and repurposed in the case of buy-back or relocation. Collective assessment further allows for centrally controlled decisions and implementation over future land-use planning, rebuilding and contracting. For example, in New Jersey's response to the 2011 Superstorm Sandy, the state government actively sought parcels of land or clusters of willing homeowners to purchase in blocks rather than single homes or buildings. This collective approach was not motivated by a pressing need to act quickly per se but rather for environmental and flood defence reasons; larger parcels of land create sinks to absorb water, which in turn protect remaining houses. The policy to create these absorbent sinks as an environmentally sound and financially prudent measure meant that a collective approach needed to be taken in identifying properties for buy-back to have contiguous parcels of land following the program's implementation.

Future consideration 3

Consider collective approaches where there are strong data from which to identify the target population. A collective approach:

- i) Enables zoning of an area to implement a consistent policy across all properties in the zone.
- ii) Supports engagement of a whole community in solutions that will affect them all.
- iii) Allows whole parcels of land and groups of properties to be addressed simultaneously.

Individual approaches involve property-by-property assessments with different resilience measures offered to each property owner, even where properties may be adjacent. Individual approaches are often an option where there is no enabling mechanism in place because they allow an initial database to be developed from the individual property assessments. Such approaches have two key benefits. First, they are pertinent when resilience programs are relatively nascent and there is no enabling mechanism already in place. In these cases, individual assessments comprise the basis for an initial database to establish a wider target population and identify the possible measures offered to different households. For example, the Brisbane City Council Flood Resilient Homes Program (FRHP) was offered as a pilot program by invitation to specific homeowners with properties in known flood-prone suburbs. This pilot program aimed to implement flood-resilient retrofitting to specific houses and to develop a database about and greater knowledge of such programs.

Second, individual approaches acknowledge structural, socio-economic, demographic and psychosocial variation in rolling out a resilience program. Not only do people have different capabilities for engaging with a program, but every home is different, often structurally, or in its exposure to a specified hazard and in terms of its meaning for the homeowner. In these situations, each individual property and property owner may be more or less adaptable to the measures being offered. For example, as shown in some of the retrofit and raising



cases we studied in Louisiana, North Carolina and New Jersey, some homes cannot be raised due to their structural features, or raising may not be suitable for some homeowners who are not able to navigate stairs. Individual approaches also apply to buy-backs, as moving from an area may not be feasible for some people due to complex reasons such as age, health, or emotional connections. Individual assessment is respectful to the great variation in properties and homeowner needs, allowing them to engage with a resilience program according to their own capabilities and in their own time.

Future consideration 4

Consider individual approaches when the target population is varied and hard to identify. An individual approach:

- i) Enables the establishment of a database on the effects of a hazard on different properties, as the basis for the identification of a target population for a resilience program.
- ii) Supports a differentiated approach to implementation, which is of value where there is marked variation in housing stock, hazard exposure and affected population socioeconomic and demographic characteristics.

Summary of collective and individual trade-offs

There is no single right way. The downsides of a collective approach are, typically, the benefits incurred from an individual approach and vice versa. Nonetheless, we note the key conditions under which one approach or the other might yield more benefits. A broad insight is that where there is a strong enabling mechanism, a more mature resilience program as part of a broader resilience roll-out over time, a collective approach has the potential to yield benefits. By contrast, where strong data are not available and there is high variation in those affected, an individual approach has the potential to yield benefits.

3.2 Trade-off two: Eligibility and equity

Eligibility and equity for participation are cornerstones of any resilience program. Eligibility refers to the criteria for deciding who, of those affected by a hazard, should be able to access a government-funded program. As resilience policies aim to generate change to the maximum number of properties, broad eligibility criteria, such as having suffered a specified level of damage or loss, may apply. Yet, resources to create those changes are constrained, necessitating trade-offs in terms of whom amongst the affected population should be prioritised. Hence, equity issues may also apply, which acknowledges that not all those who suffered damage and loss have the same capability to recover. Equity-based eligibility may prioritise those identified as having a greater need for government funds. There are, therefore, trade-offs in establishing conditions for eligibility that also address equity.

Eligibility

We found several examples of eligibility that are decided primarily by hazard loss and damage, including Christchurch, Grantham and Flood Re. Eligibility based on damage and loss has two key advantages. First, it provides a baseline for increasing resilience to a hazard within a region, as all properties/ individuals affected by the hazard have the opportunity to become more resilient. In the context of somewhere like Christchurch,



where many properties were highly affected by earthquakes, this broad eligibility enabled a collective zoning approach and buy-back of almost 8,000 affected properties, rendering whole areas more disaster-resilient.

Second, eligibility based on damage and loss can reduce the need for detailed socioeconomic or demographic data because it allows anyone, regardless of their personal circumstances, which may not be known, to access the program. Such income and circumstance-blind programs have an underlying equality of access. For example, in both Flood Re and FHRP, eligibility for retrofit is determined by propensity to flood, with the aim to reduce flood damage and loss for such properties, regardless of any socioeconomic characteristics of the property owners.

Future consideration 5

Broad eligibility criteria based on exposure to hazard rather than any socioeconomic or demographic characteristics can be considered when there is an aim to:

- i) Increase the baseline of resilience within a region.
- ii) Ensure equality of access to a program.

Equity

A key issue driving equity decisions is that not all property owners have the same financial, emotional, physical or social capabilities to access a program. For example, while a ballot ensured all property owners in Grantham had the same opportunity to be selected for relocation, not all eligible property owners could financially afford to enter the program. While some government grants were offered, those who could not afford relocation or new construction, particularly some of the most vulnerable households, did not access the program (Moore, 2024; Okada, 2014). Therefore, some resilience programs consider equity a key part of eligibility. Equity can be based on different criteria but typically provides for low-medium income households and those identified as more vulnerable to disaster.

We found two key types of equity consideration within the US programs we examined. First, several programs provided specific assistance or prioritisation for low-medium income households. For example, the Restore Louisiana Homeowner Assistance Program (RLHAP) used a nationally recognised statistic, Area Median Income (AMI), to classify an applicant's household income as low to medium. Applicants with incomes at or below 80% of the state's AMI were prioritised for government grants. Similarly, New Jersey dedicated a percentage of available funds to their Homeowner Resettlement Program to low and medium-income households to facilitate program equity.

Second, equity criteria can also consider vulnerabilities beyond the home ownership that is the typical focus of resilience programs, such as rental populations. Those who do not own homes are affected by disasters that may damage the homes they are renting and increase demand and prices for a decreased supply of rental homes post-disaster (van den Nouwelant & Cibin, 2022). Yet robust rental markets play an important role in recovery for vulnerable groups and support local industry's return to business through crucial housing for their labour force (Brennan et al., 2024). We found that some US resilience programs targeted the local rental market. For example, the Louisiana RLHAP included priority access for previous renters to return to duplexes that were repaired through the program, provided owners live in the other part of the property. Duplexes,



multi-family homes with separate entrances, are common in Louisiana and an important component of the state's rental housing stock for low-medium income households.

New Jersey's Large Multi-Family Housing Program funded repairs to multi-family buildings, such as units and townhouses, to develop rental housing in affordable or mixed-income projects. North Carolina's Hurricane Response included nine months of rental payments to assist renters in relocating where their previous rental property had been bought and demolished or bought and relocated. Expanded eligibility to accommodate households who rent their homes improves equity in resilience across the broader population, many of whom are vital to community recovery.

Future consideration 6

Equity criteria can make eligibility more targeted towards the needs of those who might otherwise struggle to access a resilience program, such as:

- i) Low-to-medium-income people or those with other potential compounding factors, such as age, health and language, who might otherwise struggle to use the program.
- ii) Non-property owners who lose access to vital rental properties that are undergoing either buy-back or resilient reconstruction and face a surge in rental demand and short supply post-disaster.

Summary of eligibility and equity trade-offs

Eligibility decisions can be grounded primarily in the extent of damage and loss to affected properties and the likelihood that buy-back or resilient reconstruction will substantively change a region's future resilience to the presenting hazard. Basing eligibility purely on such criteria can support the overall upgrading of housing stock or removing populations from harm's way. However, there is a trade-off with equity, where some of those who are eligible may be better able to help themselves without full access to government funding, whereas others will need more than the standard offer to use the program. Hence, equity criteria can target different needs by identifying specific vulnerabilities where additional support may be necessary to ensure that those people can benefit from a resilience program. All eligibility and equity criteria will be easier to establish, where an enabling policy mechanism ensures high-quality data on properties and hazards and deep knowledge about the target population so that decisions about the inevitable trade-offs can be made.



4. Mobilisation

Even with an enabling policy mechanism to provide data, knowledge and procedures, a clear set of criteria for deciding on collective or individual approaches and eligibility and equity considerations, resilience programs still take considerable time to implement following a disaster. Typically, many properties are being addressed simultaneously and people are also disrupted by the effects of disaster on their wellbeing, health and daily routines. Hence, some studies note that people can be slow or reluctant to access resilience programs even where these are intended to improve their overall resilience outcomes (Hernández, 2022). Mobilising the target population to help them access a resilience program is, therefore, key. We found two key means for mobilising the population: incentives and support agencies.

4.1 Incentives

Incentives for buy-back

First, we found various incentives that were applied to mobilise the population to take up buy-backs. One key issue with a buy-back program is that while the amount offered may be a fair estimate of the value of the property, it may not reflect the costs of buying an alternative home, particularly where the property owner may still have a significant mortgage and low equity in the home being bought back. As with the 2011 relocation program in Grantham, those who do not have the additional money needed may, therefore, not take up the program. Some programs offered specific financial incentives to bridge this personal finance gap. For example, recognising the gap between buy-back prices and the amount needed to purchase a new home at market rates, the Restore Louisiana Homeowner Assistance Program provided additional financial incentives to buy-back recipients to ensure they moved out of the flood zone. Similarly, North Carolina's buy-back subprogram received additional state funding to boost payments so households could afford to buy more expensive housing of a similar standard outside of flood-prone areas. In the New Jersey buy-back subprogram, cooperative relationships were negotiated with lending and mortgage companies to offer loan forgiveness, enabling residents to use their buy-back payment to secure housing elsewhere rather than using part or all of it to repay outstanding mortgage amounts.

Incentives for resilient reconstruction

Second, we found some incentives to support the additional costs of reconstruction. Sometimes, the actual costs of a designated resilient reconstruction program go beyond the grant offered due to increased costs of labour and materials or variations in specific properties. Other compounding factors can occur, such as property owners who, due to the time lapse between a disaster and the implementation of a reconstruction policy, have already begun some repairs that may only partially comply with the new program. The Louisiana and New Jersey programs offered reimbursement for repairs already carried out. While there were conditions around reimbursement, it did capture those who started repairs before program parameters were finalised.

Government-based insurance incentives

Third, in addition to being an enabling policy mechanism designed to identify and ensure eligibility of the target population, as with the Christchurch buy-back, we found that government-based insurance was used as a



financial incentive. Specifically, some programs offered reduced premiums on properties that had been through resilient reconstruction. For example, in Louisiana, low-medium income households that rebuilt to an identified standard were offered their first year of property insurance premium up to a maximum of \$2,000 USD. In the UK, eligibility to receive the Flood Re resilient retrofit grant is conditional upon having insurance through Flood Re. There is also partial evidence that homes that had been through resilient reconstruction had reduced private sector premiums, such as some reports of reduction in insurance costs for homes that had been through the Brisbane FRHP (Cook & Harrison, 2022). However, this is in the form of an indirect incentive as lower premium costs are not directly tied to engaging in the reconstruction program and other studies note that some homes that have been through resilient reconstruction programs in the USA still struggle to find insurance (Kousky & French, 2023).

Future consideration 7

Incentives may mobilise populations to either move out of high-risk locations or improve their current home's resilience to weather events. Despite the careful design and execution of resilience programs, homeowners may not engage with the program for three financial reasons. Firstly, existing mortgage debt and rising house prices in lower-risk locations preclude the acceptance of a buy-back offer. Secondly, costs to raise, rebuild or buy that are not covered by the program. Finally, elevated ongoing expenses from housing decisions such as home insurance. Incentives assist homeowners to bridge these financial gaps and thus encourage homeowner participation in resilience programs. Financial incentives could include:

- i) Ensuring buy-back agreements enable homeowners to purchase a home of similar standard in a lower-risk and thus likely more expensive, location.
- ii) Given rising construction costs, interest rates and inflation, ensure that raise and retrofit programs keep pace with the cost of living.
- iii) Recognising, through insurance premium relief, the improved resilience of homes due to completed works as part of the program.

4.2 Support to access the program

Many resilience programs are complex, with multiple sub-programs that evolve as the policy itself evolves to account for all the variations in both properties and the people needing to access the program. For example, New Jersey implemented 12 programs, spanning over 300,000 damaged properties, in response to Hurricane Sandy. Understandably, even property owners with considerable resources in accessing government institutions, such as reliable internet access, proficiency in the legal and professional language involved and sufficient time to navigate multiple forms and different agencies, can struggle to access such programs. Program complexity, particularly where eligibility spans multiple agencies, can, therefore, be beyond the grasp of many people also trying to cope with significantly changed living circumstances post-disaster. Hence, support to access programs is key to mobilisation.

We found that support was often a 'bolt on' to the initial program, as community organisations rose to bridge the gap or case workers were later employed to support people to access the program. For example, following Superstorm Sandy, homeowners in the nine eligible areas of New Jersey were assigned a case worker to assist with applications, construction and funding (State of New Jersey Department of Community Affairs, 2013c).

***Future consideration 8***

Support will often be needed to help people access a resilience program, particularly where the program itself is complex, with multiple eligibility criteria, or where a program spans agencies. Support should be embedded in program design and made available to homeowners in a manner that accommodates vulnerabilities and limitations in access to the Internet, email and phones. While the level of support needed will vary between homeowners, programs must anticipate that some homeowners will require ongoing high-level face-to-face support to complete the program.

Summary of mobilisation

Implementation of a resilience program requires mobilisation of a target population that is often traumatised by their experience of the disaster, financially and emotionally set back and suffering changes in living conditions. Such mobilisation can be enhanced by a set of carefully designed incentives to participate in the program, alongside targeted support to enable people to access the program.



5. Evaluating outcomes of a resilience program

Generally, evaluating the outcomes of a resilience program can be difficult. Given the complexities of designing and implementing a resilience program, as outlined above, we suggest that outcomes be evaluated for both specific structural and hazard exposure issues with properties and go beyond those indicators. We now briefly explain a range of interlinked indicators for evaluating outcomes.

1. Evaluating the measures taken against relevant criteria

A key outcome is evaluating how many properties were made more resilient to hazard by buy-back or resilient reconstruction to withstand the hazard. These are relevant and important criteria. However, on their own, these measures will not indicate outcomes unless measured against some future hazard. Clear evidence of such outcomes is not always provided in our cases, partially because some are ongoing and also because of some key complexities in evaluation. For example, evaluating the success of resilient reconstruction requires longitudinal data to see how targeted properties were maintained and how they then fared in subsequent disasters. Hence, relevant evaluation needs to assess the reconstructed property against future hazard. Buy-backs also require evaluating how many homes were purchased and whether those property owners could settle in a new, hazard-free area rather than being displaced and left equally or more vulnerable to subsequent disasters. We therefore view maintaining data as providing an opportunity to enable evaluation against relevant criteria, leading to our next point

2. Establishing a basis for future enabling policy mechanisms

Any specific resilience program is likely to be one in a series of government interventions to improve the resilience of housing stock, communities and regions. Hence, as indicated in Figure 1, the outcome of any specific program should be understood as feeding into subsequent programs (see feedback loop (5) in Figure 1). If these programs are to build upon each other cumulatively, careful collection and maintenance of data and knowledge will be critical to enable the (re)activation of a future resilience policy. While there may be a tendency for close down at the end of a program, some basis for continuity will be important for evaluating any outcomes.

3. Shifting from post-disaster recovery to pre-disaster mitigation

The cases we studied were mostly implemented in a post-disaster phase, during which the ability to mobilise people to engage in the program is also complexified by the post-disaster chaos and the need to progress with timely recovery. However, as shown by two of our cases, the Flood Re Build-Back-Better program and the Brisbane FRHP pilot, pre-disaster mitigation provides time to test resilience materials and to work with property owners on using those materials in their own properties. In other cases, such as New Jersey, the post-disaster buy-back program provided an opportunity to release large parcels of land for future mitigation efforts, such as nature-based solutions and flood defences. These measures support a shift to a mitigation rather than recovery approach to policy, during which decisions might be made about the zoning of key areas and the approach to be taken to their future viability. Therefore, consistent with our second outcome of



establishing enabling mechanisms, we view the data and knowledge developed during recovery as useful in shifting the resilience program toward a pre-disaster mitigation phase. This shift will support a more general shift towards societal resilience.

4. **Establishing a multi-dimensional approach to resilience outcomes**

Due to the starting conditions in terms of population variation heading into any resilience program (Figure 1, 1.2) and discussion of the trade-offs in collective or individual approaches and eligibility and equity criteria show (Figure 1, 3), there is no 'one size fits all' or 'one best way' for resilience programs. Some target population members will need longer and more targeted support and assistance to develop their hazard resilience than others. Therefore, a multi-dimensional approach to resilience that goes beyond the changes to properties to consider how programs can support people with physical and financial changes and the emotional and social changes presents an opportunity for a needed shift towards societal resilience.



6. Summary: Future considerations

Here we collate the eight future considerations for quick reference.

Future consideration 1: Continuing policy. Examples of how continuing policy can support a timely and expanded response to a new disaster are insightful in developing a cumulative approach to disaster resilience. Continuing programs mean changes to housing stock for a target population at one time can be carried forward to evaluate the longer-term implications of prior programs and support progressive upgrading of housing stock and incremental support for individuals and communities exposed to hazards. Therefore, the completion of any specific disaster resilience program provides an opportunity to develop and maintain a robust database within relevant government agencies that it can be easily accessed for subsequent and/or ongoing policies.

Future consideration 2: Open access to insurance data. Where a government-based insurance scheme was in place, this supported access to data and knowledge and provided an initial set of procedures and funding for rolling out the resilience programs in our cases. We, therefore, identify an opportunity for those countries with a government insurance scheme to consider, in advance of a disaster, how they might use their ownership of the insurance risk on hazard-exposed homes to activate a resilience program after a disaster. Where no government insurance scheme is in place, open access to insurance data could serve at least some similar purposes for data, knowledge and home assessment procedures. However, evidence suggests that the commercial and confidential nature of such data, when it sits within the private sector, constitutes significant barriers to its use for the purposes of resilience programs (Sheehan et al., 2023).

Future consideration 3: Consider collective approaches where there are strong data from which to identify the target population. A collective approach:

- i) Enables zoning of an area to implement a consistent policy across all properties in the zone.
 - ii) Supports engagement of a whole community in solutions that will affect them all.
 - iii) Allows whole parcels of land and groups of properties to be addressed simultaneously.
-

Future consideration 4: Consider individual approaches when the target population is varied and hard to identify. An individual approach:

- i) Enables the establishment of a database on the effects of a hazard on different properties, as the basis for the identification of a target population for a resilience program.
 - ii) Supports a differentiated approach to implementation, which is of value where there is marked variation in housing stock, hazard exposure and affected population socioeconomic and demographic characteristics.
-

Future consideration 5: Broad eligibility criteria based on exposure to hazard rather than any socioeconomic or demographic characteristics can be considered when there is an aim to:

- i) Increase the baseline of resilience within a region.
 - ii) Ensure equality of access to a program.
-

Future consideration 6: Equity criteria can make eligibility more targeted towards the needs of those who might otherwise struggle to access a resilience program, such as:

- i) Low-to-medium-income people or those with other potential compounding factors, such as age,
-



health and language, who might otherwise struggle to use the program.

- ii) Non-property owners who lose access to vital rental properties that are undergoing either buy-back or resilient reconstruction and face a surge in rental demand and short supply post-disaster.

Future consideration 7: Incentives may mobilise populations to either move out of high-risk locations or improve their current home's resilience to weather events. Despite the careful design and execution of resilience programs, homeowners may not engage with the program for three financial reasons. Firstly, existing mortgage debt and rising house prices in lower-risk locations preclude the acceptance of a buy-back offer. Secondly, costs to raise, rebuild or buy that are not covered by the program. Finally, elevated ongoing expenses from housing decisions such as home insurance. Incentives assist homeowners to bridge these financial gaps and thus encourage homeowner participation in resilience programs. Financial incentives could include:

- i) Ensuring buy-back agreements enable homeowners to purchase a home of similar standard in a lower-risk and thus likely more expensive, location.
- ii) Given rising construction costs, interest rates and inflation, ensure that raise and retrofit programs keep pace with the cost of living.
- iii) Recognising, through insurance premium relief, the improved resilience of homes due to completed works as part of the program.

Future consideration 8: Support will often be needed to help people access a resilience program, particularly where the program itself is complex, with multiple eligibility criteria, or where a program spans agencies. Support should be embedded in program design and made available to homeowners in a manner that accommodates vulnerabilities and limitations in access to the Internet, email and phones. While the level of support needed will vary between homeowners, programs must anticipate that some homeowners will require ongoing high-level face-to-face support to complete the program



Appendices - Resilience Program Summaries

A. Grantham Relocation Policy (Australia)

Devastating flash flooding in Grantham, Queensland, on 10 January 2011 claimed 12 lives (Suncorp and Natural Hazards Research Australia, 2023) and damaged more than 130 homes, destroying ten houses and leaving another 19 damaged beyond repair (Lockyer Valley Regional Council, 2011).

The program

Within days of this devastating flood event, the Lockyer Valley Regional Council (LVRC) began planning to relocate Grantham's flood-affected residents; a large privately-owned parcel of land on higher ground, close to town, was purchased (Sipe & Vella, 2014; Moore, 2020). The land purchase was followed by extensive council-led community consultation and within four months, the Queensland Government established the Queensland Reconstruction Authority (QRA) and declared Grantham a State Reconstruction area to fast-track planning and approvals (Okada, 2014). Using a ballot system, 72 eligible households nominated their preferred blocks of land in the new development. They were subsequently offered a similar block of land, with the first new home completed on 10 December 2011, eleven months after the flood (Sipe & Vella, 2014).

Funding

The cost of relocating Grantham was distributed amongst local, state and federal governments, property owners, insurance companies and philanthropic donations (Table 2). Governments paid for the purchase and development of the new site, including roads and utilities, while property owners paid for the relocation of existing homes or construction of new homes. In some cases, the relocation of existing homes and construction of new homes was supported by insurance payouts and state government grants.

Table 2 Distribution of costs associated with the Grantham Relocation Policy

Source	Contribution
Australian and Queensland Governments	Infrastructure approximately \$16.7M
Queensland Government	Grants of \$35,000 per relocated home
Lockyer Valley Regional Council	Purchase of site and development costs

Eligibility

Applicants must have owned the property on 10 and 11 January 2011 and met the following criteria to participate in the program:

- complete destruction of their house; and or
- the remains of their houses deemed unsafe/uninhabitable/not fit for habitation and only suitable for demolition; and or
- the property value of the affected house was assumed to have been destroyed and the house to be unsalable as a dwelling fit for habitation; and or
- homes and land were in the area identified in Map A of the Grantham Relocation Policy.
- Some property owners did not access the program, including some of the most vulnerable households, because they were unable to fund either relocation or construction on the new block of land (Moore, 2020; Okada et al., 2014).



Resilience

Overall, Grantham residents view the program as successful and are appreciative of the efforts made to move households out of harm's way, however, some residents feel that decisions were made too quickly while residents were experiencing acute trauma (Okada, 2014). The program brought an intense period of construction to the area that prioritised using local materials and suppliers and, in turn, created employment opportunities through apprenticeships and labouring work; over 600 workers were inducted onto the new site (Lockyer Valley Regional Council, 2011).

In the ten years following the flood event, Grantham experienced growth in population from 492 to 796, the number of private dwellings from 180 to 285 and employment in the area's main source of income - labouring (mostly agriculture) from 25% to 34% (Australian Bureau of Statistics, 2021). The program created benefits for Grantham beyond housing, including building a new water treatment plant that also services surrounding villages, parklands and worker accommodation to service the area's seasonal agricultural industry (Sipe & Vella, 2014).

While acknowledging that some (vulnerable) households did not access the program and other relocated households have since sold and moved away, the program is applauded for continuing community connection, improved infrastructure and services and a stable economic outlook (Okada et al., 2014).

Summary

While eligibility was based on individual- or household-level assessment, Grantham's small population means that the program achieved a community-wide outcome with 72 relocated households from 180 pre-flood dwellings. The program was implemented quickly because a host of community-specific factors (e.g., political will, land availability and shared experience) came together to create an enabling framework that wasn't apparent until the town experienced the devastating flood of 2011.

The program demonstrated some aspects of a collective approach in that there were centrally controlled decisions around land-use planning, infrastructure development and installing services for the new housing development and a ballot system for allocating new blocks of land. With the new housing development located close to the town, residents maintained important ties to employment and social networks, thus improving their post-disaster resilience. However, the program experienced some equity issues as not all eligible residents were able to afford to build or relocate their current house to a new block of land, thus inhibiting their participation.



B. Christchurch Residential Red Zone (New Zealand)

During 2010 and 2011, Christchurch and the Canterbury Plains in New Zealand were affected by the Canterbury earthquake sequence. The initial and most severe earthquake occurred in September 2010, however, the most destructive aftershock occurred in February 2011 causing 185 deaths, extensive damage to homes, destruction of the central business district and infrastructure and widespread liquefaction (Nga Koti O Aotearoa Courts of New Zealand, 2014). Significant aftershocks occurred in June 2011 (Potter et al., 2015).

The program

The New Zealand government initiated a voluntary buy-back program. By April 2016, five years post-earthquake sequence, 7,900 property owners had accepted a buy-back offer, which is 98% of the 8060 eligible properties (Greater Christchurch Group, 2017).

Funding

The New Zealand government spent NZD \$1.5 billion acquiring properties in the red zone, of which it will claim \$344 million from insurance, mostly from the Toka Tū Ake Earthquake Commission (EQC). The EQC was established in 1945 as a government insurer to provide earthquake insurance; property owners with private insurance automatically receive 'EQCover' against a range of disasters. EQCover is funded through a levy applied to insurance policies, which is then deposited into the Natural Disaster Fund (Toka Tū Ake EQC, 2022). When an insured event occurs, the first \$100,000 is payable from the EQC fund before private insurance kicks in.

Eligibility

Only insured property owners in the 'red zone' were initially eligible. However, most households had insurance for earthquakes through EQCover. Following legal action, eligibility was expanded to include uninsured property owners and insured business owners in the red zone. Red zones were areas with extensive and widespread damage that would be expensive, protracted and uncertain to repair and/or where there was a risk to life from landslides, cliff collapse and rockfalls (Canterbury Earthquake Recovery Authority, 2016). Eligibility decisions were based on area zoning rather than property-level assessments and subsequently, the program lacked the opportunity to review decisions for individual properties (Greater Christchurch Group, 2017). Some zoning decisions were reviewed following feedback and complaints. Given the number of properties affected, zoning-based decisions were implemented to speed up the process.

Resilience

A wellbeing survey conducted in 2012 and again in 2019 across the population showed an upward trend in residents reporting their overall quality of life as good or extremely good from 72% to 86% and a downward trend in residents reporting their quality of life as poor or extremely poor from 7% to 2% (Community and Public Health Division of the Canterbury District Health Board, 2019). However, some red-zone residents, notably women and young adults, reported reduced wages and salaries following relocation (Hoang & Noy, 2023). Another survey reported fluctuating family resilience in the years following the earthquake events (Canterbury Earthquake Recovery Authority, 2012). Media reporting that followed the lives of property owners now living elsewhere finds that: the scattering of residents amongst new neighbourhoods was difficult as connections were lost; that some residents visit their old home site in the red zone and feel nostalgia for their home and life prior to the earthquake sequence; and, that there is also relief that others will not have to experience the same trauma now that the land is vacated (Mitchell et al., 2019).



Summary

The collective approach to assessment, where whole suburbs or tracts of land were red-zoned for buy-back, meant that the program managed 7,900 buy-back offers within five years, equating to 98% of offers made.

Residents then dispersed to other areas of Christchurch and surrounds, or further afield, with some reporting negative outcomes, including feelings of grief and loss for the prior community and negative employment consequences for vulnerable groups, notably women and young people.

While having a current earthquake insurance policy was a defining feature of eligibility early in the program, earthquake insurance is provided through EQC and hence includes most homeowners. Non-insureds were a very small proportion of the number of affected homes; however, eligibility was later expanded to include non-insureds.

EQC, as a state-based insurer, was an essential mechanism for delivering and funding the program. EQC holds household-level data to identify properties and the effects of hazards and insurance payouts to homeowners formed part of the buy-back funding package



C. Restore Louisiana Homeowner Assistance Program (USA)

In 2020, Louisiana experienced its most active storm season with three hurricanes, Laura, Delta and Zeta and two tropical storms, Cristobal and March, making it the second most expensive storm season in damages on record. In 2021, Louisiana again experienced a destructive storm season, including Hurricane Ida. Following the storm seasons of 2020 and 2021, the Restore Louisiana Homeowner Assistance Program (RLHAP) was launched.

The program

The RLHAP offers four options to homeowners:

- Solution 1 - program managed construction
- Solution 2 - homeowner-managed construction
- Solution 3 - reimbursement for repairs already completed
- Solution 4 - voluntary buy-back option for high-risk homes. (Louisiana Community Development/Disaster Recovery, 2024; Restore Louisiana, 2023b).

While the program closed for applications on 31 October 2023, some projects are yet to be completed.

Funding

The State of Louisiana allocated \$680 million from the state's Community Development Block Grant Disaster Recovery Program (CDBG-DR) allocations for eligible storms to the RLHAP (Louisiana Community Development/Disaster Recovery, 2024).

Eligibility

Applicants must be the homeowner during one of the weather events, the home must be their primary residence and the homeowner must be registered with the Federal Emergency Management Agency (FEMA). The program includes detached homes, duplexes, town homes, modular homes, manufactured homes and condominiums. In October 2023, less than two years after the program launch, 39,100 homeowners had completed the survey and more than 23,700 had been invited to apply. The program had offered more than \$380 million to 4,846 homeowners (Restore Louisiana, 2023a).

Resilience

Homes that are restored under the management of RLHP (Solution 1) are built to IBHS FORTIFIED Gold, Green Building and Energy Star standards (Louisiana Community Development/Disaster Recovery, 2024).

RLHP may provide financial assistance for low-medium income households (up to 80% of the AMI) to pay for the first year of property insurance up to a maximum of \$2,000. This aims to enable homeowners to maintain insurance long-term and is supported by financial counselling services (Louisiana Community Development / Disaster Recovery, 2024). Smart Home America found that many insurance companies in Louisiana offer insurance discounts for homes that have met FORTIFIED Home Construction Standards. Across nine insurance companies, the discount ranged from 15% to 52.5% with an average of almost 30% (Smart Home America, 2024). In contrast, one report states that following the disasters of 2020/2021, 12 insurers became insolvent and in 2023, more than half of the homeowners who wanted insurance had difficulties finding a policy (Kousky & French, 2023).

The storm resilience certification requirements for reconstructed homes under Solution 1 will increase the physical and financial resilience of the communities and may increase their social and emotional resilience. Solution 4, the buy-back scheme's requirement for homeowners eligible for the Safe Housing Incentive to move to a flood-safe area, will also increase the physical and financial resilience of those who move. However, moving from familiar communities can disrupt social and possibly emotional resilience.



Summary

Eligibility for Restore Louisiana is based on household-level assessment, with 23,700 homes currently included in the program. Using the AMI, a government statistic, the program prioritises low-medium income households. It provides financial assistance to pay for property insurance in the 12 months following participation in the program. Restore Louisiana encompasses the state's varied housing profile, including duplexes, a type of multi-family housing common to the area and crucial to the rental market. The program provides an additional financial incentive to ensure buy-back recipients can secure housing out of the flood zone, recognising that property out of the flood zone is more expensive. The program includes reimbursement for works already completed, given that physical recovery was undertaken prior to the program's implementation. While the program does take an individual assessment approach, there is a broad approach to eligibility and specific measures to facilitate equity. Given the newness of the program, its full impact on social and emotional resilience is yet to be determined.



D. The State of New Jersey: Superstorm Sandy (USA)

In 2011, Hurricane Sandy made landfall on the USA's east coast with a wind field of 1,000 miles (1,600 km) wide (Ingargiola, 2013). Hurricane Sandy caused an estimated 160 fatalities, including 34 deaths in New Jersey (Casey-Lockyer et al., 2013) and damage across 24 states (FEMA, 2022). Damage costs have been estimated at \$71.5 billion (USD) (Finn et al., 2023) and more than \$4.4 billion (USD) in insurance payouts (FEMA, 2022). At the time Hurricane Sandy was the "second costliest in U.S. history" (Bryner et al., 2017). It was estimated that 776,000 people had been displaced immediately after the hurricane. The most damage and casualties occurred in New Jersey and New York (Bryner et al., 2017). The State of New Jersey later reported that 346,000 homes had been damaged or destroyed (State of New Jersey Department of Environmental Protection, 2022) and that recovery costs were estimated at \$30 billion (Georgetown Climate Centre, 2020).

The Program

The State of New Jersey implemented 12 programs in response to Hurricane Sandy. Here, we examine the four most relevant programs:

- The Reconstruction, Rehabilitation, Elevation and Mitigation Program (RREM): \$150,000 to assist eligible New Jersey homeowners in mitigating the impacts of future flooding and improving the resilience of their homes damaged by Hurricane Sandy.
- The Homeowner Resettlement Program (HRP): \$10,000 to incentivise eligible homeowners in the nine most impacted counties of New Jersey to stay in their primary residences (State of New Jersey Department of Community Affairs, 2014).
- The Blue Acres Program: voluntary buy-out of clusters or whole neighbourhoods of homes damaged by Hurricane Sandy and prone to repeated flooding (New Jersey Department of Environmental Protection, 2015b).
- The Fund for Restoration of Large Multi-Family Housing Program (FRM): funding to developers to develop rental housing in affordable or mixed-income projects (State of New Jersey Department of Community Affairs, 2014).

Funding

The majority of the funding came from the allocation of CDBG-DR funds, which totalled \$4,174,429,000 (State of New Jersey Department of Community Affairs, 2014). The CDBG-DR allocations for the four most significant New Jersey programs covered here included:

- RREM: \$1,348,533,420 for up to \$150,000 per homeowner (State of New Jersey Department of Community Affairs, 2014).
- HRP: \$202,809,469 for \$10,000 per homeowner (State of New Jersey Department of Community Affairs, 2014).
- Blue Acres: Buy-back funding totalled \$273 million from three sources; \$169 million from the Federal Emergency Management Agency (FEMA), \$82.16 million from CDBG-DR and \$4 million from the U.S. Department of Agriculture - Natural Resources Conservation Service (FEMA, 2021; State of New Jersey Department of Community Affairs, 2014).
- FRM: \$650,587,793 (State of New Jersey Department of Community Affairs, 2014).



Eligibility

- RREM: registered for FEMA assistance prior to May 1, 2013; been in one of nine designated counties in New Jersey; maintained “adequate and necessary flood insurance coverage” (State of New Jersey Department of Community Affairs, 2013c); received disaster recovery assistance since September 14, 1994; total household income that did not exceed \$250,000 (USD) and not received funds from the Hazard Mitigation Grant Program (HMGP).
- HRP: Homeowners in one of the nine most impacted counties had to have occupied the home as their primary residence when Superstorm Sandy struck and have registered with FEMA. Full verified losses (FVL) must have exceeded \$8,000 or there must have been at least one foot of water on the first floor of the home. Although not income-restricted, 60% of the funds were reserved for LMI households and “applicants were processed on a first come first serve basis” (State of New Jersey Department of Community Affairs, 2013b).
- Blue Acres: evaluated neighbourhoods based on flood damage from Superstorm Sandy, or repeated flood damage from previous storms, such as in the Passaic River Basin; willing sellers; support from the local government; clusters of flood-prone homes, or whole neighbourhoods; cost-effectiveness of the buyout according to FEMA guidelines under Federal law; opportunity for significant environmental impact and/or improvement to public health, safety and welfare and communities with homes that have submitted repeated flood insurance claims under the National Flood Insurance Program” (New Jersey Department of Environmental Protection, 2015a).
- FRM needed to be “private for-profit or nonprofit housing developers and public housing authorities capable of developing and managing multi-family developments” (State of New Jersey Department of Community Affairs, 2013a).

Resilience

Following the implementation of New Jersey’s program, reports of improved resilience are mixed; significant steps have been taken to protect residents; however, many more remain in high-risk locations in New Jersey (Freudenberg et al., 2016). While buying-back clusters of houses facilitated the creation of buffer zones and restoration created more resilient homes, many New Jersey residents continue to face financial pressures of rising insurance and housing costs. In the ten years following Hurricane Sandy, house prices increased by 75%, which is partly due to the replacement of damaged houses with larger houses and only 47% of homeowners in flood zones have flood insurance (NJ Spotlight News, 2022).

Summary

New Jersey’s program was a combination of household-level assessment within a broader program to target larger parcels of land to create eco-sinks for water absorption and to provide buffers against storm damage. The extent of the damage created by Hurricane Sandy and the large population affected meant that the program was complex and difficult to use for those for whom it was designed. As a result, caseworkers were needed to step homeowners through the program. The program included incentives to stay within the community, which has many resilience benefits, including employment and social networks, but has resulted in financial strain as insurance and housing prices rise. The program specifically targeted low-medium income households and multi-family housing and included loan forgiveness and reimbursement for works carried out to facilitate financial recovery across the population.



E. Flood Re's Build Back Better (UK)

Flood Re is the UK's government-owned insurance company whose purpose is to “promote the availability and affordability of flood insurance for eligible homes, while minimising the costs of doing so” (Flood Re, 2016). Established in April 2022, Flood Re's Build Back Better (BBB) program offers financial support for increasing the Property Flood Resilience (PFR) of homes that are repaired, through Flood Re insurance, after flood event damage.

The Program

Flood Re's operation will end after 25 years in 2039. BBB was introduced in 2022 as part of Flood Re's exit plan from the insurance market and the transition back to risk-reflective private insurance. BBB provides up to £10,000 per home to increase PFR in addition to any insurance claim made in the event of flood damage to support a home's future insurability.

Funding

BBB is funded by Flood Re, which collects revenue in three ways: a small charge on all household policies, premiums from policies with flood cover under Flood Re and excesses in the case of a claim. These sources of revenue are based on calculations set out in Regulations established by the UK Parliament under the Water Act 2014 (United Kingdom Parliament, 2015).

Eligibility

- Homeowners must be insured for Flood Re flood cover. Eligibility to hold flood cover under Flood Re is limited to individual owners of private residential buildings completed before 2009, comprising one to three residences.
- The residences covered must be occupied by the owner or their immediate family for at least some of the time during the policy period, or unoccupied.
- Flood Re can also cover outbuildings, (for example, a shed) that are 'enjoyed with' the main residence and also built before 2009.
- Mixed-use houses that include a home and a business that does not attract business rates are also eligible (Flood Re, 2023).
- Flood Re does not cover landlord properties or strata properties such as blocks of flats. Community, council and government buildings are also not eligible (Flood Re, 2023).

Resilience

BBB is designed to support long-term financial resilience through continued access to property insurance after the expiration of Flood Re in 2039. In addition, homeowners will reduce non-insured costs and disruption post-flood events and potentially improve property values. Reduced disruption should also improve emotional and social resilience as the communities remain intact and return to normal life sooner (Flood Re, 2022).

Summary

As a retrofit-focused program, Flood Re is based on pre-disaster mitigation in anticipation of future flood events. Under government-based insurance, eligibility is easy to determine and is based on potential damage. Government-owned data exists around which homes would benefit from the program and thus the program takes a household-level approach to assessment, which facilitates the retrofit needs specific to each house, but also results in a patchwork of 'resilient' homes. The program is relatively new and is yet to be tested in a flood event.



F. The State of North Carolina: 1990s hurricane and storm response (USA)

In 1996, Tropical Storm Arthur, Hurricane Bertha and Hurricane Fran struck North Carolina with Hurricane Fran resulting in 24 deaths, damage to more than 6,000 structures (The North Carolina State Climate Office, 2016) and \$5 billion in damages (ReadyNC.gov, 2022). In 1998, Hurricane Bonnie hit North Carolina and 12 days later Tropical Depression Earl brought tornadoes, causing one death and \$480 million in damages (ReadyNC.gov, 2022). In 1999, Hurricane Dennis caused two deaths and Hurricane Floyd resulted in 52 deaths and \$6 billion in damages; one month later, Hurricane Irene caused more flooding (Glavovic & Smith, 2014).

The Program

In response to this series of storms in the late 1990s, The State of North Carolina (NC) offered three voluntary programs: acquisition/relocation, acquisition/demolition and elevation of owner-occupied homes (Gehman et al., 2024). The state acquired more than 5,000 homes and elevated 1,000 following hurricanes Fran and Floyd (North Carolina Coastwatch, 2016). Acquired homes were either demolished or moved outside of the floodplain and acquired land was permanently converted to open space (Glavovic & Smith, 2014).

Funding

The FEMA Hazard Mitigation Grant Program (HMGP) allocated over \$110 million to NC projects designed to minimise future loss of life and property due to disasters. This included \$86 million for acquisition/relocation, acquisition/demolition and elevation of owner-occupied homes (State of North Carolina, 2000). Supplemental grants were also available from the Department of Housing and Urban Development (HUD). To avoid complications, the state established identical eligibility and administration rules for both funding sources (Glavovic & Smith, 2014). The NC State Acquisition and Relocation Fund (SARF) also provided supplemental grants up to \$75,000 (Glavovic & Smith, 2014), which supported lower income residents' in purchasing equivalent or better homes away from the floodplain (Glavovic & Smith, 2014).

Eligibility

Participants are eligible if they have been approved for home and property acquisition under the HMGP. The goal is to use these funds to construct new permanent housing in areas that are safe from the effects of flooding. The program is entirely voluntary. Priority is given to homeowners who:

- lost their homes in Hurricane Floyd or suffered substantial damages
- reside within the 100-year floodplain
- are in a low-income category
- have suffered repetitive losses from previous floods (State of North Carolina, 2000).

Funds may be used to provide SARF for rental assistance to involuntarily displaced renters whose primary residence is being acquired in or displaced by an HMGP or state buyout.

The renter must reside in a rental unit that will be acquired or relocated under the HMGP buyout program or must have moved into temporary housing from a unit to be acquired or displaced under the HMGP or state buyout program.

The home or unit to be acquired must be the renter's primary residence. Households in which all members are full-time undergraduate students are not eligible.

Rental relocation assistance may cover reasonable and necessary moving expenses, rent and utility differential for 42 months. Rental relocation assistance may also be provided as down payment assistance for renters who wish to become homeowners. SARF for Renters assistance may take the form of a grant, which the displaced renter does not have to repay" (North Carolina Department of Public Safety, 2015).



Resilience

The program led to the development of tools to assist homeowners in understanding their physical resilience to flood events. The State of North Carolina remapped floodplains as a participant in the FEMA Cooperating Technical Community Partnerships Initiative, committed to updating and maintaining Flood Insurance Rate Maps (FIRMs) statewide and created digital FIRMs (DFIRMs). The updated DFIRMs were easy to use and showed current information about flood risk.

The area housed many students at local tertiary institutions and therefore, some landlords resisted buy-backs and the subsequent loss of student rental income. Buy-backs also reduced the availability of low-income/rental housing. In response, the government made use of existing infrastructure, such as unused school buildings and mobile home parks, to create aged-care housing and low-income housing and additional apartments were built to add to the area's rental housing stock (Fraser et al., 2003).

The program initially moved very slowly due to community ties and a reluctance to leave; however, buy-back's eventually gained pace as the government provided financial incentives to stay within the area following a buy-back and homeowners didn't want to remain in a disappearing neighbourhood (Glavovic & Smith, 2014). According to one study, residents who relocated remained satisfied with this choice a decade after the move; however, there remained some sense of loss for old neighbourhoods, particularly those with close-knit minority groups (Office for Coastal Management, 2024).

Summary

North Carolina's program was based on individual assessment and didn't include a retrofit option. Instead, the program focussed on moving people out of harm's way, which would necessarily change the landscape of communities as homeowners were incentivised to remove or demolish homes in flood zones. The program had expansive eligibility criteria, prioritising low-medium income households and strong support for the rental market. Given the relocation or demolition of housing stock for low-medium income households, student housing and aged care, the government subsequently took steps to make use of existing infrastructure and planning regulations to (partially) address the changed housing profile of impacted areas.



G. Brisbane City Council's Flood Resilient Homes Program (Australia)

The Program

Brisbane City Council's Flood Resilient Homes Program (FRHP) was established in June 2018 as a pilot program in 12 flood-prone suburbs in Brisbane. The program is designed to encourage homeowners to implement flood-proofing on existing homes to better prepare and recover from flood events. The program consists of a free in-home service, a free tailored property report and an incentive scheme for eligible properties (Golnaraghi et al., 2020). A reported 297 homes had flood resilience assessments completed, with retrofitting of 199 homes (Brisbane Sustainability Agency, 2022)

Funding

By 2022 Brisbane City Council had invested \$9,878,860 in the FRHP program (de Jersey, 2022).

Eligibility

The program was open to selected properties by invitation only. Properties were selected that were regularly and severely impacted by overland flow flooding. The program is currently closed to new applicants (Brisbane Sustainability Agency, 2022).

Resilience

Following the Brisbane floods of 2022, property owners that had been retrofitted for flood resilience found that 45 out of 70 owners reported that the retrofits had been successful. Brisbane City Council reported that 91% of the FRHP homeowners had provided positive feedback about the improved resilience of their homes (Queensland Reconstruction Authority, 2023). There were reports from residents of homes with FRHP works that returning to their homes was easier and faster after the 2022 floods than prior floods. "This was by far the easiest post-flood recovery and that's even the highest flood levels they've experienced" (Sanctuary Renew, 2022). Some research suggests that homeowners who accessed the FHRP program became eligible for reductions in their insurance premiums (Cook & Harrison, 2022). However, there is little clear information or evidence on the correspondence between the resilience measures taken and changes in premium pricing, indicating an area for future research.

Summary

This small pilot program was based on household-level assessment and participation was by invitation only. It is difficult to comment on eligibility other than each home was in a flood-prone area. Anecdotally, homeowners report having reduced insurance premiums following participation in the program and having experienced a flood event since then; homeowners claim improved flood recovery.



References

- Ajibade, I., Sullivan, M., Lower, C., Yarina, L., & Reilly, A. (2022). Are managed retreat programs successful and just? A global mapping of success typologies, justice dimensions and trade-offs. *Global Environmental Change*, 76, 102576. <https://doi.org/https://doi.org/10.1016/j.gloenvcha.2022.102576>
- Australian Bureau of Statistics. (2021). Grantham 2021 Census All persons QuickStats. <https://abs.gov.au/census/find-census-data/quickstats/2021/SAL31227>
- Brennan, M., Srinii, T., & Steil, J. (2024). High and Dry: Rental Markets After Flooding Disasters. *Urban Affairs Review*. <https://doi.org/10.1177/10780874241243355>
- Brisbane City Council. (2023). Annual Report and Financial Statements. <https://www.brisbane.qld.gov.au/about-council/council-information-and-rates/news-and-publications/council-annual-plan-and-budget/annual-report-and-financial-statements>
- Brisbane Sustainability Agency. (2022). Flood Resilient Homes Program. Brisbane City Council. <https://www.sustainablebrisbane.com.au/programs/floodwise-homes/>
- Bryner, N. S., Garcia-Lozano, M., & Bruch, C. (2017). Washed out: Policy and practical considerations affecting return after Hurricane Katrina and Superstorm Sandy. *Journal of Asian development*, 3(1), 73-93.
- Byggeth, S., & Hochschorner, E. (2006). Handling trade-offs in Ecodesign tools for sustainable product development and procurement. *Journal of Cleaner Production*, 14(15), 1420-1430. <https://doi.org/https://doi.org/10.1016/j.jclepro.2005.03.024>
- Canterbury Earthquake Recovery Authority. (2012). CERA Wellbeing Survey. <https://www.cph.co.nz/wp-content/uploads/cerawellbeingsurvey2012.pdf>
- Canterbury Earthquake Recovery Authority. (2016). Residential Red Zone Survey. <https://www.dpmc.govt.nz/sites/default/files/2017-03/cera-rrz-surveyreport-feb2016.pdf>
- Casey-Lockyer, M., Heick, R. J., Mertzluft, C. E., Yard, E. E., Wolkin, A. F., Noe, R. S., & Murti, M. (2013). Deaths associated with hurricane sandy—October–November 2012. *Morbidity and Mortality Weekly Report*, 62(20), 393.
- Cook, M., & Harrison, E. (2022). Ten Years on: Brisbane’s Compounding Flood Risk. *Complex Disasters: Compounding, Cascading and Protracted*, 101-121.
- de Jersey, P. (2022). Brisbane City Council 2022 Flood Review <https://s3.ap-southeast-2.amazonaws.com/docs.brisbane.qld.gov.au/Council+and+Committees/2022/05-May/17+May+2022/Council/Tabled+document+-+Brisbane+Flood+Review+-+10+May+2022.pdf>
- FEMA. (2021). 3 years long, 3 years strong: New Jersey’s successful approach to purchasing homes along Sandy’s flooded path. <https://www.fema.gov/case-study/3-years-long-3-years-strong-new-jerseys-successful-approach-purchasing-homes-along>
- FEMA. (2022). Remembering Hurricane Sandy 10 years later. <https://www.fema.gov/blog/remembering-hurricane-sandy-10-years-later#:~:text=More%20than%2017%2C000%20federal%20personnel,to%20more%20than%20174%2C000%20survivors.>
- Finn, D., Chandrasekhar, D., & Xiao, Y. (2023). A region recovers: Planning for resilience after superstorm Sandy. *Journal of Planning Education and Research*, 43(1), 136-149.
- Flood Re. (2016). Annual report and financial statements: Year ended 31 March 2016. <https://www.floodre.co.uk/about-us/reports/>
- Flood Re. (2022). Flood Re launches world first ‘Build Back Better’ scheme to help householders after a flood <https://www.floodre.co.uk/wp-content/uploads/Press-Release-BBB-Flood-Re-FINAL.pdf>
- Flood Re. (2023). Could my property qualify for Flood Re? <https://www.floodre.co.uk/find-an-insurer/>
- Fraser, J., Elmore, R., Godschalk, D., & Rohe, W. (2003). Implementing Floodplain Land Acquisition Programs in Urban Localities. University of North Carolina.
- Freudenberg, R., Calvin, E., Tolkoff, L., & Brawley, D. (2016). Buy-in for buyouts: the case for managed retreat from flood zones. Lincoln Institute of Land Policy Cambridge, MA.



- Gehman, J., Thapa, U., & Cao, K. (2024). Certified B Corporations and Benefit Corporations. Oxford Bibliographies. <https://doi.org/10.1093/obo/9780199846740-0203>
- Georgetown Climate Centre. (2020). Managing the retreat from rising seas. State of New Jersey: Blue Acres Buyout Program. https://www.georgetownclimate.org/files/MRT/GCC_20_NewJersey-3web.pdf
- Glavovic, B. C., & Smith, G. P. (2014). Adapting to climate change: Lessons from natural hazards planning. Springer.
- Golnaraghi, M., Dufty, N., & Dyer, A. (2020). Flood Risk Management in Australia: Building flood resilience in a changing climate. The Geneva Association. https://www.genevaassociation.org/sites/default/files/frm_australia_web.pdf
- Greater Christchurch Group. (2017). Whole of Government Report: Lessons from the Canterbury Earthquake Sequence. <https://www.dpmc.govt.nz/sites/default/files/2017-07/whole-of-government-report-lessons-from-the-canterbury-earthquake-sequence.pdf>
- Hoang, T., & Noy, I. (2023). The income consequences of a managed retreat. Regional science and urban economics, 100, 103896. <https://doi.org/10.1016/j.regsciurbeco.2023.103896>
- Ingargiola, J. (2013). Hurricane Sandy in New Jersey and New York: Building performance observations, recommendations and technical guidance. <https://www.govinfo.gov/content/pkg/GOVPUB-HS5-PURL-gpo110213/pdf/GOVPUB-HS5-PURL-gpo110213.pdf>
- Kousky, C., & French, K. (2023). Inclusive Insurance for Climate-Related Disasters. <https://www.ceres.org/resources/reports/report-inclusive-insurance-climate-related-disasters>
- Lockyer Valley Regional Council. (2011). Strengthening Grantham Development - Factsheet. https://www.preventionweb.net/files/workspace/30411_lvrcstrengtheninggranthamlaunchfact.pdf
- Louisiana Community Development / Disaster Recovery. (2024). Restore Louisiana Homeowner Assistance Program Policy Manual. <https://www.restore.la.gov/program-overview>
- Mitchell, C., McGregor, I., & Williams, A. (2019). Red to green: The evolution of a city's abandoned acres. Stuff.co.nz. <https://interactives.stuff.co.nz/2019/09/christchurch-red-zone-to-green/>
- Moore, T. (2020, March 14). Grantham Reborn: Meet the Little Queensland Town that Moved. Brisbane Times. <https://www.brisbanetimes.com.au/national/queensland/grantham-reborn-meet-the-little-queensland-town-that-moved-20200227-p5450g.html>
- New Jersey Department of Environmental Protection. (2015a). FREQUENTLY ASKED QUESTIONS New Jersey Department of Environmental Protection Superstorm Sandy Blue Acres Buyout Program. <https://dspace.njstatelib.org/xmlui/handle/10929/42500>
- New Jersey Department of Environmental Protection. (2015b). Superstorm Sandy Blue Acres Buyout Program - Grant Performance. <https://www.nj.gov/dca/ddrm/plansreports/pdf/SANDY-4th%20Qtr-QPR%202015.pdf>
- Nga Koti O Aotearoa Courts of New Zealand. (2014). Quake Outcasts v The Minister for Canterbury Earthquake Recovery <https://www.courtsofnz.govt.nz/cases/quake-outcasts-v-the-minister-for-canterbury-earthquake-recovery-the-chief-executive-of-the-canterbury-earthquake-recovery-authority-fowler-developments-limited-1>
- NJ Spotlight News. (2022). A decade later, Shore builds back bigger. <https://www.njspotlightnews.org/2022/10/superstorm-sandy-jersey-shore-smaller-houses-were-replaced-wealthier-bigger-long-beach-island-hoboken-woodbridge-money-island-storm-infrastructure/>
- North Carolina Coastwatch. (2016). Hurricane Fran revisited: Lessons From a Benchmark Storm. <https://ncseagrant.ncsu.edu/coastwatch/previous-issues/2016-2/autumn-2016/hurricane-fran-revisited-lessons-from-a-benchmark-storm/>
- North Carolina Department of Public Safety. (2015). North Carolina Disaster Recovery Guide. <https://www.ncdps.gov/document/north-carolina-disaster-recovery-guide>
- Office for Coastal Management. (2024). Out of Harm's Way: Relocation Strategies to Reduce Flood Risk. Retrieved 30 September from <https://coast.noaa.gov/digitalcoast/training/kinston-flood-risk.html#>



- Okada, T., Haynes, K., Bird, D., van den Honert, R., & King, D. (2014). Recovery and resettlement following the 2011 flash flooding in the Lockyer Valley. *International Journal of Disaster Risk Reduction*, 8, 20-31.
- Potter, S. H., Becker, J. S., Johnston, D. M., & Rossiter, K. P. (2015). An overview of the impacts of the 2010-2011 Canterbury earthquakes. *International Journal of Disaster Risk Reduction*, 14, 6-14. <https://doi.org/https://doi.org/10.1016/j.ijdrr.2015.01.014>
- Queensland Reconstruction Authority. (2023). Real-time test validates decade of flood resilience design work. <https://www.qra.qld.gov.au/news-case-studies/case-studies/real-time-test-validates-decade-flood-resilience-design-work>
- ReadyNC.gov. (2022). Hurricanes. <https://www.readync.gov/stay-informed/north-carolina-hazards/hurricanes#Tab-History-114>
- Restore Louisiana. (2023a). Restore Louisiana Homeowner Assistance Program Extends Application Deadline to Tuesday, Oct. 31. <https://www.restore.la.gov/news/restore-louisiana-homeowner-assistance-program-extends-application-deadline-to-tuesday-oct-31#:~:text=Since%20the%20program's%20launch%20in,invited%20to%20submit%20an%20applicatio>n.
- Restore Louisiana. (2023b). Solution 4: Voluntary Buyout Option. https://cdn2.assets-servd.host/utopian-bustard/production/restore_sol-4_120523-v2.pdf?dm=1702319719
- Sanctuary Renew. (2022). Water wise: Flood-resilient design in action. Sanctuary. <https://www.timbennetton.com.au/studio-notes/water-wise-design>
- Sheehan, B., Mullins, M., Shannon, D., & McCullagh, O. (2023). On the benefits of insurance and disaster risk management integration for improved climate-related natural catastrophe resilience. *Environment Systems and Decisions*, 43(4), 639-648. <https://doi.org/10.1007/s10669-023-09929-8>
- Sipe, N., & Vella, K. (2014). Relocating a Flood-Affected Community: Good Planning or Good Politics? *Journal of the American Planning Association*, 80(4), 400-412. <https://doi.org/10.1080/01944363.2014.976586>
- Smart Home America. (2024). Louisiana Fortified Insurance Discount Sheet. <https://www.smarthomeamerica.org/resources/louisiana-fortified-insurance-discount-sheet>
- State of New Jersey Department of Community Affairs. (2013a). Fund for the Restoration of Multifamily Housing. <https://www.nj.gov/dca/divisions/sandyrecovery/pdf/largemultifamilyfinal.pdf>
- State of New Jersey Department of Community Affairs. (2013b). Homeowner Resettlement Program. <https://www.staffordnj.gov/DocumentCenter/View/345>
- State of New Jersey Department of Community Affairs. (2013c). Reconstruction, Rehabilitation, Elevation and Mitigation (RREM) Program Policies and Procedures. https://www.nj.gov/dca/ddrm/pdf_docs/RREM-Program-Policies-and-Procedures-2020.pdf
- State of New Jersey Department of Community Affairs. (2014). Superstorm Sandy CDBG-DR consolidated action plan. https://www.nj.gov/dca/ddrm/pdf_docs/Consolidated%20Action%20Plan_05.2023.pdf
- State of New Jersey Department of Environmental Protection. (2022). Remembering Superstorm Sandy. <https://dep.nj.gov/sandy-10/>
- State of North Carolina. (2000). Hazard Mitigation in North Carolina: Measuring Success. <https://digital.ncdcr.gov/Documents/Detail/hazard-mitigation-in-north-carolina-measuring-success-sustainable-housing-sustainable-business-sustainable-infrastructure-sustainable-environment/2559190>
- Suncorp. (2024). Designing homes that accept water on the floodplains of Brisbane River. <https://www.suncorpgroup.com.au/news/features/creating-homes-that-accept-water-on-the-floodplains-of-brisbane-river>
- Suncorp and Natural Hazards Research Australia. (2023). Assisted relocations: A community-centred approach. <https://www.naturalhazards.com.au/system/files/2023-11/Assisted%20Relocations%20-%20a%20community%20centred%20approach.pdf>
- The North Carolina State Climate Office. (2016). Then and Now, Fran a Standard-Bearer for Hurricane Destruction. <https://climate.ncsu.edu/blog/2016/09/then-and-now-fran-a-standard-bearer-for-hurricane-destruction/>



United Kingdom Parliament. (2015). The Flood Reinsurance (Scheme Funding and Administration) Regulations. <https://www.legislation.gov.uk/uksi/2015/1902/contents/made>

van den Nouwelant, R., & Cibir, A. (2022). The impact of housing vulnerability on climate disaster recovery: The 2022 Northern Rivers Floods. University of New South Wales. <https://cityfutures.ada.unsw.edu.au/documents/700/Northern-Rivers-postflood-housing-20221102.pdf>