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Review Article

Mind the gap: State of the art on decision-making related to post-disaster housing assistance

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ABSTRACT

A growing awareness of the long-term impact of emergency management plans is shifting the focus of post-disaster housing studies towards integrated recovery and development. These would benefit from knowledge about decision-making challenges and dichotomies which determine the success or failure of housing assistance programs, and of methods and tools that can support their holistic resolution. To establish common grounds in this area, this paper systematically reviewed the literature on temporary housing built after sudden natural hazards, from a decision-making perspective, using reflexive thematic analysis methods. This enabled the identification of critical decision-making components (i.e. open challenges, trade-offs, dilemmas and contradictions) and necessary synergies at three levels: the operational, the managerial and the strategic. Results highlight the value of a structured review of the literature to identify decision-making gaps and opportunities for knowledge integration across domains, besides the need of a constructive decision-making alignment at all decision-making levels to enable holistic recovery planning. Additionally, they show the importance of an in-depth examination of decision-making dichotomies for developing novel methods and tools, which respond to contextual needs and local dynamics. Being one of a few studies in a rather underexplored area of research, the primary aim of this review is to offer a broad and structured overview of decision-making issues documented in the literature to date, which connects both theory and practice. The results could be operationalised in future research aimed at supporting Build Back Better efforts towards a truly human-centred housing assistance culture, by investigating the connected decision-making dynamics in specific contexts.

1. Introduction

Urban sustainable development is currently facing considerable challenges linked to climate change, growing inequalities, lack of infrastructures, health hazards, population growth and rapid urbanisation processes [1]. The increasing occurrence of disasters with important human (mostly in developing countries) and economic (mostly in the global North) losses [2], thus, represents a major threat to contemporary cities. During the past few decades, the field of disaster risk reduction has received an increasing attention [3]. Many studies have highlighted the limitations of non-democratic, reductionist and technocratic approaches to disaster recovery [4,5], which in the long term can perpetuate, rather than reduce, vulnerabilities [6–9]; as well as the benefits of alternative systemic ones [10] in supporting communities [11]. Turner [12] and Davis [13] have advocated an holistic understanding of post-disaster housing recovery processes since the 70s. However their multifaceted complexity has been rediscovered only recently [14–16], especially in urban contexts [2,17]. This understanding has pushed humanitarian actors, which include governments and non-governmental organisations (NGOs), to rethink the meaning of post-disaster housing assistance, shifting it from a mere provision of shelter products to a continued effort to support people's health, security and livelihood in the aftermath of a disaster [18]. Therefore, contrarily to the past practice of gauging the impact of housing recovery programmes from cost, coverage and speed [19], their success nowadays is assessed in terms of vulnerability minimisation and quality of life improvement [20,21]. In the 4th priority of action of the Sendai Framework of Disaster Risk Reduction, which institutionalises the Build Back Better (BBB) principle, the UN highlights the importance of connecting disaster relief and development to improve resilience to future hazards [22]. Kennedy et al. [23] suggests that BBB implies tackling the root causes of vulnerability via foresight planning and by addressing

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issues of equity, fairness, and livelihoods, as well as safety and security in humanitarian shelter provision. As a matter of fact, when housing recovery is not human-centred and people-led [24], the livelihood of the affected population is at a stake and there is a risk of alienating people, harvesting corruption, triggering the migration of residents and weakening social capital [5,25,26]. BBB also suggests that urban crises ultimately put to test the effectiveness of pre-existing housing policies and laws as well as of organisational and planning structures [9,10,27].

As past issues have often emerged from an ill-managed or unacknowledged complexity, the approach assumption of this paper is that holistic decision-making processes play an important role in achieving BBB objectives. Fayazi and Lizarralde [28] note that, despite a shared non-reductionist understanding of post-disaster recovery processes, there is still insufficient knowledge of the underlying conflicting decision-making components, which determine the success or failure of housing recovery programs. To further research in this field, the paper presents a review of natural hazard-related studies from the viewpoint of decision-making: an issue that is rather underexplored and yet implicitly embedded in many existing studies on post-disaster housing assistance. This assumes that new relevant knowledge (e.g. decision-making factors which influence the outcomes of housing assistance programs and context-related constrains which influence the selection of suitable methods and tools) is generated by systematically reviewing decision-making information reported in several weakly related empirical and theoretical studies. Because linking relief and development will be imperative in future - most probably urban - disasters [29,30], this review effort represents a timely research contribution.

1.1. Housing assistance approaches

Although housing recovery is a continuum, often housing assistance programs adopt a phased approach, involving the use of different solutions (e.g. emergency shelters, temporary shelters, temporary and permanent houses) to cover housing needs at different stages of the 'disaster management cycle' [31]; what simplifies progress tracking, task-management of humanitarian actors, and separates their responsibilities. Incremental approaches (e.g. core housing, provision of site and services, semi-permanent shelters and transitional housing) [32–34], as well as novel housing assistance solutions such as cash grants for housing rental or material procurement [35] have been considered recently, due to the massive challenges brought by an increasing number of emergencies worldwide. However, deploying incremental housing solutions in private plots or resorting to non-physical housing solutions is administratively and logistically complex in dense urban areas [36], which are often highly vulnerable. While under certain conditions resources might be saved by skipping intermediate housing stages (i.e. going from tents to permanent houses) [37], Temporary Housing (TH) solutions such as housing kits, mobile homes and prefabricated houses are a highly popular choice for re-establishing household routines while coping with adverse climatic conditions, conservation requirements, lack of local capacities, lengthy debris removal, pressuring media and donors' attentions and unavailable surplus housing stock [38], both in developed (e.g. Italy, Japan and USA) [31,39,40], and in developing countries (e.g. China, Nicaragua, Peru, Sri Lanka) [13,33,41,42]. Despite TH provide many benefits, their use is controversial due to their: cultural inadequacy causing conflicts between people and local authorities [28,43], high cost [44], long-term social impact [5] and negative environmental qualities [36]. Some of these shortcomings could however be imputable to an unsatisfactory alignment of decisions due to conflicts between relief and development objectives, and to a poor coordination of humanitarian actors [14,28], independently from the specific housing approach (i.e. phased or incremental) and solution adopted.

1.2. A decision-making gap?

Decision-making has been identified as a possible cause of ineffective housing recovery planning in several areas. For instance, Platt & Drinkwater [45] note that evidence-based deliberation should be better exploited to assist experts in complex assessment tasks and achieve long-term strategic objectives. Ritchie and Tierney [46] identify assessment, logistics, governance and coordination as major decision-making challenges for humanitarian actors. Johnson & Lizarralde [47] report that decision-making is too often concentrated at one level (e.g. that of the disaster manager), where project actors are required to work with limited data and without clear leadership, rather than being delegated to the level/scale in which knowledge is available. This decisions' concentration has been spotted in the provision of TH more than in that of emergency and permanent housing [48]. As housing needs are specific to a context, several researchers suggest that inclusive decision-making plays a key role in the delivery of a truly human-centred housing assistance after disasters [29,36,49–51]. In fact, when housing-related decisions are driven by ill-defined goals, are non-inclusive and based on dynamic, incomplete, or inaccurate information, they can have unpredictable outcomes. Beyond the fact that empowering people means involving them in making decisions [52], the decontextualized framing of decision-making problems by humanitarian actors (e.g. focused on off-the shelves indicators) has been described as highly problematic because of difficulties in scrutinising the appropriateness of choices, understanding local vulnerabilities and providing true accountability [35].

1.3. Scope and objectives of the literature review

The aim of this review is to establish common grounds concerning decision-making challenges and dichotomies, capitalising on the wealth of experiences documented both in developing and developed countries. For reasons of relevance and consistency, it focuses on TH, which are highly diffused and yet highly controversial [53] and its scope is restricted to theories and practices of housing assistance after sudden natural hazards (e.g. earthquakes, tsunamis and typhoons), considering both mono- and hetero-disasters. The literature on man-made disasters is rich of studies on housing recovery but, despite it may be interesting to analyse it in the future, related research is out of the scope of this review. The ultimate objective of this paper is to identify critical decision-making components and discuss which methods and tools are best suited to support their holistic resolution. To this end, the paper illustrates open decision-making challenges and dichotomies emerging from the inherent complexity of the decision-making tasks (trade-offs), their contextual constraints (dilemmas) or from their inconsistent resolution (contradictions).

1.4. Existing reviews

Many disciplines, including architecture, economics, engineering, environmental psychology, geography, medicine, social science, and urban planning contribute to the research on post-disaster housing assistance. When collecting the documents needed for the review from this varied literature, the authors have identified four review papers related to TH [54–57]. These are primarily focused on specific operational issues and on progress in the building industry. Two of them [54,57] propose recommendations for designing TH plans based on a qualitative review of construction-related problems reported in theoretical studies and field reports, while another [55] reviews best practices and products for building sustainable TH. The methodology and documents' selection criteria of these three studies are not explicitly stated. The remaining one [56] is a systematic literature review of academic research on post disaster reconstruction, which uses counting methods to identify research trends. Contrarily to what was found in these four papers, the scope of this study is broader, holistically considering the

operational (i.e. tactical), managerial and strategic standpoints on TH programs. It, therefore, presents an original contribution to the body of knowledge through a critical and structured review of the scientific literature focusing on an analysis of decision-making challenges and dichotomies related to TH.

The paper is structured as follows: the two-steps methodology adopted in the research is outlined in section 2. Section 3 presents the framework adopted for the literature review. Section 4 presents the review outputs, whereas section 5 summarises results and discusses their implications for practice. The conclusions and promising research directions are presented in Section 6.

2. Methodology

The methodology adopted to perform this literature review encompasses two steps: (i) a 3-rounds document selection; (ii) a thematic analysis of critical decision-making challenges and dichotomies related to mid-term housing assistance based on a tailor-made review framework.

2.1. A 'quasi-systematic' literature review

The review method follows clearly defined criteria in both documents' selection (see section 2.1.1) and analysis (see section 2.1.2). Given the limitations of performing a conventional systematic literature review in a research area that is still rapidly evolving [58], the scope of the documents' search is kept relatively broad in terms of content and disciplinary field, which makes the review 'quasi-systematic'. Moreover, documents' quality, in terms of number of citations and good referencing, is not assessed to avoid excluding relevant conceptualisations, potentially innovative, still awaiting empirical validation. If, on the one hand, this choice may inadequately reflect the weight of evidence, on the other hand, this type of assessment is not central to the scope of this review.

2.1.1. A 3-rounds document selection

The documents' selection was done in three subsequent rounds: (i) extraction of target-papers using Scopus search engine; (ii) visual examination of abstracts, conclusions, and as necessary, main texts; (iii) snowball search of selected full texts. The initial documents' extraction was conducted on peer reviewed academic contributions to restrict the search to methodologically sound work. This first round was carried out between September and October 2019, using the following search string: "temporary housing" OR "temporary shelter" OR "temporary accommodation" OR "housing recovery" OR "transitional shelter" OR "interim housing" AND "disaster". The string is based on the pluralistic definitions adopted in the shelter sector to date and include concepts related to shorter-term and longer-term housing assistance [18,31]. In the second round the abstracts, conclusions and, where necessary, main texts of the 544 target papers previously identified were scanned to check if the documents fell within the scope of the review (section 1.2). More than half of the documents were excluded based on this assessment, but additional rules for keeping or excluding the documents were iteratively refined during the visual examination process. For instance, the availability of the full text in English was initially used to filter out the documents. However, later it was decided to keep some references with a sufficiently informative English abstract (i.e. containing hypothesis and results), in order to include the perspective of countries such as China and Japan, which have a long track-record in dealing with disasters. Moreover, some documents were excluded to reduce redundancy due to overlaps with past work by the same authors. Of the massive amount of available grey literature - i.e. quality documents produced by academics, businesses, governments, humanitarian agencies, which are not controlled by commercial publishers [59] - 22 relevant examples were included. Limiting their number allowed to fit better the scope of this study but their inclusion was instrumental to avoid a potential content bias related to the documents' selection method. The final round involved a snowball search of the 182 retained full texts to include relevant research that was not previously retrieved and add variety to the documents' sample. To assist theory development, an effort was made to minimise the use of subjective selection criteria at this stage, so only documents responding to the criteria set in round two and with an original content or that were frequently cited were included at this stage. In the end, 200 documents published from 1978 to 2020 were selected.

2.1.2. Extraction of decision-making challenges and dichotomies

The analysis of the selected documents follows a tailor-made review framework. This was built after performing an unstructured search of links between the field of cognitive science and disaster management studies. The search focused on holistic approaches, which could facilitate the simultaneous identification and resolution of critical decision-making issues and was limited to a restricted selection of mainstream references, which were either directly suggested by researchers with expertise in design decision-making, who were informally consulted, or cited by these and relevant to the scope of the search. When a working draft of the final tripartite review framework (Section 3) was created, the search was interrupted. This step supported a reflexive thematic analysis [60] of decision-making challenges and dichotomies in the 200 documents previously selected.

The thematic analysis process involved iterative code-adjustments, by splitting and collapsing codes or turning them into themes, as required. Meaningful pieces of content were tagged with labels (i.e. evocative codes consisting of a few words) directly within the texts to allow a comparative appreciation of contextual factors in relation to similar decision-making instances. The content analysis was undertaken using either a critical inductive or an interpretative deductive approach: the former was adopted when decision-making issues were reported in the text and were identified as an assumed reality, the latter was adopted when issues were not explicitly reported but could still be logically deducted from the information embedded in the documents and fit the coding system. This involved: (i) familiarising with the data; (ii) identifying relevant pieces of content and labelling it; (iii) tentatively collating the identified challenges and dichotomies into themes while refining the codes/themes in a recursive way. The candidate outputs were finally checked against the documents' content, and the research questions according to the review framework, to produce relevant results.

3. Review framework

In disaster management both the processes of and the options for choice are important [61]. Therefore, the framework is conceived to identify decision-making challenges and dichotomies, and put them into the context of the corresponding decision-making process, by relating them to the organisational level in which decisions are made.

3.1. Decision-making dichotomies

Dichotomies are common in decision-making theory. For instance, Kahneman [62] describes decision modes through the personification of 2 fictional dichotomic systems operating in one's mind at a different speed, which correspond to deliberation (slow and effortful) and intuition (fast but often biased). According to him, experts' mental energy, must be adequately budgeted to prevent them from relying too much on intuition; which is not reliable in 'noisy', if not 'wicked' (i.e. teaching experts the wrong lessons) decision-making environments [63]. While time pressure, which surely influences experts' capacity to deal with difficult decision-making tasks [64–66], remains a major constraint in post-disaster housing assistance programs [67], dichotomous thinking can foster deliberation via complexity reduction in the identification of critical decision-making tasks [68]. This suggests its suitability as a

framework to study key decision-making components, which seek a practical application in a crisis context. Therefore, the following categories of decision-making dichotomies are identified in this review:

- *Trade-offs*: compromise solutions balancing two or more desirable, but incompatible qualities.
- *Dilemmas*: difficult situations, which require choosing between alternative options.
- *Contradictions*: issues characterised by the presence of inconsistent elements.

Additionally, to be sufficiently comprehensive in the review, open decision-making challenges are also mapped.

3.2. Decision-making levels

According to Wallace & Balogh [61] disaster management choices can be clustered at three different levels, corresponding to a varying time horizon and degree of decision control: operational, managerial and, strategic planning and policy. Fig. 1 illustrates a similar tripartite hierarchical model, which is adopted in this review to classify decision-making components according to the different types of decisions and agents involved:

- *Operational*: technical decisions taken by designers, architects, planners, and other professionals responsible for the execution of emergency management plans.
- *Managerial*: decisions taken by disaster managers and other professionals in charge of coordinating efforts and liaising with key stakeholders during disaster response, recovery, mitigation, and preparedness.
- *Strategic*: meta and programmatic decisions taken, e.g., by national governments, local authorities, and policy makers; possibly informed by a holistic vision.

This simple model seems suitable to identify dependencies within and across organisational levels, so as to obtain meaningful insights for BBB practices. According to a decision alignment perspective [69], the proposed division enables observing how higher-level decisions constraint the scope of those at the lower levels and, conversely, how well lower level ones align with those above (this idea is illustrated by the arrows in Fig. 1). This perspective assumes that misaligned managerial and operational decisions are likely to undermine the fulfilling of high-level goals and generate decision-making contradictions. Moreover, the systematic association of decision-making challenges and dichotomies to the operational (technical), managerial (coordination) and strategic levels, is instrumental to activate auditing mechanisms within (intra) levels, and across (inter) the three domains. Naturally, this model is a simplification of reality as, depending on the specific organisational structure in place, there can be no hard boundaries between the three domains, and decisions can be taken at one or more levels simultaneously. Despite this apparent limitation, adopting this framework adds flexibility in the exploration of decision-making challenges and dichotomies across multiple contexts.

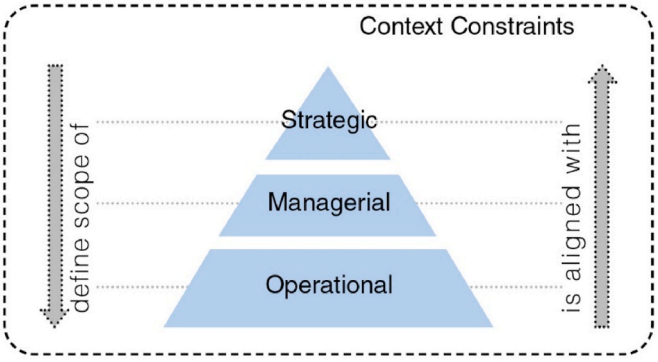

Fig. 1. Tripartite hierarchical structure and decision-making levels.

4. Review results

Decision-making themes are presented in this section following the format: open challenges, trade-offs, dilemmas, and contradictions; divided among the operational (4.1), managerial (4.2), and strategic (4.3) levels.

4.1. Operational decision-making

Operational decisions (Table 1) include planning, design, and executive construction choices. They often involve a critical trade-off between speed and deliberation, whose resolution requires flexibility, a place-based approach, the alignment with strategic priorities and interdisciplinary collaboration between all those who exercise an influence on the built environment [48,70,71].

4.1.1. Technical problem definition and problem-solving history tracking

'Wicked' problems are defined by designers and planners in different ways, mostly according to their abilities and priorities rather than according to the problem itself [72]. Designing and planning for complexity and performance requires reconciling higher level goals, exploiting multiple disciplinary competencies and both creativity and analysis [73]. Existing simulation tools give a limited support in this front and tend to be used in a confirmatory way to check design proposals against regulatory targets [74]. While system performance has been proposed as new design and planning paradigm, and integrated spatial models (e.g. ecological systems and land use, water and energy infrastructure) as a promising tool to deal with urban complexity and uncertainty [75,76], lots of relevant options may be overlooked or accidentally lost simply because of a collection of partial appreciations of the problem, which drive its framing by the experts (including those in disaster-related fields other than planning and design). In addition, information on how to map decision-making processes in common design workflows has not been found in the literature, meaning problem-solving history is normally undocumented. These issues undermine knowledge transfer and obscure accountability, which ensures that well-balanced decisions and actions are made after a natural disaster though transparency, co-operation and governance capacity [77], besides potentially belittling stakeholder's participation in design and planning proposals.

4.1.2. Choice of specifications and performance criteria

Housing as a process means involving both specifiers and end-users in projects' design and development. If to BBB "is important to consider how 'safer' and 'better' are defined, and by whom" [24], making supporting information and design decisions more explicit may help enriching and - in certain circumstances also reconciling - the different perceptions of various professional experts and households. Better mutual understanding may guide a more comprehensive assessment of proposals, conflict reduction, and possibly lead to the implementation of better compromise solutions [70]. Local authorities and governments can bring an effective contribution to this process, by balancing the control of non-technical individuals over technical decisions [19]. Additionally, digital information and fabrication technologies may open opportunities for lean housing production and process innovation in both TH design and planning [71]. The local institutional, organisational and technological context may thus act either as an opportunity or as a constraint for human-centred architecture and planning. There is nonetheless uncertainty regarding the actual impact of the decentralisation of the means of production and knowledge in the making of TH. Overall, there is a need to disambiguate and possibly go

Table 1
Summary of operational decision-making themes and dichotomies.

Operational	Description	Disaster Type	Country/ Context	References
Open Decision-Making Challenges	Technical problem definition and problem-solving history tracking	Generic natural hazard	Not specified	[72–77]
	Choice of specifications and performance criteria	Earthquake, earthquake + tsunami, generic hazard, typhoon, volcanic eruption	Developed, developing, not specified	[19,21], [23,24], [70,71], [78–80]
	Multi-dimensional design decision-making	Earthquake, generic natural hazard, hurricane	Developed, developing, not specified	[15,47, 81–86]
Trade-Offs	Site selection (many)	Earthquake, generic hazard	Developed, developing	[7,82, 87–90]
	Houses, site design and infrastructure (many)	Earthquake, earthquake + tsunami, generic hazard, generic natural hazard, typhoon	Developed, developing, not specified	[23,54,71, 87,91–95]
	Typologies, materials and building technology (many)	Earthquake, earthquake + tsunami, generic hazard, hurricane	Developed, developing	[14,23,31, 47,81, 96–98]
Dilemmas	Professional values and existent policies	Earthquake, generic natural hazard	Developed, developing, not specified	[9,18], [97,99]
	Bottom-up initiatives and changing role of professionals	Earthquake, earthquake + tsunami, generic hazard	Developed, developing, not specified	[16,18], [93,100], [101,102]
Contradictions	Scarce availability of land and use of single storey solutions	Earthquake	Developing	[42]
	Combination of a reversible system with glued joints and moist external finishes	Earthquake	Developed	[81,103]
	Combination of sustainable architectural solution and use of irreversible ground attacks	Earthquake	Developed	[7,81,103]
	Provision of housing solutions with different safety construction standards in the same disaster event	Earthquake	Developed	[6]
				[104,105]
	Planning of large temporary sites and lack of community relations after disasters	Earthquake, earthquake + tsunami	Developed, developing	

beyond universal minimal technical criteria, such as those contained in the Sphere handbook [78], to adequately translate functional requirements into coherent design and planning specifications made of fit-for-purpose metrics and values. Kılcı et al. [79] point out that a lack of advanced criteria, methods and tools to plan and implement transitional housing after an earthquake, may impact on the quality of reconstruction operations in unpredictable ways. Similarly Nappi & Souza [21] note that "the lack of criteria with respect to the selection and location of temporary shelters […] can lead to unforeseen factors, threatening the quality of the logistics operation as a whole". Omidvar et al. [80] report cases where a lack of comprehensive criteria in selecting shelter sites has led to the selection of arid and thus socially unsustainable lands for housing. Kennedy et al. [23] highlight the importance of adopting risk reduction criteria in planning transitional settlements.

4.1.3. *Multi-dimensional design decision-making*

Operational technical criteria should be aligned with those used at the strategic and managerial levels. Decisions need to be taken at the right moment and coherently across the different spatial scales: the architectural, the neighbourhood, the city and the regional. For example, if environmental sustainability is a priority, this needs to be factored both in the choice of land for the temporary housing sites by considering the land use prior to and after the disaster [82] as well as in the choice of the materials and building technology of the transitional houses in order, e.g. to allow for recycling recoverable components [47]. If spatial physical resilience is a priority, modularity at the level of both design and planning can be beneficial [83–86]. Threshold elements, such as the building envelope, constitute critical design components linking multiple scales and sustainability dimensions. While some authors propose criteria related to one scale only, others such as De Berardinis and De Gregorio [15,81] list cross-scale criteria suitable to achieve integrated design goals. For example, to ensure temporality, they look simultaneously at the construction (reversibility of the process), use (adaptable spatial configuration) and location (moveable construction) of TH solutions. Furthermore, they identify interdependencies between site and housing unit layouts such as the shape of plots, which may contemporarily influence the possibility to adapt the housing units and build semi-private outdoor living spaces. These examples show that, when two or more aspects are related, one may act as a constraint to the other and operating trade-offs becomes necessary.

4.1.4. *Operational trade-offs*

- **Site selection.** Selecting a site is challenging because multiple factors need to be in equilibrium: the centrality of the location and the higher cost of land, as well as potential bureaucratic issues connected to land ownership (e.g. securing leases from landowners) and subsequent evacuation of an attractive area; the choice of cheaper non-urbanised areas and the cost of preparation works; the capacity of the selected site and that of the existing grid; the availability of public facilities to overtake (e.g. schools, sports areas) and the resulting lack of services; the choice of closer terrain with a difficult topography and the need of water drainage and other infrastructure [7,82,87]. Furthermore, the size and configuration of the initial settlement

needs to be considered in the choice, because the creation of TH sites in small settlements can foster urban decentralisation [88–90].

- **Houses, site design and infrastructure.** The design and construction of both hard and soft infrastructure should foster tangible and intangible aspects of community development and be timely integrated with the design of the houses and sites' layout, considering ownership issues [91]. Among other things, this can: improve accessibility and thus logistics [87], walkability, care and social gathering [54]; enable the implementation of passive design strategies [71]; sustain urban agriculture via water recycling [92]; help reducing the risk of violence and abuses on vulnerable categories of people such as women and children, e.g. by locating latrines in well-lit areas close to the housing units [93] or by adding a second door and a way out on the rear of the transitional houses [94]. Additionally, this can avoid situations where infrastructure construction threatens the stability of houses, but rather supports synergies that reduce housing exposure to natural elements [23]. It can, however, bring some challenges to pre-design and planning. For example, pre-installed solar panels coming with prefabricated structures may be orientated in a suboptimal way due to the position of the houses on site, which reduces power production capacity as well as the possibility to compensate for their share of embodied carbon [95].
- **Typologies, materials and building technology.** When choosing housing typologies, materials and construction technologies there is a need to balance components' durability with the many uncertainties connected to the houses' lifespan, intended and real. Some researchers have proposed a 'speed and seed' approach where building components made of durable materials are engineered to be flexible and adaptable, allowing incremental changes [96]. Moreover, past research has shown the impact of typology and materials on the psychological wellbeing of the affected population [97]. Additional considerations concern: the use of windproof materials and the need of ventilation [98]; the use of high performance materials and their local availability [47]; the choice of a performative building technology and the capacity of local people to adopt it at a later time for safely adapting TH units to their needs [14]; the use of traditional building methods and the availability of necessary materials [23]; the use of new efficient technologies that add complexity to old threats [31]; the presence of buy-back options and the unavailability of clear criteria to establish end-of-use prices [81].

4.1.5. Operational dilemmas

- **Professional values and existent policies.** Architects and planners are familiar with aesthetic and behavioural aspects of design and concepts such as 'genius loci'; which refer to the idea of layered historic identity and sense of place, besides beauty, tradition and home. Professionals may however be forced to ignore these values if they are not explicitly stated in the major disaster guidelines [18]. This can result in the design of uniform TH site layouts that ignore the original social organisation and settlement patterns of the affected communities, leading to a socio-spatial disarticulation. Albeit beneficial from the perspective of psychological and physical recovery [97], these values may conflict with instances of resource efficiency due to connected higher urbanisation requirements [99]. Moreover, excessively ambitious plans which require time or threaten developers' private profit can generate social conflicts [9].
- **Bottom-up initiatives and the consequent changing role of professionals.** When people are required to take responsibility for the financing, planning, design, construction and management of their homes, architects and planners need to assume the role of expert consultants [18] and become facilitators/mediators between local people and governments. Professionals can assess design proposals in terms, for example, of their lightness, easiness of assembling and installation, thermal resistivity and comfort [100], evaluate the potential to re-use and recycle the houses, as well as the land and the infrastructure [101], and undergo post-occupancy assessments to feed forward future practices [16]. Additionally, they may be required to evaluate the eligibility of local skills [93], including the informal sector, supervise the building construction process and ensure that local resources are used in a sustainable way [102]. Further activities include awareness raising and advocacy, construction monitoring and training for capacity building. Performing these tasks can be challenging due to potential conflicts of values between professionals and lay people and may require both hard and soft skills, which are not always part of professionals' training.

4.1.6. Operational contradictions

As shown in Table 2, operational contradictions are likely to emerge from ill-resolved technical trade-offs. Therefore, appropriate design methods should either address these first, potentially through the use of Axiomatic Design [106], or accepting that contradictions are inevitable but potentially resolved through innovative design methods such as TRIZ [107]. Machine learning could be used in different scientific domains to facilitate operational knowledge management and further foster creativity, besides enabling knowledge transfer and wider information sharing in practice. For instance, computer vision techniques can contribute to augment BIM capacities and speed up situation assessment [108], convolutional neural networks could be exploited to rapidly perform spatial and environmental analyses, and statistical learning can help to comparatively evaluate multiple design options and their spatial resilience patterns [109]. However, related development efforts may require development time and resources, which are usually available only in the preparedness phase; besides knowledge about how to flexibly tailor methods and tools so that they can suit different design/planning workflows [110].

Table 2
Operational decision-making contradictions.

Contradiction	Underlying conflicting objectives	Consequences of contradiction
Scarce availability of land and use of single storey solutions	Save land resources while improving safety in relation to aftershocks	• Unhealthy (lack of floor space) • Unsafe (reduced privacy, solitary environment) • Mental health issues • Expenditure of ground
Combination of a reversible system with glued joints and moist external finishes	Re-use the structure while using fast and cheap methods to mount structures and apply finishes	• Delay in dismantling • Impossible components' re-use
Combination of sustainable architectural solution and use of irreversible ground attacks	Ensure the sustainability of the building while constructing reliable foundations rapidly	• Not reversible (impossibility to move the unit and recycle it) • High land consumption
Provision of housing solutions with different safety construction standards in the same disaster event	Ensure safety of construction while using standard solutions across a large area	• Waste of material resources where standards are higher than necessary • Unsafe conditions where standards are lower than necessary
Planning of large temporary sites and lack of community relations after disasters	Keep people close building large uniform TH settlements while maintaining social capital	• Difficulties in maintaining community bonds if issues of leadership, ownership, transparency, planning and participation are not addressed

4.2. Managerial decision-making

Managerial decisions (Table 3) involve project management and coordination including financing, housing procurement, progress monitoring and reporting, besides communication with stakeholders.

4.2.1. Standardisation of managerial procedures

If existing, managerial decisions are supported by a strategic plan, which is updated every time according to the specifics of the disaster (e.g. economic and political context, extent of damage, weather etc.) [67]. Otherwise, these and operational decisions are made after a disaster in an impromptu planning phase, under pressure of time. As a matter of fact, the typical operating environment is characterised by changing circumstances, which challenges the possibility to standardise managerial procedures. Nonetheless, Nappi & Souza [21] argue that identifying relevant patterns in disaster management can bring an advantage in the coordination of future humanitarian efforts.

4.2.2. Managerial collaboration

The review evidences an absence of methods to ensure an effective collaboration across sectors (e.g. academia, government, industry, informal sector, international funding agencies and NGOs) towards improved performance [5,67,111]. Collaboration is a rather underexplored area of research in the emergency management literature. Contreras et al. [5] report a lack of empirical research relating collaboration patterns, engagement and task interdependency with specific collaboration conditions. Despite being a somehow limited attempt, the pioneering work of Xu et al. [48] suggests that network science could be successfully exploited to study collaboration networks; which would have the advantage to gather under the same methodology social and spatial analysis. A multi-level network analysis can indeed help studying both self-organised social resilience mechanisms and the physical resilience properties of urban infrastructure, as well as the role played in these by 'weak ties'. Additionally, a poor collaboration can cause a duplication of tasks and functions (e.g. between local administrations and government disaster management agencies), leading to conflicts and confusion in both managerial and operational decision-making activities [20];

4.2.3. Data management and decision support systems

An additional challenge is represented by the explosion of data during crises and the parallel absence of accurate and timely data elaboration and information gathering protocols to support decisions [45]. Furthermore, there is a risk in decontextualizing the use of decision support systems (DSS). DSS should reflect the legal framework and planning practice of a country, including bureaucracy and assistance procedures, and account for local resources and contextual data. For instance, a Life-Cycle Analysis (LCA) should always be performed using applicable values of embodied energy and carbon. Using a dataset in a LCA analysis which is built for another country with different characteristics, as done in a few of the reviewed documents [95,112], puts into question the validity of the analysis and the possibility to learn from its results. Varied carbon emission inventories should hence be made available and integrated in BIM platforms, if BIM models (which have started to appear in prefabricated post-disaster housing supply tenders) are to allow performing sustainability assessments rather than giving a competitive advantage to construction companies with CAD capacities. Similar limitations have been found by Vecere et al. [113] in a comparative analysis of 6 DSS estimating the need of public sheltering after a disaster. The number of homeless people to house can be hardly established using a universal tool immediately after a disastrous event because, for instance, entitlement to housing assistance may depend on local rules for needs' assessment [99]. The number of houses needed may become a dynamic quantity, not just because of aftershocks, but also due to subsequent updates of lengthy (and/or contested) structural surveys [6] or modifications of key policies [8].

Table 3
Summary of managerial decision-making themes and dichotomies.

Managerial	Description	Disaster Type	Country/ Context	References
Open Decision-Making Challenges	Standardisation of managerial procedures	Earthquake, generic natural hazard	Developed, developing, not specified	[21,67]
	Managerial collaboration	Earthquake, generic hazard	Developed, developing, not specified	[5,20,48, 67,111]
	Data management and Decision Support Systems	Earthquake, earthquake + tsunami, generic natural hazard, generic hazard	Developed, developing	[6,8,45, 95,99,112, 113]
Trade-Offs	Speed versus quality	Cyclone, earthquake, earthquake + tsunami, flooding, hurricane, volcanic eruption	Developing	[8,23,36, 46,47, 114]
	Customised solutions versus standardisation	Earthquake, earthquake + tsunami, generic natural hazard, hurricane	Developed, developing	[50,66, 115–117]
	Participation versus process efficiency	Cyclone, earthquake, earthquake + tsunami, flooding, generic natural hazard, typhoon, volcanic eruption	Developed, developing	[5,19], [23,24,28, 48,49,52, 66,93,114, 118–120]
Dilemmas	Use of available decision support systems	Earthquake, generic hazard, hurricane	Developed, developing, not specified	[64,65,80, 106, 121–124]
	Use of participatory practices	Generic hazard, generic natural hazard, typhoon	Developed, developing	[19], [125,126]
Contradictions	Timely use of available funding and actual needs	Earthquake, earthquake + tsunami	Developed, developing	[8,23,99]
	Need for customisation and unsuitable protocols/ practices	Earthquake	Developed	[45,127]
	Importance of participation as part of preparedness and focus on methods for the response phase	Earthquake, generic natural hazard	Developed, developing	[36,66,67]
	Rural intervention skills and urban response	Cyclone, earthquake, earthquake + tsunami, flooding,	Developing	[18,29,32, 114,128]

(continued on next page)

Table 3 (*continued*)

Managerial	Description	Disaster Type	Country/ Context	References
		generic hazard, hurricane, volcanic eruption		
	Complex operational tasks and use of unskilled human resources	Earthquake, earthquake + tsunami	Developing	[23,46]
	Preference for local materials and unsustainable procurement	Earthquake, earthquake + tsunami	Developing	[23,36]

4.2.4. Managerial trade-offs

- **Speed versus quality.** A balance should be stricken between these two variables in different fronts, including environmental sustainability [36]. In relation to the delivery of TH solutions, the push for quick and visible outputs regardless of their quality may cause, for example, the provision of infrastructure and services (e.g. power, roads and water grid, school and healthcare facilities) to be left behind [47]. To rapidly fulfil donors' expectations, NGOs may target areas that are more easily accessible and offer a higher probability of success in the short term [46]. As both speed and quality are key for promoting livelihoods, safety and security [23], consensus should be reached case by case on the appropriate speed for construction. A balanced choice needs to be made also between TH quantity versus quality [114] because housing anxiety and difficulties in coordinating housing recovery efforts can arise when there is both a pressure to rebuild and to go beyond providing a mere stock of houses [8].
- **Customised solutions versus standardisation.** Customised solutions may serve a variety of purposes including aesthetic (e.g. culturally adequate solutions fostering interpersonal identity and sense of ownership as opposite, e.g. to the Disneysation of temporary settlements), functional (e.g. accessibility for disabled people), health (e.g. good indoor air quality, comfort and care) and safety (e.g. protection against violence and hazards); which standard solutions can hardly satisfy. It is key to address different vulnerabilities such as those of children, disabled people, the elderly and women living in TH sites, because they can be exposed to a variety of mental (e.g. anxiety, depression, post-trauma stress, social isolation) and physical diseases (e.g. musculoskeletal, respiratory) [50,115–117]. However, attempts to introduce a top-down customisation can cause delays in material procurement, and in the manufacturing and distribution of the temporary houses [66].
- **Participation versus process efficiency.** Despite this being a largely discussed topic, the benefits of different types of participation in relation to the outcomes of shelter programmes are not yet well understood. Davidson et al. [52] suggest the importance of user participation in the project design and planning phases. Opdyke et al. [19] note that, under certain conditions, overlooked forms of participation such as 'sweat' labour can further project goals , stating it is important to give more control to people over decisions in the early planning stages and during construction activities than in the design phase. In the past few decades, a nourished number of authors [114,118,119], have argued that participation is necessary for effective problem solving and to reduce dependency of affected populations by supporting local efforts and abilities, speed up recovery and underpin the continuation of cultural values. However, recent research has challenged the ubiquitous validity of this assumption. For instance, Maly [24] notes that participation does not always guarantee to achieve a people-centred recovery because, if detached from long-term capacity-building efforts, it may not lead to community empowerment [19]. Here, two key components are civic awareness and civic rights [48]. Fayazi & Lizarralde [28] argue that participation does not always help resolving conflicts between stakeholders. Rather, a late and simplistic engagement in such a practice may intensify discussions over solutions that experts consider too costly and technically infeasible or create voice opposition to highly needed projects, policies and programs. This can nonetheless be a positive sign of communities struggling to take back control [49]. Subasinghe [93] highlights that regarding self-labour as non-skilled can result in verbal and physical conflicts with local aid managers or in shelter abandonment due to an unhealthy competition with foreign volunteers. Nevertheless, relying on self-labour only may not be sufficient in large-scale disasters and, if deadlines are missed, issues arise due to the resulting discontent [23]. Participation takes time [120] and requires transparency of information and actions, which is not always there [5] because a time-limited participation of organisations and actors (due to the turnover of relief organization personnel) may prevent actual knowledge sharing and may be influenced by stereotyped cultural judgements. A continued fruitful participation of all stakeholders, depends both on citizens' and local authorities' capacity to engage in the process and on the presence of social capital and local collaboration networks [66].

4.2.5. Managerial dilemmas

- **Use of available DSS.** Whether to use or not available DSS is a dilemmatic element because of a lack of methods to tailor existing DSS to the problem of post-disaster housing assistance and because further research on disaster operation management is needed [65,121]. Most of the operational research done to date concerns deterministic decision support systems such as multi-criteria or multi-objective optimisation methods to: assess temporary housing alternatives and allocate displaced families to them using a selection of KPIs or/and bottom-up inputs [122,123]; choose desirable temporary settlement locations [80]; estimate optimal inventory levels for temporary housing procurement [64]; and identify sustainable housing types [124]. Arguably these methods are not fit to explore 'what if' questions considering participatory practices, nor to allow for hesitancy in decision-making, because they tend to force choices even if decision-makers are in doubt, rather than accommodate it in solutions' development [106].
- **Use of participatory practices.** This emerges as a dilemmatic and yet key component of managerial decision-making to reach consensus among stakeholders considering their priorities and perceptions. Research indicates that, under certain conditions, citizen participation can advance social sustainability by enhancing urban disaster management, but its impact in different contexts is still unclear. Participation in shelter projects can be understood in the minimum terms of a sequence of decisions and actions [19]. It seems thus important to define when these decisions and actions are made and by whom: being individuals, communities, or local governments. A suitable selection of the time in which participants are engaged (e.g. situation assessment, design and planning, resource procurement and construction, monitoring and management, preparedness), and their level of control over the process are crucial to achieve the intended outcomes and may be chosen and varied in relation to a specific context. Participants should be defined with a suitable level of detail, considering their participation capacities as well. The concepts of 'user' and 'citizen' are not interchangeable, as they reflect a different focus/goal in the participatory process and refer to individuals with different institutional rights. For the principle of equifinality, there is no unique solution concerning participation. In

fact, it can be pursued both at the managerial and at the operational levels via different routes among which, in the former case, sweat equity and serious games and, in the latter, co-design and collaborative planning. Digital 3D modelling, online collaborative platforms, physical prototyping and testing, real-time simulations, social networks and Virtual Reality applications can be differently exploited to support participatory processes. For each of these modalities it should be in place a protocol suitable to assess the effectiveness of the process against its objectives. In fact, many technological platforms suggested in the literature as suitable for using in participatory spatial planning processes, design and project management (e.g. CityEngine, GIS and BIM applications, Rhino/Grasshopper) are not yet accessible by the lay public [125] nor fully scalable [126]. Overall, the review identifies a lack of a solid framework for different modes of participation in post-disaster housing decision-making as well as of methods for assessing their different impact on decision outcomes.

4.2.6. Managerial contradictions

Table 4 presents numerous examples of managerial contradictions, related to coordination of recovery efforts, financing, information and human-resources' management, participation and scheduling (the two at the bottom of the table are labelled as managerial despite they originate in practice from an ill-resolved coordination of trade-offs between this and the operational level). To tackle these issues, comparative studies of housing management practices in different contexts have recently started to emerge; which allow an iterative definition of similarities and differences useful to derive theoretical insights, inform future housing efforts and help towards the reported lack of systematic institutional memory in the shelter sector [114]. A key example, although oriented to practitioners, is represented by the Shelter Projects series [129]. Additionally, Patel and Hastak [66] suggest that process trade-offs existing between cost, resources and time can be strategically balanced case-by-case in the preparedness phase, by simulating post disaster response and iteratively modifying managerial guidelines. Future managerial scenarios will also have to consider how to build trust in different contexts and how to deal with new emerging problems such as that of the 'tourism of macabre' or 'dark tourism', involving people making selfies in front of the ruins.

Table 4
Managerial decision-making contradictions.

Contradiction	Underlying conflicting objectives	Consequences of contradiction
Timely use of available funding and actual needs	Maximise use of available funding while tailoring response to actual needs	• Development policies based on self-help are weakened • Heritage conservation goals are undermined • Contribute to build new vulnerabilities by causing competition or confrontation among aid organisations
Need for customisation and unsuitable protocols/practices	Provide a customised response while following protocols or common practices	• Disaster managers relying on standard protocols and expert intuition despite the availability of custom information • Critical information not shared when needed
Importance of participation as part of preparedness and focus on methods for the response phase	Make key decisions as part of preplanning while enabling participation in disaster response	• Ineffective preplanning • Ineffective participatory processes (preparedness should be understood as an early engagement in participatory planning)
Rural intervention skills and urban response	Answer requests from donors to aid in urban disasters despite inexperience in the field while providing a skilled housing assistance	• Biased response to a growing number of urban disasters • Interactions with the market and the private sector to ensure an effective response and recovery can be ineffective or inexistent
Complex operational tasks and use of unskilled human resources	Resolve complex operational tasks while employing unskilled local human resources	• Excessive workloads • Delays • Sub-standard service delivery • Weaken recovery policies • Coordination difficulties
Preference for local materials and unsustainable procurement	Use of local materials to boost environmental sustainability while ensuring a quick provision of needed resources	• Unsustainable procurement practices are encouraged • Environmental vulnerabilities are created, putting at risk local ecosystems • The risk of landslides, topsoil erosion and impairment of water supply increases

4.3. Strategic decision-making

Strategic decisions (Table 5) address in different ways the issue of balancing long-term versus short-term housing priorities and needs and are generally guided by an inspirational vision besides being concerned with permanent reconstruction. To be truly useful in pursuing a development recovery the vision needs to be consistent with a dynamically changing reality [18] and should be supported by contextual knowledge and strong leadership. This decision-making level dictates the scope of managerial decisions in terms of long-term objectives and available funding.

4.3.1. Lack of contextual standards

Because of contextual differences, across a large disaster area, solutions of strategic issues do not have to be unique and homogenous [51]. Trade-off decisions should rather be approached case by case as appropriate. A plethora of research on policymaking related to TH was conducted in the past using case-studies (e.g. the coastal zone policy after the 2004 tsunami in Sri Lanka), which possibly reflects the need to adopt a contextualised approach and to overcome the temptation to look for 'one size fits all' solutions. The latter is reflected, for instance, in the ubiquitous use of the Sphere's minimum housing standards [78], albeit their adoption in different contexts is culturally problematic because either it ignores the higher state of development of a country [14] or the lower living standards of the non-affected population [32]; which causes social tensions between the displaced and the host community. Providing substandard solutions relatively to the context can cause delays, improvisation and increase the cost of the solutions eventually adopted [130]. To solve this issue Davis & Alexander [18] suggest setting shelter standards nationally rather than internationally; according to local cultures and economies and possibly after consulting local governments.

4.3.2. Lack of contextual knowledge

The current quest for human-centred solutions seems not to be backed up by a sufficiently detailed characterisation of end-users [131] and contexts, with the subsequent risk of stereotyping people and situations due to cultural and knowledge gaps. For example, studies addressing the needs of minorities differ in their focus according to the context: elderly needs are mainly researched in the developed world, where issues linked to an ageing population are more pressing; whereas gender differences are more studied in the global South. Possibly, the cause of the current research polarisation is the practical orientation of

Table 5
Summary of strategic decision-making themes and dichotomies.

Strategic	Description	Disaster Type	Country/Context	References
Open Decision-Making Challenges	Lack of contextual standards	earthquake, earthquake + tsunami, generic hazard	developed, developing, not specified	[14,18,32,51,78,130]
	Lack of contextual knowledge	earthquake	Developing	[131]
Trade-Offs (Dilemmatic)	Top-down versus bottom-up	earthquake + tsunami, typhoon	developed, developing	[19,51]
	Sustainability as efficiency versus resilience	cyclone, earthquake, earthquake + tsunami	developed, developing	[36,45,79,132]
	Individuals versus society	cyclone, earthquake, earthquake + tsunami, flooding, generic hazard, hurricane, volcanic eruption	developed, developing	[18,20,30,39,47,114]
	Resettlement versus minimum displacement	cyclone, earthquake, earthquake + tsunami, generic hazard	developed, developing	[5,30,49,88,93,132–135]
	Temporary versus permanent	earthquake, generic hazard	developed, developing	[47,67,136–139]
Contradictions (Inter-level)	Collection of disaggregated data and one size fits all response	earthquake, generic hazard	developing, developing	[140,141]
	Push for environmentally sustainable TH solutions and lack of holistic planning	earthquake, earthquake + tsunami,	developed, developing	[23,36,67]
	Programmed temporariness and actual permanence of TH	earthquake, earthquake + tsunami, generic hazard, nuclear hazard	developed, developing	[7,81,88,142,143]

the field, where typically research follows action. Assuming the usual modalities of interventions as a starting point for research may however induce an anchoring effect, skewing research efforts in some areas while overlooking other promising ones such as, for instance, discussing opportunities and threats of the digital revolution in the shelter sector. This may involve evaluating the impact of the sharing economy (e.g. Airbnb), social media and of bottom-up collaborative web-platforms on housing recovery processes in different countries as well as that of the decentralisation of the means of production and knowledge in the making of TH.

4.3.3. *Strategic trade-offs*

Some of the dichotomies listed below can be recognised as recurring dilemmas rather than actual trade-offs, but the latter expression is used to highlight that balanced and fit-to-context compromise solutions, in the form of hybrid approaches i.e. seeking a positive synergy between opposites, are perhaps more appropriate and more viable options in strategic planning.

- **Top-down versus bottom-up**: these represent two opposite modes of governance corresponding to control and trust routes, respectively. The first being centralised and the second highly decentralized with distribution of risk among project actors involving a 'people-driven' procurement. The latter allows coping with limited resources and response capacities by supporting self-recovery but requires: achieving high levels of coordination, especially in complex urban environments [19]; empowering local actors in different phases of decision-making (from strategic planning to post-occupancy management); and implementing plans for building local capacities. Within the realm of the public administration, a hybrid solution may correspond to a mixed decentralized model for recovery management with inputs from the central government as well as from the regional and municipal administrations [51].
- **Sustainability as efficiency versus resilience.** Sustainability and resilience are umbrella terms, which can be used to identify different priorities, which may eventually end up being in contrast [45]. For example, a narrow and improper definition of sustainability as a purely economic principle ruling in short term (i.e. maximum cost saving in the short term), may hinder social and environmental resilience [36,79]. Community resilience is higher when there is a contemporary overlap of economic (households' livelihood), environmental (natural resources and services) and social (community bonds) capital; which are interdependent dimensions creating truly sustainable communities [132].
- **Individuals versus society.** Strategic decisions should help striking a balance between individual and collective aspects of life [20]. Furthermore, they should consider the rights of all stakeholders, rather than only those of a restricted group of individuals in order to avoid tensions and conflicts over the use of resources [47]. In planning, this means seeking a rational urban form rather than prioritising patterns of land ownership [18]. This trade-off is reflected in the equity versus fairness dilemma, that is the choice between all people being treated equally or according to their (subjectively assessed) needs [114] and prioritising the preservation of pre-existing territorial communities [30]. Under certain conditions, the decision of providing support to vulnerable people first, may cause the disruption of former communities and their isolation from society [39].
- **Resettlement versus minimum displacement.** Displacement should be generally avoided because resettlement has a social cost in terms of loss of livelihood and social fragmentation [5,30] as well as infrastructure. In some instances, it weakens the capacity of the affected community to take a larger role in reconstruction activities. Instead of preventing risk for health, relocation in unsuitable transitional housing sites may cause mental stress, putting at higher risk vulnerable categories of people with lower income and education levels [133]. Additionally, difficult living conditions and socio-economic factors can lower communal civility [49], trigger violent behaviours [93], and worsen drinking habits [134]. Historic failures in both planned and spontaneous resettlement plans, show that, simply moving the location of a settlement does not necessarily reduce vulnerability [88]. Given its impact on the territory and the life of its inhabitants, when this strategy is considered, it should rely on an inclusive and participatory plan, supporting the socio-economic resilience and equity of disaster-stricken communities [135]. Among other key issues to address are the ownership of assets, including for example the houses themselves, the availability of land for urban gardening and that of knowledge resources, such as skills' development and consolidation programmes aimed at strengthening individual and group adaptive resilience capacity [132].
- **Temporary versus permanent.** To enable a coherent alignment of strategic objectives with decisions taken at lower levels, a choice regarding the future of the temporary houses needs to be made early on. If a long-term strategy in not in place, results may be unpredictable and problematic or cause the waste of important resources. The unplanned use of temporary solutions as permanent ones and the lack of a clear pathway towards permanent housing solutions may compromise peoples' safety, security and quality of life [67,136] and cause management issues connected to the absence of formal and functional coherence in TH sites [137]. However, the speed of recovery may vary according to different contextual factors related to

the situation before and after the disaster [47]. A possible strategy to address this issue is to reduce the overall lifecycle costs of housing assistance, by making economically, politically and technically feasible to reuse, store, sell or recycle the temporary houses and sites [67,138]. Under certain conditions, adopting a circular economy model has the potential to augment the value of the resources already immobilised for local communities by exploiting the assets in different forms in the long term. Furthermore, strategic choices should acknowledge that, far from being exceptional, temporary housing is currently embedded - in several non-ordinary and transitory forms - in the urban and social fabrics of most big cities worldwide [139].

4.3.4. *Strategic contradictions*

Due to their generic character, strategic decisions do not usually generate intra-level decision-making contradictions, but still require to coherently resolve difficult trade-offs, which if not numerous, are huge in terms of their consequences for the future of the affected population and territory. Since strategic decisions establish the objective of lower level decisions, contradictions at this level can be interpreted as a misalignment between strategic intentions and lower-level actions. Fig. 2 illustrates that besides intra-level dichotomies, which decrease in number but increase in importance going from the operational to the strategic level, the literature presents examples of inter-level contradictions across two or more decision-making levels. The latter point is further exploded in Table 6, which summarises information extracted from the literature to highlight 'intention and action' gaps.

Table 6
Strategic decision-making contradictions.

Contradiction	Inter-level misalignments	Consequences of contradiction
Collection of disaggregated data and one size fits all response	Lack of adequate professional expertise, executive protocols, financing, and leadership	• Consideration of physical accessibility only (e.g. provision of a ramp) • Insufficient inclusion of disabled people in decision-making for defining guidelines for shelter clusters or to design and test housing infrastructure
Push for environmentally sustainable TH solutions and lack of holistic planning	Absence of a plan to re-use TH infrastructure and land and operational difficulties in re-cycling material from rubble	• Low environmental impact of TH is ultimately not achieved
Programmed temporariness and actual permanence of TH assistance programs	Lack of an end-of-life plan for TH units and sites	• Long-term economic, environmental, and social negative impacts • Impact on health and safety of inhabitants (e.g. loss of vitality, physical and mental stress etc.), leading, in some cases, to disaster-related deaths

5. Discussion

The resolution of intra- and inter-level contradictions is crucial for BBB, as they materialise a clear mismatch between disaster recovery and development goals. To tackle them, it is key to reconcile objectives in two directions: (i) among different technical disciplines and (ii) between experts and people.

The multi-domain nature of several decision-making dichotomies identified in the review indicates that dichotomies could be better addressed via interdisciplinary and transdisciplinary decision-making;

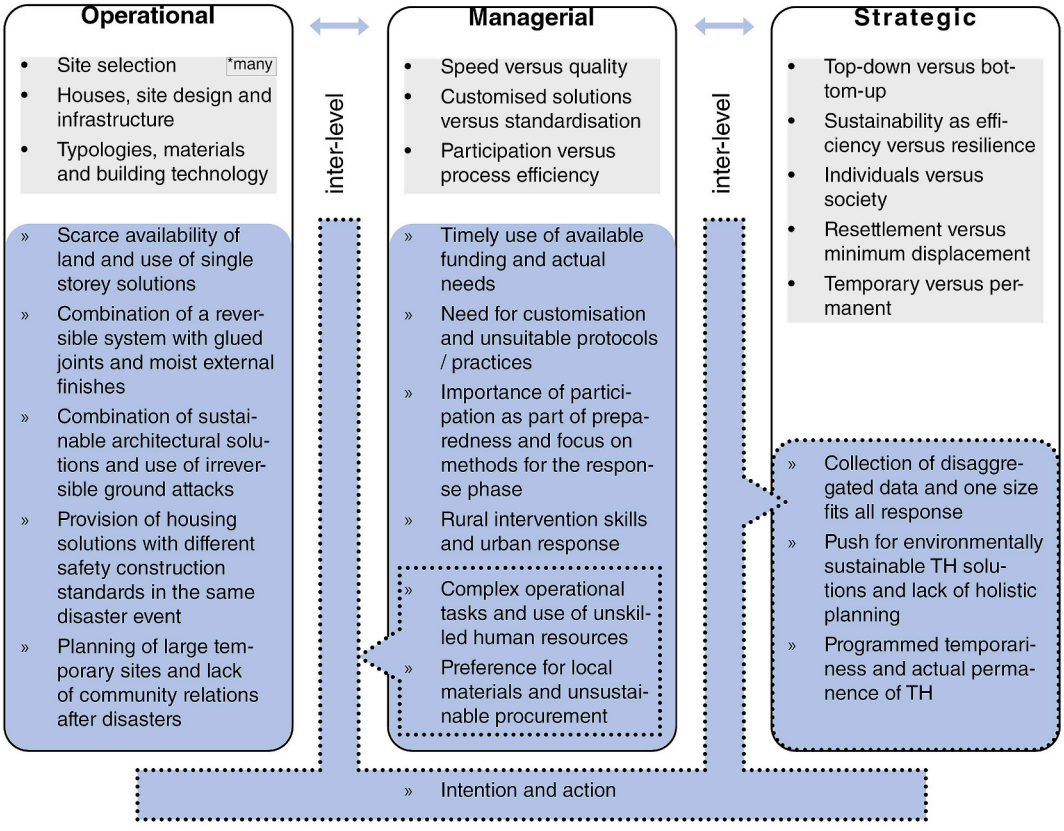

Fig. 2. Map of trade-offs (grey, top) and contradictions (light blue, bottom) found in the review. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

what confirms the claim of Spokane et al. [144], that cross-disciplinary expertise is needed to reduce post-disaster housing vulnerabilities of individuals and communities. The fact that the literature on TH is populated by a multiplicity of points of views, each taking in relatively low consideration the others, affects decision-making in a negative way. For instance, Yang et al. [145] report that geological disasters and vegetation density have not been used together for assessing the suitability of TH sites simply "because of different research backgrounds". Additionally, this paper shows that existing knowledge is not sufficiently exploited by decision-makers for the following reasons: lack of human resources and training, reliance on unsuitable protocols, time and money pressure, or simply because they are unaware of, or unable to, search though the plethora of available information. Indeed, it was the fragmentation of the TH literature [26], which in the first place, suggested the opportunity of its systematic analysis, to reorganise interdisciplinary knowledge in the area of decision-making. Other reviews on TH have not previously undergone a similar process because they were mainly focused on just one decision-making level, namely the operational, and concerned with specific decision-making tasks such as TH design and planning; what represents a missed opportunity for broader lessons learning and conflicts' resolution.

Even if at an aggregate level, this review shows the variability of decision-making challenges and dichotomies based on contextual factors. These factors can cause conflicts over TH-related decisions between experts and local people [49], because citizens are prone to contextual cognitive biases when evaluating risk and acting upon it (e.g. the availability heuristic) [146]. Nonetheless, the gaps that contribute to separate the real utility of TH (value effectively delivered by professionals operating in humanitarian contexts) from its expected value (needs and expectations of affected people) should be mapped in an organised manner and then closed. This may involve mapping decisions and organisational structures in different case studies, possibly starting from existing documental evidence, using a standard notation system (e.g. BPMN) to identify bottleneck activities, misalignments of decisions and overlapping roles; what would enhance accountability, process transparency and reproducibility, besides enabling the assessment of participatory processes and the extraction of common decision-making patterns. Business process mapping methods, as well as other tools developed for the industry, may however need to be adapted to better reflect the values and performance objectives of humanitarian housing programs [147], starting from an in-depth examination of decision-making dichotomies. Additional research is nonetheless needed to analyse more in detail decision-making dynamics in specific contexts and develop novel tools and methods suitable to inform truly evidence-based decisions. Field research will need to consider risks of research fatigue in certain population groups and overcome methodological challenges in studies addressing underrepresented minorities (e.g. disabled, minor ethnic groups, old people etc.). To tackle these issues researchers could resort to co-operation with humanitarian actors, local governments and news agencies, and to the use of storytelling and narrative analysis [148] in addition or in alternative to statistic assessments, which seem complicated because of the different ways in which these different organisations measure, obtain and record information. Narratives could be particularly relevant to assess the alignment of participatory processes across all decision-making levels and can be judged according to the soundness of their arguments via knowledge engineering methods, which could be also exploited to examine the contradictory certainties that characterise different domains of expertise.

6. Conclusion

This research has surveyed and deconstructed the existing body of knowledge to grasp common decision-making issues in post-disaster housing assistance programs across disparate disciplines. Using a simple tripartite framework to group decision-making challenges and dichotomies it was possible to grasp cross-scale dependencies amid strategic, managerial, and operational choices. In this way it was possible to prove the hypothesis that decision-making contradictions are generated by a misalignment of decisions made at these three different levels. The identified challenges and dichotomies are not necessarily applicable to all contexts and may be relevant only under specific circumstances. Additionally, the list is not exhaustive and does not differentiate between disaster types and specific housing approaches, solutions, and countries. Nonetheless, this review allowed to establish common grounds in a critical research area and conclude that:

- Existing knowledge could be better exploited through analysis of post-disaster decision-making.
- Interdisciplinary and transdisciplinary decision-making is essential to address dichotomies.
- A constructive alignment of decisions made at the strategic, managerial and operation levels is needed to enable BBB.
- An in-depth examination of decision-making trade-offs, dilemmas and contradictions is the next step towards developing new methods and tools to support and address BBB.
- These tools and methods should be responsive to contextual needs and local dynamics.

In relation to the latter point, promising ways forward to be validated in future research were identified at the three analysed decision-making levels:

- Operational: exploit methods such as Axiomatic Design or TRIZ to deal respectively with trade-offs and contradictions and adopt a data-driven approach exploiting machine learning capacities to deal with multiple dimensions following people-centred performance criteria.
- Managerial: use comparative studies of housing management practices and scenario testing to identify and tackle likely contradictions in advance, make a tailored use of available DSS tools and exploit graph analysis methods to tackle resilience in collaboration networks.
- Strategic: exploit/adapt industry-standard methods such as BPMN to map inter-level decision-making gaps, analyse narratives with knowledge engineering methods and make use of participatory processes to produce strategic guidelines tailored to both end-users and contexts.

Ultimately, this review uncovered the existence of a decision-making gap, which manifests itself at all the three analysed decision-making levels, through the many decision-making challenges and dichotomies often left unaddressed in post-disaster housing recovery planning, in developing and developed countries alike. The contemporary connectedness, information decentralisation and the possibility to access an increasing amount of computational power offer a unique opportunity to advance knowledge of the mechanisms that drive related decision-making and to support deliberation. Yet, to foster more holistic practices, a better understanding of how decision-makers operate in different disaster contexts is needed, which will require a critical mass of targeted empirical research (e.g. direct observation, human interaction, and systematic documentation). Decision-making challenges and dichotomies need to be better documented and analysed and potentially will then yield the discovery of patterns at different decision-making levels, which can then suggest further methods and/or tools to be used. To this end, academic research resorting to interdisciplinarity and cross-sector collaboration could provide a much-needed support to experts and decision-makers in the shelter community operating under high cognitive stress. Future research may build on the theoretical outputs of this study to assess the weight of the links amid decision-making challenges and dichotomies reported in the literature. Additional research could also attempt testing in real-life scenarios the viability of the identified decision support methods as tools to orient

critical decisions and explore more in detail how data/information are managed and mined across the three decision-making levels in practice.

Declaration of competing interest

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Annexes.

Annex 1
Abbreviation table.

Abbreviation	Extended Version
BBB	Build Back Better
NGO	Non-Governmental organisation
TH	Temporary Housing
BIM	Building Information Modelling
DSS	Decision Support System
LCA	Life-Cycle Analysis
CAD	Computer Aided Design
KPI	Key Performance Indicator
GIS	Geographic Information System
BPMN	Building Process Modelling Notation
UN	United Nations

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