From Knowledge to Action: A Grounded Theory Framework for Design for Emergencies

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Abstract
Contemporary societies face increasing climate, health, and humanitarian emergencies demanding rapid coordinated responses. Design plays a crucial role in immediate response, prevention and reconstruction. Yet, designers lack shared operational frameworks to translate resilience principles into practice.
This study adopts a constructivist Grounded Theory approach to model how scientific knowledge and local know-how become coordinated action. Through open, axial, and selective coding plus comparative memos, we derive a five-stage process model — Know–Communicate–Decide–Act–Learn (K–C–D–A–L) — and a communication pipeline — Visibility–Comprehension–Action (V–C–A) — linking information architecture, validated symbols, and executable procedures under degraded conditions.
Findings highlight the centrality of validated information design, coordinated governance, and adaptable technological and logistical solutions in accelerating decision-making and sustaining service continuity under disruption.
Operational outputs — including a deployable canvas, symbol libraries, and offline-first kits — can enhance usability, inclusivity, and resilience. The contribution bridges theory and practice through an interdisciplinary framework, empowering designers and communities to act decisively in emergency contexts.

Keywords
Design for emergencies
Disasters
Grounded theory
Information design
Crisis governance

Introduction

Climate, health, and humanitarian emergencies increasingly challenge contemporary societies, demanding rapid, coordinated, and interdisciplinary responses. Climate change has amplified the frequency and intensity of socio-natural disasters, while armed conflicts and global health crises continue to devastate communities and territories (Ripple et al., 2022). Within this context, design — across its disciplinary spectrum, from construction sciences to urban planning, from product design to communication design, and including logistics — plays a crucial role not only in immediate response but also in the phases of prevention and reconstruction (Charlesworth & Fien, 2022; United Nations Office for Disaster Risk Reduction [UNDRR], 2015; van Manen et al., 2023). Recent research highlights the need for interdisciplinary design methodologies able to integrate diverse competencies and strategies to address the three critical stages of emergencies: preparedness, management, and reconstruction (Hay, 2016, 2020; Bertin, 2018). Although concepts such as Disaster Risk Reduction, Disaster Prevention Design, and urban and social resilience are now well established, designers still lack shared guidelines and operational frameworks to translate these principles into effective practice (Twomlow et al., 2022).

To respond to this gap, this study adopts Grounded Theory as a methodological framework. Unlike approaches that test pre-existing theories, Grounded Theory constructs theory directly from empirical data (Glaser & Strauss, 1967). Its iterative process — comprising simultaneous data collection and analysis, open, axial, and selective coding, theoretical sampling, saturation, and the use of theoretical memos — makes it particularly suited to capturing the practices, experiences, and design strategies that emerge in emergency contexts (Charmaz, 2014). Applied to the field of Design for Emergencies, Grounded Theory offers two main advantages. First, it enables the development of theoretical frameworks that remain closely connected to the actual conditions in which emergencies unfold, grounding knowledge in lived practices and case studies. Second, it supports the construction of an interdisciplinary framework that, informed by empirical data, can guide designers in formulating strategies and guidelines for prevention, management, and reconstruction. In this way, the study contributes to bridging the gap between abstract theory and applied design practice, aiming to provide a shared operational knowledge base that can strengthen resilience and empower communities facing contemporary crises.

This work is part of the research project conducted at Università Iuav di Venezia, *Design and Emergency. Interdisciplinary design methods for prevention, management, and reconstruction in emergency situations*. The project's main objective is to build an interdisciplinary framework for design in emergency contexts, aimed at integrating knowledge and practices from different disciplinary fields to support prevention, management, and reconstruction. Within this framework, the present study contributes to the development of conceptual and operational tools that can be adopted by designers, researchers, and practitioners from different design disciplines in crisis settings. For clarity, we adopt the definition of 'emergency' as a sudden and extraordinary condition that severely disrupts the social, environmental, or health balance of a given context, generating immediate risks to life, health, property, and infrastructure. The term ‘emergency’ is often used interchangeably with ‘disaster’, defined as “a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts” (UNDRR, 2017). An emergency, or a disaster, requires urgent, coordinated, and timely action, and it differs from other crisis situations because of its unpredictability, rapid onset, and high level of decision-making uncertainty, as highlighted by the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015). A broader definition may also be considered: both an unforeseen circumstance requiring rapid response and an act of emerging that reshapes priorities. This dual reading implies two design tracks — protocols and operational supports for immediate action, and tools for sensemaking, learning, and longer-term reconfiguration (Piscitelli, 2019, pp. 24–25).

Method

This study adopts a constructivist Grounded Theory (GT) approach to explain how Design for Emergencies translates scientific knowledge and local experience into coordinated action.

We adopt GT given the lack of codified, structured academic legitimation for emergency design, especially in Italy (Piscitelli, 2019, pp. 20–21). An inductive, data-grounded approach allows categories and theory to emerge from practice, creating testable foundations for standards and curricula.

GT is well suited to contexts in which processes are emergent, multi-actor, and contingent (Glaser & Strauss, 1967; Charmaz, 2014). Rather than testing prespecified hypotheses, we iteratively generate theory from data while maintaining a close link to practice — an orientation consistent with design research’s emphasis on usefulness and fit (Leedy & Ormrod, 2019, pp. 2–3).

We assume knowledge is co-constructed among practitioners, communities, and researchers. Following Charmaz (2014), categories are not ‘discovered’ as fixed entities but built through comparative analysis, memoing, and negotiation of meanings. This stance is compatible with the normative and interventionist nature of design, in which the aim is to improve decision quality under uncertainty, not merely to describe phenomena.

The study theorizes how Design for Emergencies is conceived, implemented, and perceived across climatic, geological, and humanitarian settings, with the goal of improving decision quality under uncertainty. By Design for Emergencies, we refer to an interdisciplinary set of design practices — spanning product, communication, architectural, urban, and logistical domains — dedicated to conceiving and developing artefacts, systems, plans, and processes that are tangible, adaptable, and contextually responsive. These practices support individuals, communities, and institutions in conditions of risk or crisis, operating across all phases of prevention, preparedness, response, and recovery. Design for Emergencies ensures usability, safety, resilience, and inclusivity and, by mediating between humans, technologies, spaces, and sociocultural contexts, aims to contribute to both immediate protection and long-term adaptive capacity Fig. 1.

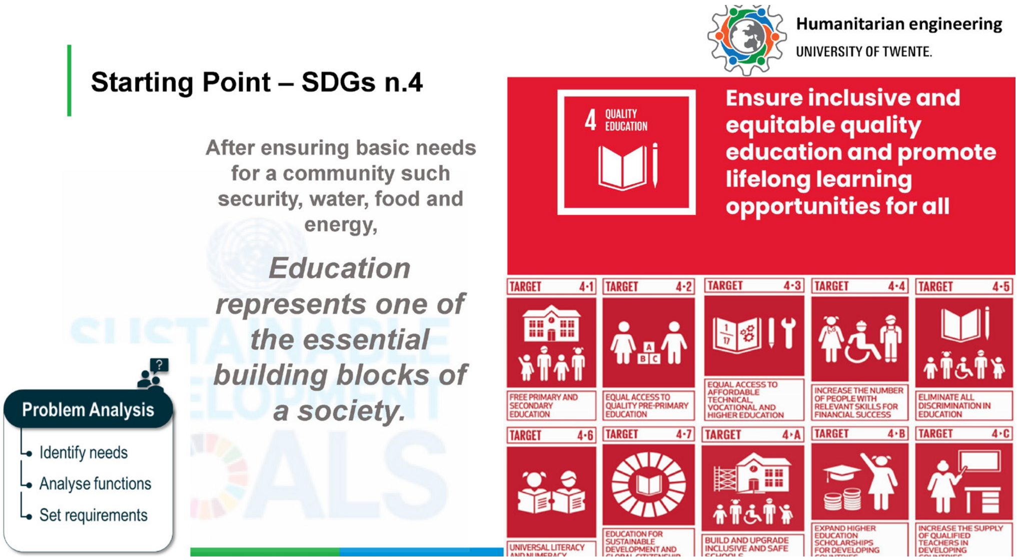

Fig. 1
Ensure inclusive education (Source: Alberto Martinetti's video presentation, Università Iuav di Venezia).

The project proceeds through classic GT phases — open, axial, and selective coding — while integrating operational tools typical of design inquiry. In this perspective, each coding phase is interpreted not only as an analytic step but also as an opportunity to generate actionable insights for design.

- Open coding: line-by-line analysis used to surface actions, constraints, and consequences in talks, symposium discussions, and expert interviews.
- Axial coding: clustering codes around causal conditions, context, influencing factors, actions, and outcomes (Corbin & Strauss, 2015, pp. 123–142).
- Selective coding: integrating all categories into one core process explaining differences across risks and contexts.

Constant comparison throughout guided the analysis of data from different sources and cases, while analytic memos tracked how categories developed, explored alternative explanations, and highlighted design implications (Charmaz, 2014; Birks & Mills, 2015).

The entire analysis was organized as a structured workflow that included preparation, coding cycles, memoing, category building, and integration.

- Preparation: Verbatim transcripts were generated using Adobe Premiere and Vizard.ai, subsequently verified through manual review, standardized with the assistance of ChatGPT (GPT-5), anonymized where necessary, and segmented into action–context–outcome units.

- Coding cycles: early data were coded by two researchers to align code use; later data were coded by one lead analyst, with occasional checks to ensure consistency. During coding, ChatGPT (GPT-5) was occasionally used as an auxiliary tool to support language refinement and consistency checks. Interpretive coding decisions remained the responsibility of the research team.
- Memoing: structured memos recorded emerging ideas, their limits, and possible design actions.
- Category building: codes were grouped into eight cross-cutting categories (knowledge, communication, governance, technology, territory, society, forecasting, and ethics).
- Integration: findings were combined into a core process model (K–C–D–A–L; see Section 3) and translated into a canvas with roles, constraints, and key performance indicators (KPIs).

Building on the analysis, a dedicated canvas was prepared, configured, and iteratively refined to translate findings into practice. It serves two purposes: it externalizes the emerging theory as actionable modules and operates as a site for further validation. Artefacts such as symbol libraries, protocol posters, and evacuation-map minima can be used to test the 'work' of the theory under realistic constraints, in line with practical research's emphasis on feasibility, clarity, and application (Leedy & Ormrod, 2019, pp. 46–50).

We addressed GT quality through four criteria adapted to design research: credibility, dependability, transferability, and confirmability.

- Credibility was pursued via triangulation across different types of data, examination of cases that did not fit the pattern, and checking interpretations with participants when possible (Charmaz, 2014).
- Dependability was supported by keeping a record linking data to codes, categories, ideas, and case studies, along with versioned memos.
- Transferability was supported by providing descriptions of context and constraints and by explicitly stating boundary conditions, including dual-use risks — where tools or information may be appropriated for unintended or harmful purposes — and digital vulnerabilities, such as dependence on unstable infrastructures, connectivity loss, or system failures in disrupted environments.
- Confirmability was supported by recording decisions with reasons and by checking alternative explanations.

Where appropriate, we proposed indicative validation targets (e.g., symbol meaning ≥ 85% correct, comprehension ≤ 5 s; see Metrics section) to link categories to measurable performance. These thresholds are hypothetical and require empirical validation, consistent with design's evaluative logic and the planning–validation cycle (Leedy & Ormrod, 2019, pp. 141–147). Theoretical saturation was claimed when new materials reiterated existing categories without altering their relationships and when propositions stabilized into a coherent explanatory set (Glaser & Strauss, 1967; Charmaz, 2014). Additional sampling would have yielded diminishing returns relative to project timelines and the need to translate insights into practical guidance.

Because emergency contexts are sensitive, the canvas explicitly requires limiting identifiable details, representing participants respectfully, and clearly reporting uncertainty and trade-offs. The canvas embeds ethical safeguards (e.g., inclusive communication and cultural translation) to avoid harm through misleading or unusable artefacts.

Methodologically, the study demonstrates how constructivist GT can be fused with design operationalization, moving from category to capability. Overall, it produces a process model and a set of propositions linking design, governance, and technology choices to decision speed, protocol compliance, and service continuity across different hazards.

To ground and refine these outputs, the corpus comprised symposium materials and semi-structured practitioner interviews.

The symposium (Università Iuav di Venezia, 2025; Buffagni et al., in press) comprised two sub-sessions with a roster of 12 speakers (6 per session), including municipal emergency managers, volunteer coordinators, and design researchers. The program alternated 30-minute keynote lectures with 15–20 minutes presentations by each speaker. When recording was permitted, audio was captured; otherwise, data collection relied on field notes and slide images. All materials were coded at the level of individual utterances or slide units. The symposium also included two post-presentation Q&A panels that brought together practitioners and students for approximately 25–35 minutes each. Questions explored, for example, how well symbols are understood, how messages work in different languages, what happens when devices fail, and how people are trained. While audience questions were treated as contextual cues, expert responses served as the primary analytic units.

Semi-structured practitioner interviews (n=10), conducted remotely and lasting 45–60 minutes, provided procedural depth. Profiles spanned information designers, curators, urban planners, product designers, architects, teachers, and related practitioners.

The mix of formats was intentional: broadcast narratives (talks), real-time stress tests of ideas (Q&A), collaborative problem framing (sub-groups), and deep procedural detail (interviews).

Topics covered symbol validation protocols, evacuation-map constraints, governance ‘red lines’, KPI selection, and anecdotal accounts of risk situations and the role of design in them. Early coding indicated gaps in symbol validation, offline-first communication, inter-agency coordination, and interaction with communities and local contexts; subsequent sampling targeted those gaps to densify categories (Bryant & Charmaz, 2007). Theoretical sampling followed the 'fit' and 'work' criteria, adding new data only when it clearly improved explanation and practical utility.

Across all sources, consent and anonymization were applied as required. The research was approved by the Ethical Committee of Università Iuav di Venezia.

Results

The development of the K–C–D–A–L model followed a constructivist Grounded Theory approach, making explicit the analytical transition from empirical data to theoretical abstraction.

During open coding, recurrent concepts were identified across interviews and discussions, including empathy and humility, cultural adaptability, multidisciplinary collaboration, technological mediation, and the role of communication and information design.

Through axial coding, these concepts were progressively related and grouped into higher-level categories, such as design processes, communication as mediation, required competencies, and social impact.

Finally, selective coding enabled the integration of these categories into a coherent processual structure describing how knowledge is transformed into coordinated action in emergency contexts. This integrative step led to the articulation of the K–C–D–A–L model as a sequence of interdependent phases — Know, Communicate, Decide, Act, Learn — reflecting the dynamic and adaptive nature of design practices under conditions of uncertainty.

In this sense, while regulatory frameworks (e.g., ISO, UNDRR, and NIMS) informed the operational context, the K–C–D–A–L model emerged inductively from Grounded Theory coding and was subsequently articulated as a design-oriented framework to support action under emergency conditions.

The transition from axial categories to the K–C–D–A–L model can be traced by examining how higher-level categories identified during analysis were progressively reorganized into a processual structure.

The category 'Design Processes' — capturing the tension between immediate response and long-term adaptation — directly informs the overall structure of the model, spanning from Know (understanding context) to Act (implementation) and Learn (feedback and adaptation).

The category 'Role of Communication', which emerged as central to mediation across stakeholders and contexts, is primarily articulated in the Communicate phase but also operates transversally by enabling transitions between knowing, deciding, and acting.

The category 'Training and Competencies' contributes to both Decide and Act, reflecting the role of expertise, judgment, and situated knowledge in translating information into actionable strategies under conditions of uncertainty.

Finally, the category 'Social Impact', related to resilience and community building, is consolidated in the Learn phase, where outcomes are evaluated and reintegrated into future cycles of action.

The core category conceptualizes Design for Emergencies as a situated, adaptive system that translates scientific and local knowledge into safe action through information design and coordinated governance under conditions of ongoing disruption. Through selective coding, these interrelated categories were integrated into a cyclical and adaptive process model, resulting in the K–C–D–A–L structure.

A ‘Know’ integrates multi-source risk analysis with local knowledge, lived experience, and participatory activities (e.g., engagement with communities, participatory co-design activities) to create a shared understanding of the situation.

B ‘Communicate’ advances this picture through a V–C–A (Visibility–Comprehension–Action) pipeline. The V–C–A pipeline frames emergency communication as a behavior-oriented sequence. Within this pipeline, ‘Visibility’ requires a clear information architecture, legible visual hierarchies, appropriate color selection, and multi-channel redundancy, with mobile-first delivery and offline fallbacks to preserve reach and accessibility (ISO 7010:2019; Grodzicka et al., 2023). ‘Comprehension’ relies on validated graphic elements and structures and plain-language, layered messaging, supported by standardized comprehension testing protocols to ensure consistent interpretation across diverse audiences (ISO 9186-1:2014; ANSI Z535.3-2022; Mayer, 2009). ‘Action’, in turn, links messages to affordances and procedures, using constraints and feedback to support safe execution under time pressure and infrastructure constraints (Norman, 2013; Wogalter, Conzola, & Smith-Jackson, 2002; Zannoni, 2024, pp. 32–39).

C ‘Decide’ formalizes roles, thresholds, and explicit trade-offs, aligning incentives so that decisions can be made rapidly and implemented consistently.

D ‘Act’ deploys both low- and high-tech prototypes, prioritizing rapid reconfiguration and defaulting to off-grid solutions to ensure service continuity during infrastructure failure.

E ‘Learn’ closes the loop through field testing, audits, and systematic versioning, while also involving participatory activities — such as co-design, evaluation, and refinement — to improve visual communication, protocols, and tools.

Major findings

Emergencies behave as a structural, networked condition rather than isolated events. Effective strategy pairs backcasting with forecasting to handle both fast shocks and slow drift, the *bradisismo* of design (slow, cumulative shifts in risk and constraints) Fig. 2, where risk accumulates incrementally. Information design proves decisive: validated iconography and disciplined microtypography increase comprehension and speed; when geography adds little, charts on small screens can substitute for maps; a narrative layer over graphics improves recall.

We therefore formulated the following operational propositions. The adoption of solutions improves markedly when initiatives invest in soft skills, engage in co-design with users, and rely on empirical validation rather than static guidelines. Communication becomes more effective when symbols meet widely accepted comprehension thresholds — ≥ 85% according to ANSI Z535.3 or ≥ 67% according to ISO 9186 — within five seconds, while offline redundancy ensures that coverage is preserved even under

Fig. 2
Bradisismo of design (Source: Daniela Piscitelli's video presentation at Università Iuav di Venezia).

Fig. 3
Infectious disease unit — Uganda (Source: Michele Di Marco's video presentation at Università Iuav di Venezia).

degraded or absent network conditions. Delays in cross-agency activation decrease when governance is coordinated and shared semantics enable consistent interpretation across organizations. In resource-constrained contexts, solutions that prioritize maintainability and leverage local supply chains consistently outperform designs optimized solely for theoretical efficiency. Over time, strategic spatial repositioning and the development of self-sufficient districts prove more effective at mitigating recurrent losses than restorative rebuilding in exposed sites, highlighting the value of proactive, anticipatory planning.

The operational deliverables form a cohesive set of tools and procedures that are immediately deployable. A deployable canvas integrates the V–C–A model with defined roles, non-negotiable red lines, and key performance indicators, supporting accountable and traceable decision-making. A standardized system for symbol validation is proposed, defining how symbols and graphic elements are tested against explicit acceptance thresholds to ensure consistent interpretation across audiences and channels. Complementing this, an offline-first implementation framework provides guidelines for designing modular signage, '1–2–3 protocol' posters, and minimum-layer evacuation maps, alongside a planned cache-first progressive web application intended to maintain functionality under limited connectivity.

A validation protocol prescribes tests for meaning, comprehension timing, and in situ walkthroughs, verifying usability and decision-making speed in realistic conditions. Execution is further supported by matrices and checklists that cross-tabulate red lines by department, define maintainability criteria, map stakeholder incentives, and structure a backcasting timeline. Together, these elements form an integrated operational framework that balances clarity, resilience, and responsiveness, ensuring that both people and systems are prepared to act effectively in complex, high-stakes scenarios.

Metrics

To move on from explanation to performance, the GT-derived process model was instrumented with metrics that enable falsification, benchmarking, and refinement. These metrics turn the V–C–A pipeline and the K–C–D–A–L process model into falsifiable specifications and support acceptance thresholds and cross-case benchmarking by applying identical KPIs across deployments to compare performance and guide model refinement (ISO, 2018; Sauro & Lewis, 2016; Tullis & Albert, 2022, p. 302).

To operationalize this evaluation framework, a set of specific indicators — meaning index, time to decision, protocol adherence, D+7 recall, MTBF, MTTR, alert coverage, inter-agency latency, cultural acceptability, and clinical throughput — was selected to measure the effectiveness of communication, the speed of decision-making, and the resilience of technical solutions.

The 'meaning index' quantifies the share of users who correctly interpret a symbol or message (ANSI, 2022; Arcia et al., 2019; ISO, 2014). Example: 92% correctly identify the "assembly point" symbol. 'Comprehension time' captures the seconds from exposure to understanding the required action; it indexes cognitive efficiency in context (Mayer, 2009). Example: an evacuation poster is understood in ≤ 5 s.

'Time to decision measures the interval from information exposure to a behavioural choice, linking comprehension to action (Tullis & Albert, 2022, pp. 82–89). Example: 18 s from alarm to start of evacuation.

'Protocol adherence' is the percentage of users completing all steps correctly; operational error rate captures critical mistakes (Wogalter et al., 2002). Example: 85% complete the 1–2–3 sequence without error; 6% choose the wrong route despite signage.

'D+7 recall' — the percentage of key content correctly recalled seven days after training or initial exposure — estimates durability of training by testing retention after a one-week delay (Roediger & Karpicke, 2006). Example: 70% remember assembly-point locations after seven days.

'Mean time between failures' (MTBF) is the expected operating time between consecutive failures, computed as total uptime divided by the number of failures; it is a proxy for reliability.

'Mean time to repair' (MTTR) is the average elapsed time needed to restore full function from fault detection, including diagnosis, parts replacement, and verification; it is a proxy for maintainability. Together, MTBF and MTTR quantify the reliability and maintainability of field artefacts and support lifecycle planning and spare-kit sizing (Chukwuemeka, 2024, pp. 8, 35; O'Connor & Kleyner, 2012). Example: signage kit MTBF ≈ 18 months; MTTR ≈ 30 minutes.

'Alert coverage' is the share of the target population reached by warnings across channels (ISO, 2015; International Telecommunication Union [ITU], 2014). Example: 92% receive WEA/CAP or siren.

'Inter-agency latency' measures elapsed time for incident information to propagate between organizations (ISO, 2018; Terentieva et al., 2021; U.S. Department of Homeland Security, 2017). Example: 4 minutes from civil protection to local authorities.

'Cultural acceptability' assesses cross-group acceptance of symbols and solutions (Arcia et al., 2019; Ferreira & Venturelli, 2022; ISO, 2014, 2019a).

'Clinical throughput' tracks patients treated per time unit under surge (Asplin et al., 2003).

Together, these metrics enable targeted iteration and transparent trade-offs; current limits include an expert-heavy corpus and limited longitudinal embedding, with several propositions still pending causal tests in live deployments.

To situate the GT-derived model within existing design frameworks, we compared it with the user-centred design (UCD) cycle proposed by Twomlow et al. (2022). Tab. I shows the correspondences between the five stages of the K–C–D–A–L process, the V–C–A communication pipeline, and the Define–Design–Refine phases of the UCD framework. This comparison highlights how the operational outputs (canvas, symbol and graphic-elements guidelines, and offline-first kits) can be read as tangible instantiations of a broader UCD process, while the GT-derived metrics provide falsifiable specifications to strengthen iterative evaluation.

In this mapping, Define aligns with Know–Communicate (shared situation picture, symbol and graphic-element validation), Design parallels Communicate–Decide (iterative tests of hierarchies, redundancy, and procedural affordances), and Refine mirrors Act–Learn (behavioural uptake, emotional responses, and long-term retention). Methods indicated by Twomlow et al. (2022) — ethnographies, stakeholder mapping, focus groups, and serious games — support this integration and address heterogeneous profiles and Type 1/Type 2 processing. Metrics such as comprehension thresholds, time to decision, and recall durability then plug into UCD evaluation practices, moving from expert judgment to observed user behaviour; likewise, the operational outputs — deployable canvas, curated symbol libraries, and offline-first kits — serve as tangible instantiations of the integrated cycle under degraded conditions.

Tab. I
Mapping between the GT-derived process model (K–C–D–A–L and V–C–A) and the UCD framework (Twomlow et al., 2022).

GT-derived model	UCD framework (Twomlow et al., 2022)	Integration point
Know: multi-source risk analysis, shared situational picture, ethnographies	**Define:** contextual analysis, stakeholder mapping, user understanding, ethnographies	Builds a shared understanding of risks, context, and users
Communicate: information needs, validation; V–C–A pipeline, visual communication, layered messages, redundancy, participatory co-design	**Define / Design:** information framing; iterative prototyping, think-aloud tasks, surveys, participatory co-design	Frames and tests communication systems (visibility, comprehension, action) across users and channels
Decide: roles, red lines, explicit trade-offs	**Design (later iterations):** scenario testing, expert review	Structures decision protocols, thresholds, and consistent action under uncertainty
Act: deployment, offline-first tools, rapid reconfiguration	**Refine:** evaluation in real or simulated contexts	Operationalises and adapts tools and procedures in real conditions
Learn: field testing, audits, systematic versioning, participatory refinement	**Refine:** evaluation, user feedback, long-term monitoring	Feeds back improvements into communication, protocols, and tools

Discussion

This study demonstrates that Design for Emergencies functions as an adaptive, situated system capable of translating scientific and local knowledge into safe, coordinated action in complex and unpredictable emergency contexts. The application of constructivist Grounded Theory enabled the development of a practice-driven theoretical framework, resulting in an operational model that integrates prevention, management, and reconstruction while simultaneously considering technological, territorial, social, and organizational dimensions.

Findings indicate that emergencies should be conceptualized as structural, networked conditions rather than isolated events. Combining forecasting and backcasting proves essential to address both rapid shocks and slow-onset risks. Information design emerged as a critical lever: validated symbols, disciplined microtypography, and layered narratives enhance comprehension and decision speed, reducing errors and response times. Coordinated governance and shared semantics across agencies decrease activation delays and procedural fragmentation, while resilient technological and logistical solutions prioritize maintainability, local sourcing, and offline functionality. Territorial strategies that emphasize functional redistribution and self-sufficient districts are more effective in mitigating recurrent losses than restorative rebuilding in exposed sites. Social capital, continuous training, and volunteer empowerment constitute essential drivers of adoption, adaptation, and sustainability over time.

The K–C–D–A–L model (Know–Communicate–Decide–Act–Learn) and the V–C–A pipeline (Visibility–Comprehension–Action) provide operational tools for translating theoretical principles into actionable procedures. The integration of measurable metrics — including comprehension time, time to decision, protocol adherence, alert coverage, and MTBF/MTTR — enables validation, benchmarking, and iterative refinement, ensuring a direct link between analysis, decision-making, and field performance.

Methodologically, the study illustrates the compatibility between constructivist Grounded Theory and design research, showing how iterative coding, memoing, and empirical validation can produce operational knowledge capable of guiding concrete interventions in emergency contexts.

Beyond these methodological and empirical insights, the originality of this study lies in three main contributions. First, it proposes an empirically derived, process-based model (K–C–D–A–L), grounded in data rather than derived from existing standards. Second, it operationalizes communication through the V–C–A pipeline, explicitly linking perception, cognition, and behavior. Third, it translates these insights into deployable design artifacts and measurable metrics, thereby bridging the gap between design theory and emergency practice.

Unlike standard-driven approaches, which primarily define compliance criteria, this framework provides generative tools for design action under uncertainty, supporting designers and practitioners in adapting solutions to dynamic and resource-constrained contexts.

Several limitations should be acknowledged. The analyzed corpus is expert-centric, longitudinal embedding remains limited, and some propositions require further causal testing in real-world deployments. Generalizability is constrained by specific cultural and infrastructural contexts, necessitating adaptation for other geographic areas or emergency types. In conclusion, the Design for Emergencies framework can serve as a bridge between theory and practice, producing concrete tools and measurable metrics. The development of interdisciplinary frameworks, standardized protocols and symbols, and the integration of local and scientific knowledge are critical strategies for improving preparedness, safety, and resilience in contemporary crises. Future research should explore large-scale adoption, long-term effectiveness, and replicability across diverse contexts, thereby strengthening the empirical and operational foundation of Design for Emergencies.

Finally, the K–C–D–A–L model frames design as a creative and situated practice, turning emergencies into opportunities for

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practical and impactful solutions. It supports the development of context-specific responses — such as temporary structures, mobile classrooms, or information tools — tailored to local resources and user needs. It can be applied in scenarios involving rapid interventions, such as those illustrated by Di Marco's mobile educational units and Martinetti's container-based learning and production environments, where solutions are iteratively prototyped, tested, and refined on site. Unlike primarily administrative tools, the K–C–D–A–L model steers the design process from concept to real-world deployment, fostering iterations informed by field feedback. In this way, it serves as a generative platform that converts the uncertainty of emergencies into actionable, design-driven solutions.

Author Roles Acknowledgement

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