



Post-disaster recovery systems: A systematic review of the Wenchuan earthquake

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Abstract. Wenchuan earthquake is one of the most extensively studied large-scale disaster-recovery scenarios, providing a unique empirical basis for understanding the design, implementation, and sustainability of complex recovery systems. However, governance, infrastructural, social, economic, and environmental research is fragmented, limiting system-level knowledge of post-disaster recovery processes. Addressing this gap, a systematic analysis of 735 peer-reviewed articles from 2008 to 2025 aims to synthesize interdisciplinary evidence on post-disaster recovery. The PRISMA-guided assessment incorporates interdisciplinary insights into governance, infrastructure reconstruction, social recovery, livelihood regeneration, environmental restoration, and technology innovation. Institutional capabilities, resource mobilization, and risk circumstances alter recovery as a dynamic system-level transformation. Governance coordinates sectoral policymaking. Centrally coordinated systems, particularly the paired-assistance model and large-scale financing, enabled rapid and complete reconstruction in Wenchuan. The research also indicates coordination inefficiencies, uneven recovery outcomes, and policy goals that don't fit local realities. The review reveals that social and environmental variables affect long-term rehabilitation beyond physical recovery. Psychosocial rehabilitation, community cohesion, and livelihood stability take longer than infrastructure restoration and are seldom planned. Landslides and debris flows influenced recovery over time in dynamic hazard settings. To remedy such shortcomings, a governance-mediated post-disaster recovery paradigm, defined by enabling conditions and structural constraints, is proposed. The approach links policy tools to cross-domain recovery processes and emphasizes adaptive learning and long-term resilience to increase understanding. Future catastrophe recovery methods must combine rapid rebuilding with high-quality coordination, social inclusion, environmental risk management, and system resilience, as shown by the Wenchuan experience.

Keywords: Integrated recovery systems; post-disaster recovery; reconstruction governance; social resilience; Wenchuan earthquake;

1 Introduction

The 2008 Wenchuan earthquake is consistently characterized in the literature as a system-disrupting catastrophe that triggered large-scale recovery and reconstruction across Sichuan's mountainous regions and beyond. With a magnitude of



30 Ms 8.0, the event caused extensive physical destruction and widespread disruption to infrastructure, public services, and
regional economic systems (Wang et al., 2013). Evidence from heavily affected areas, including damage to health systems,
rapid mobilization, and large-scale displacement management, shaped early response priorities. Importantly, the effects
extended beyond physical impairment. Studies of transport interruptions and indirect economic losses reveal that recovery
pressures spread through regional systems, influencing economic functioning (Wang et al., 2013; Wei and Su, 2016). In
35 addition, the earthquake occurred in a complex mountainous embayment, where secondary hazards, including landslides and
debris flows, continued to impede recovery (Wang et al., 2022). Specifically, Wenchuan's multisectoral effects on
infrastructure repair, public services, livelihoods, environmental risk management in hilly terrain, and secondary hazards,
including landslides and debris flows, made it unique (Svirchev et al., 2011). Differences in rural and urban reconstruction
pathways further reveal how pre-existing socio-spatial inequalities shaped recovery experiences and long-term outcomes
40 (Chen et al., 2020; Li et al., 2024; Sun et al., 2010).

In the context of earthquakes, the Wenchuan disaster has been widely regarded as a global benchmark case, not only because
of the scale of destruction but also because of the intensity and structure of its policy-driven reconstruction program (Zhu
and Thanh, 2023). The recovery process was distinguished by centrally coordinated governance, large-scale resource
mobilization, and the institutionalization of interregional support through the paired-assistance mechanism, which linked
45 external jurisdictions with affected areas to facilitate the transfer of capacity, expertise, and financial resources (Xu et al.,
2018; Xu and Lu, 2013; Zhong and Lu, 2018). Evaluations approach partnered assistance as a governance tool whose
success and sustainability rely on how priorities are determined, and outcomes are reviewed (Zhang and Tao, 2018). Rapid
mobilization and large-scale reconstruction financing helped accelerate community reconstruction, supported by dedicated
financing arrangements and the ability to translate large investments into implementation capacity (Xiao et al., 2020).
50 Wenchuan is a particularly instructive case for disaster governance because it shows how centrally steered coordination,
interregional assistance, and large-scale resource mobilization can enable rapid resilience-building and provide a clear basis
for evaluating policy design choices, implementation pathways, and perceived recovery success.

The Wenchuan earthquake has generated a substantial body of research (Kabilijiang et al., 2024), but the final included
corpus shows that the database is widely fragmented across disciplines, making it impossible to draw coherent judgments
55 about the effectiveness of recovery systems. Governance-focused studies evaluate institutional architecture, command
structures, and policy tools, such as partner assistance, to assess implementation capability and recovery effectiveness.
Infrastructure-oriented study details transit interruptions, rebuilding strategies, and housing implementation challenges,
including varied urban–rural pathways that affect recovery outcomes. Social recovery research focuses on mental health
burdens, social capital, participation, and longer-term satisfaction, showing that psychosocial and social stability outcomes
60 take years and are not fully captured by physical rebuilding metrics. Economic and livelihood studies use quantitative
metrics to study resilience, recovery efficiency, reconstruction investment effects, and poverty or vulnerability dynamics,
rarely connecting them to governance mechanisms or community-level experiences. Finally, environmental and ecological
studies document the ongoing hazards of landslides, debris flows, and evolving terrain risk, and monitor and assess



restoration efforts, emphasizing that recovery occurs in persistent and changing risk landscapes. Identified cords provide substantial domain-specific information, but they also reveal a recurring gap: a lack of synthesis linking governance options to infrastructure delivery, community rebuilding, livelihood trajectories, and ecological risk management over time. Fragmentation, reconstruction/recovery as the major hub, psychosocial consequences, and geo-hazard/remote-sensing research as discrete communities reflect parallel growth rather than persistent integration across disciplines. Another systematic review is needed to reconcile partial insights, trace linkages across recovery dimensions, and better understand what enabled (and constrained) resilient recovery after the Wenchuan earthquake.

The current review summarizes and explains the final Wenchuan evidence base for post-disaster recovery policy and practice. Using the 735-study corpus, the review synthesizes 16 years of published research on governance arrangements, infrastructure rebuilding, community and psychosocial recovery, livelihood regeneration, and ecological risk management, which are often studied separately despite their practical interdependence. Second, it evaluates significant reconstruction models and policy tools, including the paired-assistance system and administrative procedures that organized interregional cooperation, resource transfer, and implementation capability in impacted areas. Third, the research shows that mobilization speed, investment volume, coordination quality, local legitimacy, and the ability to manage unequal socioeconomic outcomes and persistent environmental concerns throughout the rebuilding process affect recovery success. The Wenchuan case provides unusually rich evidence on how large recovery systems operate under real constraints, showing where centrally steered programs deliver reach and pace, where collaboration and implementation cause friction, and how governance design and assessment choices shape long-term outcomes rather than infrastructure completion alone. The review concludes with a unified post-disaster recovery framework that links policy instruments to infrastructure delivery, social rebuilding, livelihood stabilization, and ecological risk governance to help decision-makers prioritize competing recovery goals while maintaining resilience (Shao and Xu, 2017; Zhou et al., 2022).

2 Research Design and Method

This systematic review synthesizes and critically assesses peer-reviewed disaster recovery and rebuilding studies following the 2008 Wenchuan earthquake. The vastness, disciplinary variety, and fragmentation of the evidence base require a systematic and transparent methodological approach to ensure consistency, repeatability, and analytical rigor. The review identifies, filters, and selects relevant publications using PRISMA and specifies decision criteria. This method connects to major academic databases and filters material through deduplication, metadata validation, and relevance-based screening to ensure a comprehensive and reliable literature collection. The technique collects knowledge and enables cross-domain synthesis, examining governance, infrastructure, social recovery, economic regeneration, and environmental elements as interrelated components of the recovery system.

Figure 1 shows the structured search technique used to build this review's evidence base. The chart shows how core and topical search phrases were used to get Wenchuan earthquake papers from Web of Science and Scopus (2008–2025).



Governance and policy, infrastructure and engineering, social and community recovery, environmental and ecological restoration, and technological innovation were employed to refine the search beyond general “core studies” on recovery and reconstruction. Provided multi-layered keyword technique identified a comprehensive and diverse pool of research prior to PRISMA screening, ensuring broad coverage while preserving thematic specificity.

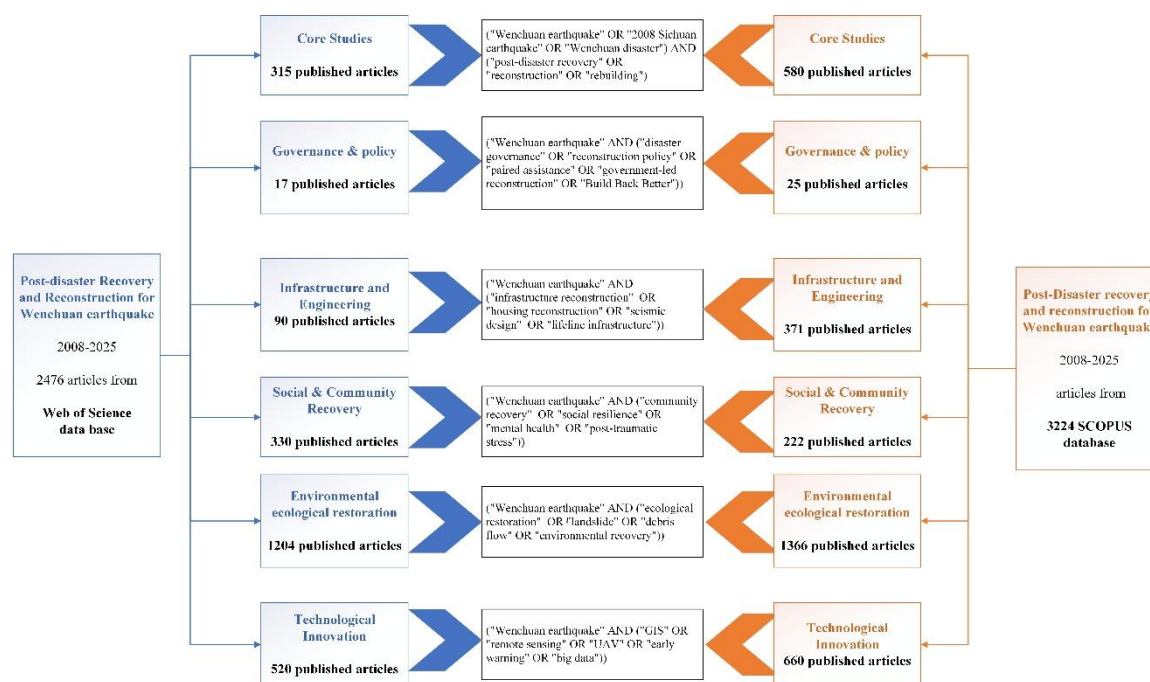


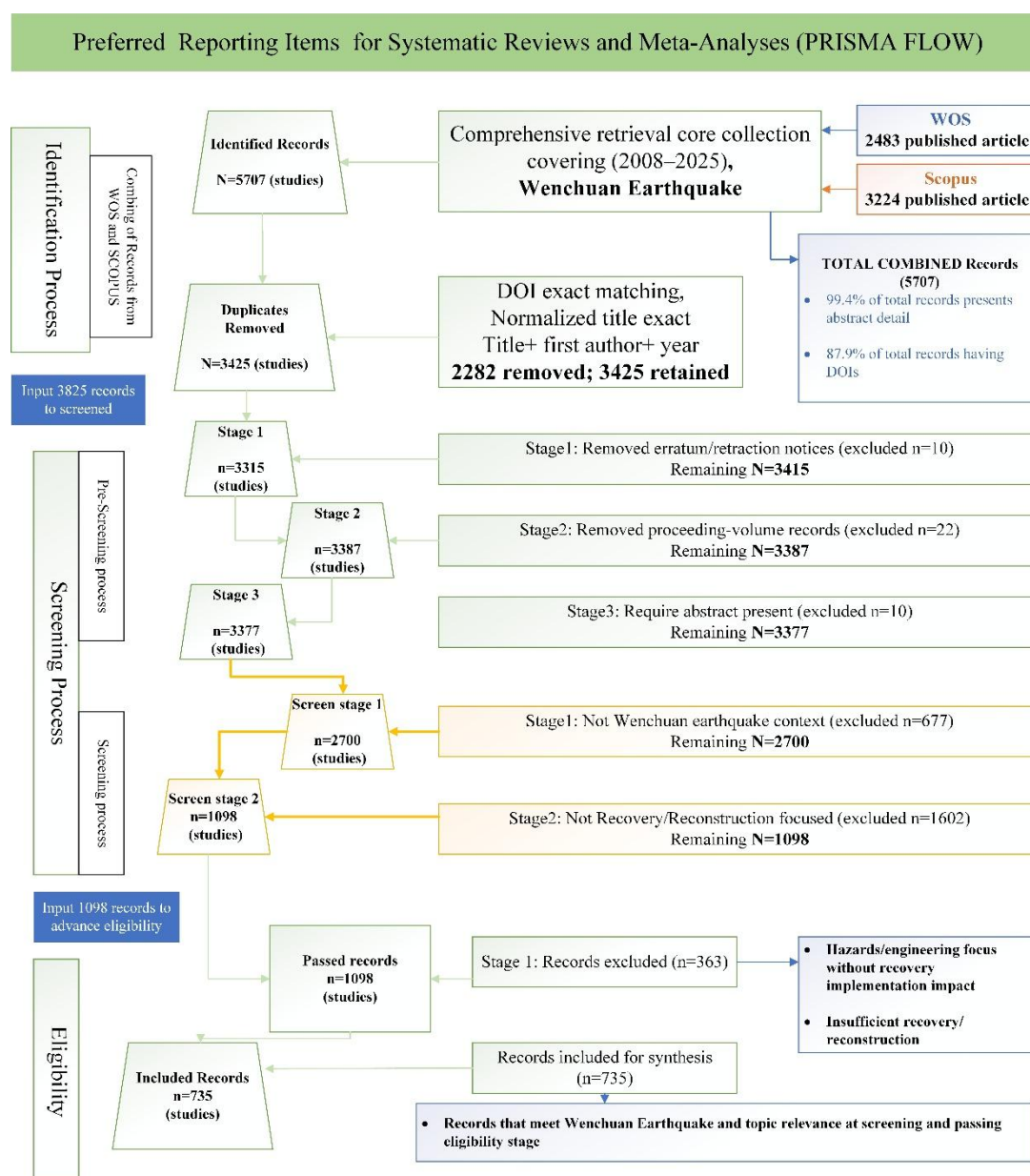
Figure 1: Thematic structuring of Wenchuan earthquake recovery literature from Web of Science and Scopus

2.1 PRISMA analysis:

The current systematic review organizes and critically evaluates peer-reviewed material on the 2008 Wenchuan earthquake recovery and reconstruction. To complete this review, the methodological workflow is reported using a PRISMA-style structure, which provides a standardized way to present the movement of records through each stage of the review process and to justify exclusions using explicit, consistent criteria (see Figure 2). The PRISMA process was divided into phases (identification-final) to produce the final dataset. During the identification phase, records were retrieved from WoS (n = 2,483) and Scopus (n = 3,224), yielding a total of 5,707 published articles. To prepare rich evidence, records from WOS and Scopus were merged into a single dataset to enable uniform handling of bibliographic metadata (e.g., titles, abstracts, keywords, document type, year, and DOI) across sources. In the second phase, the duplication detection process was applied, which relies on matching the DOI, publication time, and title. After a conservative fallback to duplicate detection, 2,260 entries were removed, and 3,418 unique records were retained. For final data preparation, metadata completeness was evaluated to support a reliable downstream screening. In the third phase, a pre-screening process was used to enhance the



integrity and interpretability of published data. The evidence base before topical screening: (i) erratum/retraction notices
115 were removed (excluded $n = 10$; remaining $N = 3,415$), (ii) proceeding-volume records were removed (excluded $n = 22$;
remaining $N = 3,387$), and (iii) records were required to have an abstract present to support consistent relevance judgments
at the title/abstract level (excluded $n = 10$; remaining $N = 3,377$). The pre-screened dataset constituted the final input set
advanced to formal screening.



120 **Figure 2:** Structured evidence filtering and eligibility assessment of post-disaster recovery literature: A PRISMA approach



Next, the screening process was performed sequentially and transparently. Out of 3377 articles, 677 records were excluded that did not match the Wenchuan earthquake context, leaving 2,741 records. Of 2741 papers, 1643 did not focus on post-disaster recovery and reconstruction, which were excluded. In the screening phase, 1098 articles remained, which were aligned with post-disaster recovery and reconstruction. In the final phase, eligibility was evaluated on 1098, with each record assessed for whether it contained sufficient evidence (at the abstract level in the exported file) to support inclusion in the synthesis, while excluding studies that were primarily hazard/engineering-focused, lacked recovery implementation or impact content, or had insufficient recovery/reconstruction relevance. The final dataset includes 735 studies that fulfilled Wenchuan-event relevance, recovery/reconstruction thematic relevance, and eligibility requirements (see Figure 2). Three hundred sixty-three records were deleted. Table 1 presents the topic distribution of the 735 papers in this evaluation, illustrating the structure of the evidence base. Infrastructure and governance studies dominate the literature, whereas economic, environmental, and technological studies are few. This distribution shows analytical strengths and areas for integration and research.

Table 1: Thematic Distribution of the Wenchuan Recovery Evidence Base (n = 735)

Domain	Description	No. of Studies	Key Focus
Governance & Policy	institutional design, coordination	175	paired assistance, command systems
Infrastructure	transport, housing	426	roads, relocation
Social Recovery	mental health, participation	98	PTSD, social capital
Economic Recovery	livelihoods, resilience	11	employment, SME
Environmental	hazards, restoration	21	landslides, GIS
Technology	GIS, RS, big data	3	monitoring, planning

2.2 PRISMA analysis:

Figure 3 presents the thematic organization of Wenchuan post-disaster recovery and rebuilding literature from the 735-record corpus is shown in Figure C. With 31 nodes and 111 linkages (density = 0.2387), it indicates moderate connectivity, suggesting thematic clustering rather than full integration. The keyword network is moderately linked, and most subjects co-occur with multiple others (average degree = 7.16). The modularity score (Q = 0.423) indicates that the literature is organized into multiple, related thematic groups rather than a single stream.

The “Wenchuan earthquake” node in the cluster “Wenchuan Earthquake / Post-Earthquake Reconstruction / Recovery” is the predominant hub. This pivotal position demonstrates how the event anchor integrates multiple lines of study and immediately addresses essential recovery themes, including post-earthquake rebuilding, sustainability, sustainable development, CRS, and ecological restoration. Most of the corpus views recovery as a long-term development and sustainability issue, not just rebuilding.

Two notable communities focus on psychosocial outcomes: “Earthquake/Mental Health / Natural Disaster” and “PTSD / Depression / Risk Factors”. Similar keywords “PTSD”, depression, anxiety, risk factors, prevalence, social support, quality of life, and demographic terms (e.g., adolescents, gender, longitudinal cohort), which indicate a mature stream that examines mental health burdens, determinants, and long-term well-being as recovery components. The “Landslide / Debris Flow / Remote Sensing” cluster represents environmental risk and monitoring in the third major pillar. Landslides, debris flows, rainfall, vegetation recovery, GIS, and remote sensing co-occur in mountainous, hazard-prone environments, highlighting secondary hazards and technology-enabled evaluation. Governance and rebuilding are the major hubs, complemented by strong psychological recovery and geo-hazard/environmental monitoring streams, giving the network a total link strength of 854.

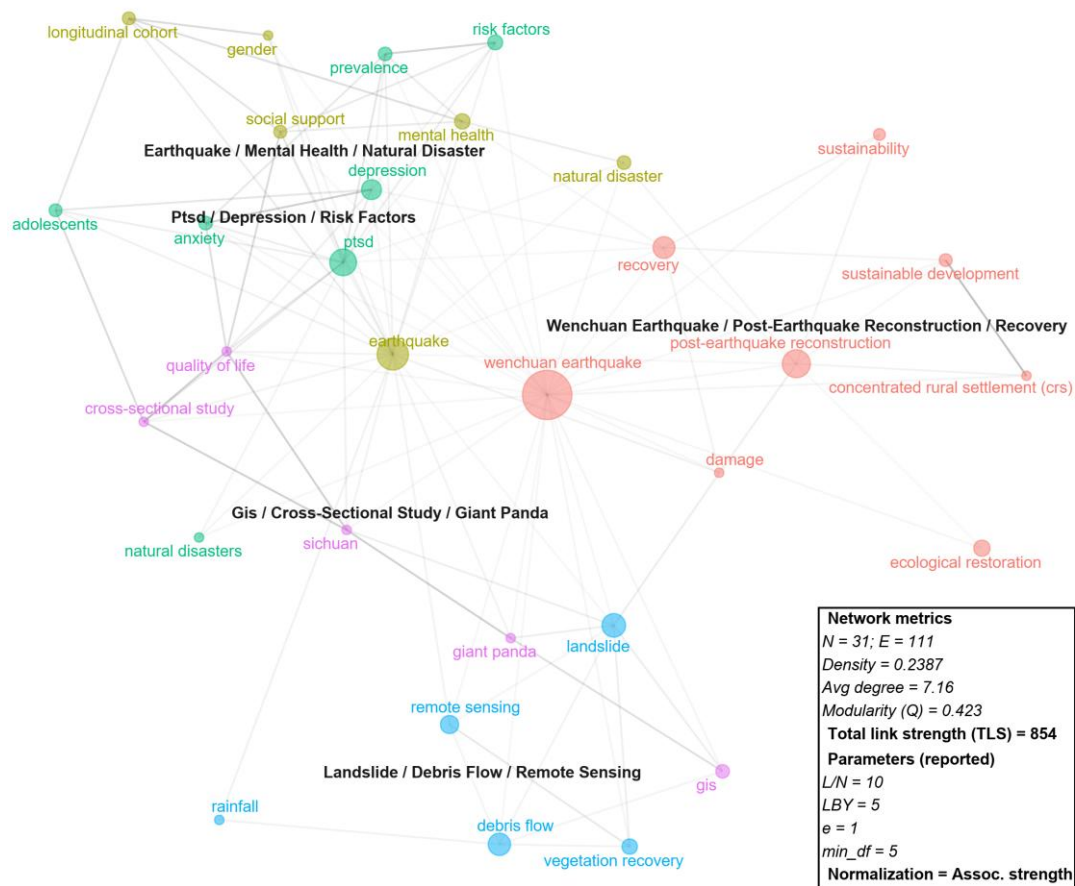


Figure 3: Co-occurrence network analysis of Wenchuan earthquake literature



3 Theoretical foundations of the Wenchuan earthquake:

Disaster Recovery & Reconstruction Theory: Based on the final dataset of 735 articles, the theoretical foundations of post-disaster recovery and reconstruction following the Wenchuan earthquake include governance, community mobilization of social resources, reconstruction of household livelihoods and well-being, and longer-term resilience. Within this literature, recovery is rarely treated as a purely technical rebuilding task; instead, it is conceptualized as an interlinked socio-institutional process in which policy design and implementation, collective participation, and community-level resources shape what “recovery” becomes over time (Bahmani et al., 2025; Zhang and Tao, 2018; Zhu and Hu, 2019). Post-disaster recovery and reconstruction are always defined as a process that progresses from stabilization to rehabilitation and rebuilding. Work that distinguishes post-earthquake rehabilitation and reconstruction as distinct yet connected phases, and research that focuses on the managerial, technical, and organizational requirements of rebuilding over time, show the underlying logic in that arrangement (Chang et al., 2011; Liu et al., 2017). That phase-oriented view is supported by studies that show how reconstruction requires mobilizing and coordinating financial, material, and organizational resources under rapidly changing post-disaster conditions (Chang et al., 2010; Chang et al., 2011). This literature delineates “recovery” as the gradual reconstitution of systems: housing, livelihoods, institutions, and community operation through planning, implementation, and adaptation during the reconstruction period (Chen et al., 2020; Qiang et al., 2019).

In this broader context of recovery, a strong theoretical strand aligns with Build Back Better (BBB) as a way to assess recovery quality that goes beyond just getting things back to the way they were before the disaster. Studies focused on the BBB stress the need to increase sustainability, risk sensitivity, and development outcomes during reconstruction. It regards recovery as an opportunity to build stronger institutional and socio-environmental foundations within reconstructed systems (Zhou et al., 2022). Rebuilding decisions can lock in (or disrupt) long-term development patterns, according to research on low-carbon transitions and sustainability (Jiang, 2023; Lu and Xu, 2016). The study supports recovery theory by arguing that post-disaster reconstruction can be transformative when evaluation and governance processes explicitly target future-oriented sustainability objectives (Lu and Xu, 2016; Zhou et al., 2022). To synthesize the diverse theoretical perspectives underpinning post-disaster recovery research, Table 2 summarizes the core concepts, their application in the Wenchuan context, and their analytical contributions based on the reviewed evidence.

Table 2: Theoretical Foundations and Application in Post-Disaster Recovery: Evidence from the Wenchuan Earthquake

Theoretical Perspective	Core Concept	Wenchuan perspective	Evidence Focus	Analytical Contribution
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Disaster Recovery & Reconstruction Theory	Phased, adaptive recovery (response → reconstruction)	Used to interpret Wenchuan recovery as a staged trajectory (rapid emergency mobilization → rehabilitation of services → reconstruction of housing/infrastructure → longer-term recovery outcomes) and to distinguish “delivery” from “lived recovery” across time	Emergency response; reconstruction sequencing; infrastructure rebuilding	Explains recovery as a temporal system process
Build Back Better (BBB)	Reconstruction for safer, sustainable outcomes	Applied to evaluate whether Wenchuan reconstruction moved beyond replacement to improved safety, sustainability, and long-term performance; used to frame assessment of recovery quality rather than speed alone	Resilience-based planning; sustainability assessment	Clarifies speed–quality trade-offs
Urban & Community Resilience	Capacity to absorb, adapt, and reorganize	Used to analyze urban redesign, relocation/resettlement, and community recovery capacity; applied to explain variation across places and settlement types (urban vs rural) and the durability of recovery under persistent risk	Urban planning; relocation; resilience metrics	Links spatial change to adaptive capacity
Social Capital Theory	Networks, trust, and social support	Used to explain differential recovery capacity across communities (including rural settings) and to connect social resources to mental health, trust, and longer-term recovery experience	Social capital; trust; mental health	Shows how social dynamics shape recovery outcomes
Governance & Institutional Capacity	Coordination and implementation capacity	Applied to Wenchuan’s centrally steered reconstruction architecture, including command systems and paired-assistance as institutional mechanisms for mobilization, resource transfer, and implementation	Policy design; command systems; financing	Links governance to implementation outcomes



Collaborative Governance	Multi-actor coordination	Used to analyze NGO participation, nonprofit collaboration patterns, and cross-actor coordination during response and reconstruction; applied to explain how collaboration affects resource use and delivery effectiveness	NGO collaboration; participatory governance	Highlights coordination and legitimacy effects
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Urban and social resilience concepts are widely used in the included studies to interpret differences in recovery across places and social groups. Urban resilience is used to explain how cities and communities adapt to rebuilding, especially when housing, infrastructure, and spatial planning decisions change long-term urban growth (Guo, 2012; Li et al., 2024). Multidimensional community recovery capacity measures and frameworks that include social, institutional, and psychosocial components, rather than only repaired assets, build social resilience (Liu et al., 2018). At the individual and household levels, resilience is linked to longer-term psychosocial adaptation and differentiated recovery experience, including evidence on resilience among adult survivors several years after the event (Ni et al., 2015). Moreover, studies examining social capital conceptualize it as a key theoretical mechanism connecting community relationships and trust to recovery trajectories, including changes in recovery processes over time and impacts on well-being (Han, 2017; Wang, 2022; Wei and Han, 2018). Building on the social perspective, researchers have shown that long-term recovery outcomes following a disaster can include a return to a sense of place connection and residential satisfaction, as well as the restoration of meaningful life experiences (Qian et al., 2025).

Governance and Institutional Capacity Theories: Recovery effects are perceived as consequences of well-designed, well-coordinated, and effectively implemented institutions; such an approach provides the second major theoretical foundation for the studies considered. Research rooted in governance theory underscores the organizational role of administrative systems in allocating resources and duties across levels of government and regions, particularly in scenarios where recovery is facilitated by extensive state-led initiatives (Zhang and Tao, 2018; Zhong and Lu, 2018). In the current systematic review, institutional capacity extends beyond official power; it encompasses the ability to coordinate among many stakeholders and to align implementation with community realities and evolving requirements following a disaster (Wang et al., 2026; Zhu and Hu, 2019). Thus, the governance frame explains why post-disaster reconstruction can be uneven, even with substantial financial and governmental commitments: rules, coordination, and accountability during implementation determine effectiveness (Bahmani et al., 2025; Zhong and Lu, 2018). Cross-sector interaction is similarly important to governance capacity in Wenchuan recovery literature, but the studies focus more on government–NGO connections and coordinated multi-actor collaboration than formal PPP models. NGO participation research shows how non-state actors become involved in recovery delivery and community-level processes and how partnership patterns change over reconstruction (Lu and Xu, 2015). Current literature supports the idea that post-disaster recovery is negotiated and relational, shaped by actor interdependence rather than a hierarchical policy rollout (Lu and Xu, 2015; Xu et al., 2018). Participatory and pluralistic



210 governance framing views community reconstruction as a multi-stakeholder process whose legitimacy and efficacy depend on participation and locally based planning (Zhu and Hu, 2019). It is concluded that the theoretical emphasis on collaborative governance is also evident in analyses that explicitly interpret post-disaster reconstruction through the lens of collaborative crisis management and coordination performance (Wang et al., 2026).

Theoretical Perspective of Wenchuan (Why This Case is Unique): The current literature on Wenchuan earthquake recovery distinguishes itself by combining an extreme disaster scale with an unusually intensive, policy-driven reconstruction environment, characterized by national governance design, interregional support, and long-term rebuilding programs. The included literature emphasizes the paired or counterpart aid mechanism, which provides a tangible institutional framework for understanding multi-level governance, interregional cooperation, and resource mobilization at scale (Xu and Lu, 2013; Zhang and Tao, 2018; Zhong and Lu, 2018). The resulting policy architecture allows recovery theory to be investigated in Wenchuan, not just in terms of community adaptability but also in terms of how big governance structures determine reconstruction priorities, implementation paths, and perceived recovery success (Bahmani et al., 2025; Wang et al., 2026). Reconstruction and spatial reorganization are inextricably linked, especially in relocation and resettlement contexts where recovery aims include community inclusion, boundary-making, and long-term settlement transformation (Chen et al., 2020; Zhang et al., 2020). Housing reconstruction studies likewise reinforce the case's analytical value in linking governance capacity to build-environment outcomes, including the complexity and differentiated urban-rural challenges that shape recovery trajectories (Li et al., 2024; Qiang et al., 2019). In combination, identified literature positions Wenchuan as a case where disaster recovery theory, resilience thinking, and governance capacity frameworks intersect tightly, enabling recovery to be interpreted simultaneously as institutional coordination, community resource mobilization, and long-horizon rebuilding of lived environments (Han, 2017; Zhou et al., 2022; Zhu and Hu, 2019).

230 **4 Emergency response phase: “What Worked and What Didn’t.”**

The emergency response phase is often depicted as a race against cascading disruption: significant physical damage, rapidly escalating public health threats, and the need to establish coordination mechanisms during operations. For example, Lei et al. (2008) found that the earthquake damaged numerous local health systems in Mianyang, yet dedicated headquarters were established within 30 minutes, and medical teams were deployed to severely affected counties within hours. Emergency medical literature emphasizes quick institutional activation and practical triage and transfer channels as “what worked” elements.

Search and Rescue effectiveness: According to final data, early response efficiency is usually demonstrated through rapid triage, high-throughput evacuation and transport, and structured dispatch and routing. In the worst-hit Mianyang areas, emergency headquarters for disaster relief and medical rescue were established within 30 minutes, medical teams were deployed to the hardest-hit county within four hours, and large numbers of wounded were transported to local hospitals after triage and rapid treatment. The emergency medical dispatch system in Chengdu was also efficient after the earthquake, with



calls rising sharply, prompting the opening of additional alarm reception stations and the rapid scaling of dispatch capacity for ambulances and medical teams in the first 58 hours, as well as coordinated transfers through airports and railway stations in subsequent days.

245 *Mobilization of National Forces:* The literature on the Wenchuan emergency phase emphasizes the scale and speed of mobilization. Literary works describe the earthquake relief and reconstruction response as extremely quick and wide-ranging in the mobilization of resources, portraying it as a large-scale national operation that addressed numerous critical responsibilities. Emergency systems quickly established command centers and dispatched specialized teams (e.g., medical
250 quick mobilization worked best with organizational systems that could absorb the surge and integrate national-level inputs into deployable teams, dispatch capability, and coordinated transfers.

Challenges in Remote Mountainous Areas: Evidence also indicates that the emergency phase was difficult in remote, severely affected areas where health systems were severely damaged, and epidemic-prevention and public health functions had to be established quickly under tight conditions. In Aba Prefecture, the disease control system is severely damaged,
255 necessitating the rapid activation of contingency plans and the deployment of epidemic prevention teams, while building a county-, township-, and village-wide epidemic prevention network using local resources and external aid. Environmental disinfection, water and food safety restoration, and large-scale resettlement demonstrate the operational complexity of public health alongside immediate rescue and displacement management. The reports claim that what "worked" was the rapid construction of multi-level preventive networks and constant supervision, whereas what "didn't" was the stated extent of
260 system damage and the need to quickly restore functional capability. Next, coordination determines and constrains reaction performance. In the Mianyang medical rescue account, emergency work is linked to a dedicated headquarters and to the ability to integrate epidemic control and large-scale health education into the response, implying that unified direction supports execution across multiple tasks. Studies on charities indicate that after Wenchuan, nonprofits became a vital force in emergency response and formed various types of collaborations to leverage limited resources, while also analyzing factors
265 in collaboration formation to improve collaboration quality.

Communication and information system failures: It is noted that during emergency operations, information flow and communication capability are both enabling and stressful. The Chengdu 120 emergency medical command system study defines "failure risk" as sudden emergencies that flooded the center within the first hour, requiring rapid expansion of alarm reception and real-time tracking and dispatch using wired and wireless systems, and GIS/GPS for road monitoring. Another
270 scholar recommends diversifying communication modalities and command information systems to meet peacetime and disaster ("wartime") needs, indicating that the earthquake exposed functional bottlenecks and development gaps even as the system operated under pressure. An emergency interpretation group was quickly formed, and firsthand information on disaster conditions and secondary hazards was produced and submitted to site rescue teams to support rescue decisions and disaster relief actions. Together, the findings portray the emergency phase as an information-intensive environment in which
275 response effectiveness depended on how quickly communication and data systems could scale, integrate, and translate



situational intelligence into operational action. System overload and the need for more flexible, disaster-ready information infrastructure were recurring pressure points.

5 Reconstruction, Governance, and Policy

280 *Central Government Leadership:* Current research characterizes Wenchuan recovery governance as state-centric and directive, positioning reconstruction as a centrally directed initiative that necessitates robust vertical coordination and swift institutional alignment across various actors and jurisdictions. According to analyses of central government-led responses, leadership is not just about politics. It is also about how to organize information flow, assign tasks, and carry out tasks by multiple agencies under extreme time pressure (Zhu and Thanh, 2023). The literature review illustrates the central government as the fundamental framework for reconstruction governance, facilitating mobilization and standardizing
285 implementation, while establishing a definitive analytical foundation for assessing the efficacy of command systems in enhancing performance and identifying limitations in flexibility and coordination.

The Paired-Assistance Reconstruction Model: Research on counterpart aid delineates a structured framework wherein supporting jurisdictions are connected to disaster-affected regions to synchronize organizational capacity, technical expertise, and material/financial assistance for reconstruction (Xu and Lu, 2013). The paired/counterpart assistance approach
290 is a unique governance mechanism, as evidenced by the provided evidence. It is always seen as an institutional means of matching external capacity with local reconstruction needs. Institutional accounts elaborate on this as an administrative mechanism, emphasizing how the paired-assistance program operates through formalized intergovernmental relationships and implementation routines that translate national objectives into local rebuilding capabilities (Zhong and Lu, 2018). From a sustainability perspective, evaluations expand the rationale by framing paired assistance as both a delivery mechanism and
295 a policy instrument, with outcomes dependent on the incorporation (or absence) of sustainability objectives within reconstruction priorities and performance evaluation (Zhang and Tao, 2018). Recent collaborative crisis management research interprets paired assistance as a coordinating framework that channels resources and aligns players across levels to determine rebuilding trajectories (Wang et al., 2026). The included studies view partnered aid as a major pillar of the Wenchuan reconstruction paradigm, institutionalizing interregional support and quantifying governance design and recovery
300 outcomes (Wang et al., 2026; Xu and Lu, 2013; Zhang and Tao, 2018; Zhong and Lu, 2018).

Funding mechanisms: For the last group, money is usually a problem with governance: how to pay for rebuilding quickly enough to keep up with demand while balancing central direction with local delivery limits. Using the Wenchuan example, work on financing quick community reconstruction shows how financing arrangements helped communities rebuild (Xiao et al., 2020). Additional research links national aid to downstream outcomes, such as economic performance, demonstrating
305 that financial flows and aid allocation can affect recovery trajectories and post-disaster development patterns (Zhao et al., 2018). Along with public funding, the included literature documents philanthropic efforts and coordinated giving throughout the crisis, showing how nonprofit-driven contributions were part of the recovery and rebuilding resource ecosystem (Han



and Ji, 2009). In combination, the results show that Wenchuan reconstruction finance was anchored in state aid and reconstruction financing channels and interacted with organized charitable activities that helped the recovery ecosystem (Han and Ji, 2009; Xiao et al., 2020; Zhao et al., 2018).

Institutional innovations introduced after the Wenchuan earthquake: The investigations emphasize Wenchuan's role in institutional experimentation and adaptation, particularly in the combination of centralized steering and evolving coordination in reconstruction governance. Command-system analyses approach response-and-reconstruction command structure design and refinement as a crucial institutional domain where functioning, and inadequacies can be analyzed and improved, providing one strand of “innovation” evidence (Zhu and Thanh, 2023). Another stress is pluralistic and participatory governance, which interprets community regeneration through development planning procedures that involve multi-actor governance and prioritize bottom-up delivery rather than top-down delivery (Zhu and Hu, 2019). Research on NGO collaboration and nonprofit coordination examines the post-Wenchuan context to illustrate how patterns of multilateral collaboration emerged under duress, influenced recovery capacity, and were shaped by circumstances that facilitated or hindered collaboration (Lu and Xu, 2015; Tang and Wang, 2020). Finally, research that provides structured techniques for analyzing “build back better” and sustained recovery performance demonstrates institutional innovation in the evaluation and definition of recovery (Zhou et al., 2022).

Critical evaluation (strengths and weaknesses): According to the evidence, the Wenchuan governance model has strengths in capacity concentration and implementation reach. Central coordination and command structures made it easy to organize and cover a lot of ground quickly. Paired assistance made interregional assistance a normal part of the process and enabled capacity to be transferred to areas that needed it (Wang et al., 2026; Xu and Lu, 2013; Zhong and Lu, 2018; Zhu and Thanh, 2023). Financing-focused research also suggests that governance efficacy depended on whether financial arrangements could enable rapid community restoration, supporting the notion that governance design and financial mechanisms were interdependent (Xiao et al., 2020; Zhao et al., 2018). The weaknesses in the selected literature are also systematic. Evaluation and legitimacy are essential governance considerations, as public perception and observed recovery outcomes may differ from the planned policy effects, according to several studies (Bahmani et al., 2025). Another investigation addresses the fundamental challenge of restoring institutions and livelihoods quickly and in a socially stable manner, including tensions regarding post-disaster property rights reconfiguration that affect reconstruction governance in transition environments (Deng, 2010). The literature also notes how difficult and uneven it is to rebuild and implement housing projects, especially the need for the government to address both urban and rural areas and develop new policies in complex situations (Li et al., 2024). Finally, while charity engagement is valued, collaboration is often seen as a governance issue that needs correction rather than a success, showing a continuing coordination frontier in reconstruction governance (Lu and Xu, 2015; Tang and Wang, 2020). In the final analysis, Wenchuan is a governance model with strong mobilization and delivery but ongoing issues with coordination, social acceptance, institutional tensions, and sustainability-oriented evaluation (Bahmani et al., 2025; Zhang and Tao, 2018; Zhou et al., 2022).



6 Infrastructure Reconstruction

Transport systems (roads, tunnels, bridges): The concluding literature treats transport infrastructure as both a recovery lifeline and a reconstruction bottleneck, focusing on how network disruption increased recovery costs and how rebuilding decisions affected resilience. Wenchuan research specifically links highway traffic interruptions to indirect economic losses, demonstrating that restoring mobility requires both engineering and economic stabilization strategies (Wang et al., 2013). In parallel, technical studies examine how to detect and rank damage, for example, by using high-resolution satellite imagery and road maps to automatically identify road damage and support post-earthquake repair planning (Ma et al., 2013). Design and innovation narratives for key transport assets, including as bridge-related concepts and engineering solutions for the post-Wenchuan (Chengdu–Dujiangyan) intercity railway restoration project, document reconstruction at the project level (Chen and Zhu, 2012). Risk-oriented studies of highways affected by debris flows in the Wenchuan earthquake area indicate how secondary hazards combined with transport rebuilding goals, demonstrating that route restoration and risk control were closely intertwined in mountainous areas (Wang, 2022). In conclusion, the findings from these studies indicate that transport rebuilding should be a program of rapid operational restoration, damage assessment, design modification, and risk management informed by hazards (Chen and Zhu, 2012; Ma et al., 2013; Wang et al., 2013).

Urban planning redesign: The papers show that urban planning was used as a tool for reconstruction, turning post-disaster goals into spatial form through decisions about where to relocate people, how to structure settlements, and how to coordinate land use and infrastructure provision. Planning-focused work shows how New Beichuan's off-site resettlement was implemented through a process of "differentiation and integration." This shows how important it was to balance orderly placement with the functional integration of the new urban form after the earthquake (Zhang et al., 2020). Complementing this planning logic, technology-enabled planning is also reflected in case-based evidence highlighting the application of "3S" technologies in urban planning during the reconstruction in Yingxiu, indicating a data-supported approach to redesign under post-disaster constraints (Chang et al., 2011a). Resilience-oriented scholarship frames reconstruction planning as a regulatory challenge and advocates a shift toward resilience-based approaches to guide post-disaster reconstruction in China, thereby shaping how planning goals are defined and enforced under rapid rebuilding pressures (Shao and Xu, 2017). Such instances show that urban planning redesign is both a spatial strategy and an institutional practice that must achieve speedy functional settlement while implementing resilience principles (Shao and Xu, 2017; Zhang et al., 2020).

School & Hospital Reconstruction (Improved Safety Codes): The evidence encompasses the implications of social infrastructure rehabilitation on system performance and structural safety. Research indicates that reconstruction in severely affected regions substantially obstructed pre-hospital medical care capabilities in Deyang (near Wenchuan city), illustrating how rebuilding processes and disrupted service environments affect emergency care delivery (Wei et al., 2012). Related engineering-focused work examines seismic measures to improve vulnerable wall systems, confirming that Wenchuan "rebuild" discussions often focused on structural behavior and mitigation interventions rather than administrative replacement (Zhang et al., 2014). Broader reconstruction strategy analysis links regional engineering damage to choices in



the Wenchuan reconstruction plan (Ou and Li, 2011). The facts show that damaged evidence and targeted mitigation options
375 molded school and health infrastructure rehabilitation around continuity of critical services and safety performance (Ou and
Li, 2011; Zhang et al., 2014).

Housing reconstruction models (rural resettlement and urban relocation): Whenever reconstruction involves evaluating the
delivery, acceptability, and long-term functioning of recovery policies, housing rebuilding is regularly cited as a key
implementation sector. The debate is grounded in the practical implementation of recovery following the Wenchuan
380 earthquake, with a case study of Dujiangyan (Wenchuan) documenting rebuilding efforts through the lens of house
reconstruction (Qiang et al., 2019). Newer evaluation-oriented research builds on this Dujiangyan emphasis by investigating
the efficacy of centralized post-disaster house restoration in rural areas following the Wenchuan earthquake. This suggests a
body of evidence that shifts its focus from delivery counts to post-implementation evaluation (Kabilijiang et al., 2024).
Comparing urban and rural paths during the Chi-Chi and Wenchuan earthquakes offers a new framework for understanding
385 the complexity of housing reconstruction. This highlights that different types of settlements and governance contexts pose
different issues during rebuilding and warrant distinct policy investigations (Li et al., 2024). Furthermore, research on policy
outcomes has shown that the design of post-disaster policies affects community trajectories and lived recovery outcomes.
This supports the idea that the "housing models" discussed in the literature are closely tied to decisions about relocation and
resettlement (Chen et al., 2020). Across these works, rural resettlement and urban relocation are treated not as
390 interchangeable modalities but as distinct reconstruction pathways with different implementation logics and evaluative
criteria (Chen et al., 2020; Kabilijiang et al., 2024; Li et al., 2024; Qiang et al., 2019).

Critical assessment: speed versus quality trade-offs: It is implied across all included articles that reconstruction speed was a
defining element of the Wenchuan event. However, the literature also reveals that the constant need to align short-term
functionality with longer-term resilience and performance stems from the pressure to restore quickly. Studies on planning
395 and reconstruction strategies show that decisions made during reconstruction affected future risk exposure and settlement
functioning, and economic loss evaluations indicate that speed was important, as transportation disruptions exacerbated
indirect costs (Ou and Li, 2011; Shao and Xu, 2017; Wang et al., 2013). The conflict is further emphasized by housing-
focused evaluation and implementation studies, which shift focus from narratives of execution to assessments of efficacy.
Thus, the reconstruction record should include information about both the speed at which assets were replaced and the
400 contextual performance of reconstructed systems (Kabilijiang et al., 2024; Qiang et al., 2019). Rather than resolving the
issue of "speed" and "quality" through construction completion alone, the endeavour to integrate new settlement form and
function after relocation serves as further evidence in urban planning and resettlement practice (Shao and Xu, 2017; Zhang et
al., 2020).



7 Social Recovery and Community Rebuilding

405 The social recovery literature in the final included records says that rebuilding social life depends on how relationships, participation, and local institutions are rebuilt over time. This literature consistently underscores that recovery transcends the mere physical replacement of lost items. The significance of social capital and networks in rehabilitation pathways is a persistent topic. Studies conducted in regions affected by the Wenchuan earthquake illustrate how social capital influences the nature and pace of recovery, highlighting that recovery processes evolve over time due to disruptions and subsequent reconfigurations of social connections, trust, and local coordination capabilities (Han, 2017). The fact that pre-disaster social capital is a measurable predictor of post-disaster recovery in rural Wenchuan communities suggests that social relations can be as important as material inputs during reconstruction (Wei and Han, 2018). In parallel, participatory governance-oriented work views community rebuilding as a negotiated, pluralistic process that integrates participatory development planning and post-disaster community reconstruction to shape recovery priorities (Zhu and Hu, 2019). Community participation is explicitly discussed as a mechanism aligned with “build-back-better” ambitions, positioning it not as symbolic inclusion but as a practical pathway to more locally grounded and socially sustainable reconstruction outcomes (Fan and Albuérne, 2022). A second important thread examines post-traumatic stress and mental health, showing that psychosocial effects began early and remained long after the catastrophe. Early post-earthquake shelter assessments show survivors' psychological burden and the necessity of psychological intervention alongside life-saving and emergency care (Zhao et al., 2008). Clinical and epidemiological studies confirm the frequency of post-traumatic stress disorder and associated risk factors among Wenchuan earthquake survivors, establishing a consistent conclusion: Mental health repercussions are neither trivial nor short-lived and require specific recovery agenda attention (Kun et al., 2009). Later mental health consequences are linked to ongoing exposure and social factors in long-term research. Media exposure and generalized trust predict post-traumatic stress symptoms ten years after the earthquake, showing how informational contexts and social trust remain important during recovery (He et al., 2018). Research linking social capital to mental health indicates that social resources and relational supports are significant factors influencing psychological well-being among populations affected by the Wenchuan earthquake, reinforcing a perspective on recovery that integrates mental health within social structure rather than treating it as merely a clinical outcome (Wang, 2022). Research on rebuilding as the restoration of everyday life systems, such as local social contexts and community functioning, fosters social healing. The last set of questions looks at community facilities differently, but living and social environments can affect health and healing. In earthquake-affected counties, residential satisfaction is linked to social factors. This means that people's perceptions of the rebuilt living environment and its social conditions may affect their recovery (Qian et al., 2025). Long-term place attachment research frames recovery as the restoration of meaningful bonds to place and links it to residential environment, tourism development, and social and cultural capital in long-term post-disaster settings (Qian et al., 2025). The findings from these investigations show that community rebuilding involves co-producing physical and social reconstruction through lived experience in rebuilt areas (Qian et al., 2025).



The featured research additionally highlights the importance of NGOs, volunteers, and grassroots organizations in social rehabilitation and reconstruction. Field research on NGO collaboration in community post-disaster reconstruction in Wenchuan establishes that collaboration is a crucial tool for organizing and sustaining community-level recovery operations (Lu and Xu, 2015). Social work-oriented evidence further examines NGO participation patterns and roles during reconstruction, illustrating how NGOs became embedded within reconstruction processes and how their engagement relates to community needs and service provision (Kenan et al., 2011). Broader evaluations show that NGO participation in post-disaster reconstruction alters as recovery proceeds from emergency response to prolonged reconstruction phases (Lu et al., 2020). The articles emphasize civil society participation as a key element of social recovery and coordination and collaboration quality as key effectiveness factors (Lu and Xu, 2015; Tang and Wang, 2020). Finally, the evidence strongly suggests long-term social implications, especially 10–16 years after the earthquake, moving the analytical focus from rebuilding delivery to health, satisfaction, and recovery success. A large-scale survey-based study conducted 10 years after the Wenchuan earthquake examines the long-term effects of housing damage on the health of rural Chinese survivors, showing that disaster-related housing loss can have lasting social and health consequences (Han et al., 2021). Furthermore, a ten-year post-earthquake survey indicates that villagers' satisfaction with post-disaster reconstruction remains an active outcome domain long after physical rebuilding, shaped by lived experiences and everyday evaluations of the reconstruction (Ao et al., 2022). When read alongside evidence on generalized trust and post-traumatic stress ten years after the earthquake (He et al., 2018) and long-term place attachment restoration (Qian et al., 2025), the social recovery literature in the final set collectively portrays Wenchuan recovery as a prolonged social process in which rebuilding outcomes continue to unfold through health, trust, participation, cultural continuity, and lived experience in reconstructed places (Ao et al., 2022; Han et al., 2021; He et al., 2018; Qian et al., 2025).

8 Livelihood Recovery and Economic Regeneration

Agricultural recovery: The articles addressed how it can help people make a living and rebuild areas hit by earthquakes, especially in rural and peri-urban areas. Household-level evidence clearly shows that disasters pose a risk to agriculture and can change the vulnerability of rural areas. It examines how vulnerability changes before and after a disaster and what this means for policy-making to support people's recovery (Sun et al., 2010). Related work treats the Wenchuan case as an empirical setting for understanding how post-disaster reconstruction interacts with poverty alleviation over time, emphasizing that livelihood restoration should be read alongside longer-run distributional outcomes rather than evaluated solely through short-term rebuilding progress (Jia et al., 2018). According to a study of two rural communities, farmland is a key channel through which recovery policies and relocation approaches affect livelihood restoration and well-being (Chen et al., 2020). This strand views agricultural recovery as a process that links land access, household vulnerability, and poverty dynamics within the broader recovery trajectory (Chen et al., 2020; Jia et al., 2018; Sun et al., 2010).



Industrial reconstruction and SME recovery: The investigation of industrial recovery in disaster-stricken areas examines how reconstruction investments and the sectoral mix can affect long-term economic upgrading. The Wenchuan earthquake setting is used to determine whether reconstruction efforts lead to technical advancement by measuring total factor productivity and comparing post-shock trends to counterfactual baselines (Chen et al., 2020). Complementing this productivity perspective, household-survey evidence links post-disaster recovery resilience to the job-provision capacity of different sectors, treating regional industrial structure as a determinant of recovery resilience in the most severely affected counties (Liu et al., 2024). Disaster impacts are assessed through regional and industrial propagation mechanisms, emphasizing that reconstruction-relevant economic losses are not limited to the epicentral area when supply-chain interdependence is high (Huang et al., 2022). Collectively, these studies position industrial recovery as more than restarting output; instead, they highlight pathways through which reconstruction spending, sectoral employment capacity, and interregional production networks influence recovery robustness and longer-term economic reconfiguration (Huang et al., 2022; Jia et al., 2018; Liu et al., 2024).

Employment restoration: The included literature addresses employment recovery as a policy domain that affects well-being and livelihood reconstruction. Employment assistance policies in earthquake-affected areas are treated as a formal component of reconstruction policy, with an examination of their effects on labor-market recovery and survivors' health outcomes, positioning employment restoration as part of social and economic recovery rather than as an economic indicator. Related synthesis work examines the effects of disasters on displaced workers, reinforcing the salience of employment disruption and labor displacement as consequences that require explicit recovery mechanisms (Chang-Richards et al., 2018). In post-disaster Sichuan, community-embedded asset-building and livelihood-rebuilding initiatives highlight livelihood recovery as a sustained process shaped by compounding stressors and the practical challenges households face even under rapid reconstruction (Ting, 2013). The findings show that employment restoration stabilizes household trajectories, mediates well-being, and supports livelihood rebuilding across the reconstruction timeline. (Employment assistance policies of the Chinese government play a positive role (Chang-Richards et al., 2018; Ting, 2013).

Economic resilience: The primary topic in the included literature is economic resilience, which examines how quickly and efficiently local and regional economies recover, as well as the variables that influence this. Foundational conceptual-quantitative work emphasizes “dynamic economic resilience” and links it to policies that accelerate repair and rebuilding investment, using the Wenchuan earthquake as a case study to show how resilience can reduce disaster losses through faster recovery (Xie et al., 2018). From this perspective, resilience and recovery efficiency are operationalized using time-series and long-run socio-economic data, generating economic resilience indices and relating them to policy design for post-disaster economic reconstruction in severely damaged areas (Zhou et al., 2019, 2020). Complementary assessment work also quantifies indirect economic loss associated with the Wenchuan earthquake, reinforcing that post-disaster economic evaluation includes both direct disruption and secondary, system-mediated losses that inform recovery priorities (Wei & Su, 2016). Economic resilience evaluation links reconstruction investment, recovery speed, and system-wide loss dynamics, making “recovery” a measurable process rather than a goal (Xie et al., 2018; Zhou et al., 2020).



9 Environmental and Ecological Restoration

Environmental and ecological restoration is consistently framed as a recovery-critical domain in Wenchuan recovery and reconstruction literature because the earthquake's impacts extended beyond the built environment, creating cascading geo-hazards and landscape disruption that shaped risk conditions during reconstruction. A common theme is that landslides and debris flows threatened resettled populations, reconstructed assets, and recovery investments long after seismic shaking. Risk reduction, exposure control, post-event landscape stabilization, and ecological evaluation during the longer recovery period are operationalized as “environmental restoration” in this frame. A large number of studies focus on landslide, debris flow, and geo-hazard management for safe reconstruction. Rapid hazard assessment and mapping, including the use of readily available GIS tools to analyse landslide threats posed by the earthquake and its aftershocks, enable post-seismic decision-making (Sato and Harp, 2009). Landslide susceptibility mapping is explicitly related to reconstruction needs, employing GIS-based statistical modelling to guide post-earthquake rebuilding and evaluate environmental capacity (Su et al., 2010). Debris-flow impacts on highways are examined in terms of hazard effect types and damage processes, and quantified using indices to facilitate practical risk assessment in the earthquake-affected region (Du et al., 2012).

Ecological restoration is also evaluated and programmed, with studies on how ecological conditions are altered and how restoration success can be measured. Remote-sensing-driven analysis explicitly combines satellite data with geological information derived from radar sources and employs a pressure–state–response framework to track post-seismic ecological restoration dynamics (Huang et al., 2022; Lei et al., 2008). Environmental risk evaluation is presented as a planning-relevant instrument for minimizing impacts in the affected region, reflecting an understanding that large-scale reconstruction can create environmental pressures that require systematic assessment rather than being treated as incidental side-effects (Du et al., 2012). In this way, the ecological restoration literature in the included set moves beyond a narrow “recovery of vegetation” narrative to emphasize structured evaluation of ecological conditions and explicit attention to environmental risk within reconstruction processes. Exposure reduction as a recovery goal links environmental risk to risk zoning, relocation pressures, and land-use options. Community-focused analysis shows how geo-hazards affected recovery options and reconstruction constraints in mountainous settings, contrasting livelihoods tied to tourism and natural park systems with locations where landslide burial fundamentally altered settlement feasibility. Preventing and reducing geo-hazard exposure is a practical recovery lesson from post-earthquake community experiences and reconstruction realities (Svirchev et al., 2011). Current concentration supports the overall theme of the included studies: reconstruction decisions are ecologically important, and environmental conditions directly affect “successful reconstruction” in high-risk terrain. Finally, the included records emphasize “green” rebuilding approaches as a strategy to link recovery with long-term sustainability goals, especially given reconstruction-scale material flows and energy demands. A meta-synthesis method specifies sustainable, resilient, low-carbon community reconstruction as a system-level post-disaster development requirement (Lu and Xu, 2016). Material circularity is treated as a practical response to the large volume of earthquake-generated debris: recycling construction and demolition waste is framed as a sustainable environmental management strategy in post-earthquake reconstruction (Xie et



535 al., 2018). Proposed ways for reusing post-earthquake waste building materials include utilization design, construction process control, and cyclic regeneration (Tang and Wang, 2020). Current contributions converge with the environmental risk evaluation strand (Du et al., 2012), collectively depicting environmental recovery as both (i) managing geo-hazard and ecological conditions during reconstruction and (ii) shaping reconstruction practices to reduce environmental pressures while rebuilding at scale.

540 **10 Technological Innovations in Post-disaster Recovery**

Geographical technologies are the most consistent technological underpinning of Wenchuan post-disaster decision-making in the final records. GIS-based methods assess earthquake-induced landslides and predict spatially explicit risks for reconstruction planning (Han and Ji, 2009; Sato and Harp, 2009). Remote sensing monitors damage and danger at many scales. Road damage diagnosis using high-resolution photos prioritizes access restoration and repair logistics (Gong et al., 545 2012). UAV image processing and categorization in earthquake districts can improve post-event evaluation when satellite collection is delayed or limited (Wei and Su, 2016). Post-earthquake aerial imagery is used to automatically identify collapsed houses and rapidly generate reconstruction-relevant indicators, such as collapse extent and rate, thereby demonstrating how image-based analytics support early reconstruction targeting (Duan et al., 2010). Post-earthquake reconstruction planning includes geographical data and decision help using integrated “planning support systems” (Zhou et al., 550 al., 2009). Big data and early warning look more like an emerging operational logic that blends forecasting, preparation, and responsive allocation than a platform. In Wenchuan, a life-cycle approach to disaster management formalizes “forecast and early warning” as a key phase alongside rescue/disposal and recovery/reconstruction, emphasizing communication and readiness for whole-process emergency management (Han et al., 2012). A collaborative dispatching framework for relief materials uses demand forecasting, urgency evaluation, and multi-objective optimization to generate alternative dispatch 555 plans under “big data” keywording, improving fairness in relief distribution and decision quality in humanitarian logistics modeling. The corpus includes multi-temporal debris-flow datasets for hazard-focused early warning, indicating that monitoring-oriented data infrastructures were developed after Wenchuan to support longer-horizon hazard awareness (Wang et al., 2022). Multi-algorithm detection pipelines for rainfall-induced debris-flow catchments following earthquakes are emerging to increase anticipatory risk assessment in post-event landscapes (Xiao-Yan et al., 2025).

560 Despite not using “digital twin” nomenclature, the final included data regularly employ functional analogs, or digital representations of recovery dynamics and decision-support models. Adaptive regional input–output modeling simulates the recovery and reconstruction phase to investigate recovery routes and quantify reconstruction-linked dynamics at the regional scale (Li et al., 2012). Information on post-earthquake planning support systems indicates that digital tools are integral to rebuilding governance and execution, not just technical add-ons (Zhou et al., 2009). These studies support “smart 565 reconstruction” logic, which uses integrated modeling, data, and planning assistance to facilitate scenario reasoning, prioritizing, and coordination across recovery tasks.



Wenchuan-focused evidence reveals scalable technological paths. First, image-based categorization and automated identification of collapsed dwellings and damaged infrastructure for rebuilding decision-making prioritize speed, repeatability, and quantitative outputs (Duan et al., 2010; Gong et al., 2012). Second, multi-sensor and algorithm-fusion monitoring may be useful for hazard detection and post-Wenchuan risk governance, as multi-temporal datasets and multi-algorithm techniques can track debris-flow processes. Third, studies that incorporate technology into emergency-management life-cycle design and optimization-based relief dispatching show that sensing technologies and decision systems increase coordination, readiness, and allocation under uncertainty in future-ready recovery systems. Technologies that reduce the gap between observation, analysis, and implementable recovery options are particularly useful for reconstruction planning, hazard and risk management, and logistics coordination in complex post-disaster contexts, according to the included data.

11 Long-Term Resilience Outcomes (2008–2024)

The remaining included research studies view long-term resilience after the Wenchuan earthquake as a multi-dimensional outcome: the durability and safety of reconstructed systems, the steadiness of socioeconomic recovery over time, the restructuring of populations through relocation and resettlement, and the social conditions (trust, satisfaction, and perceived fairness) that determine rebuilding success in daily life. This research examines resilience by monitoring how reconstructed ecosystems operate under continuous risk, how livelihoods and well-being change, and how people adjust to reconstruction policy-induced institutional and geographical changes. Infrastructure durability and safety are long-term resilience indicators because they reveal if restoration improves performance and risk sensitivity. In resilience-based reconstruction planning, regulatory and planning frameworks impact rebuilding results, especially when the goal is safety and resilience (Shao and Xu, 2017). A companion “build back better” research advises using specified criteria rather than assumptions to measure sustainable recovery results over time (Zhou et al., 2022). The development and use of strengthening and protection solutions, such as structural mitigation and seismic isolation technologies, demonstrate an ongoing focus on safety performance beyond reconstruction delivery in engineering and construction (Sun and Li, 2010). To synthesize the multidimensional nature of long-term resilience outcomes identified across the evidence base, Table 3 presents key dimensions, indicators, analytical focus, and temporal dynamics observed in the Wenchuan recovery process.

Table 3: Multidimensional Indicators of Long-Term Resilience Outcomes Following the Wenchuan Earthquake

Resilience Dimension	Key Outcomes	Analytical Focus	Temporal Dynamics	Resilience Implications
Infrastructure Resilience	Durability	Reconstruction quality and structural robustness	Short-term recovery → long-term performance	Determines physical system reliability under future risk



	Seismic safety	Safety upgrades and mitigation measures	Short-term recovery → long-term performance	Enhances resistance to future hazards
	Infrastructure performance	Engineering adaptation and system functionality	Short-term recovery → long-term performance	Reflects the operational stability of rebuilt systems
Economic Resilience	Recovery speed	Dynamic economic resilience and recovery efficiency	Short-term shock → medium-term recovery	Reflects system capacity to absorb and recover from shocks
	Economic efficiency	Resource allocation and reconstruction investment effects	Medium-term recovery → long-term growth	Indicates efficiency of recovery processes
	Productivity	Industrial and sectoral recovery performance	Medium-term recovery → long-term growth	Supports sustained economic development
Social Resilience	Trust	Community perception and institutional confidence	Slow recovery with long-term persistence (10+ years)	Determines governance legitimacy and social stability
	Satisfaction	Long-term recovery evaluation and lived experience	Slow recovery with long-term persistence (10+ years)	Reflects perceived recovery success
	Social stability	Social capital and community cohesion	Slow recovery with long-term persistence (10+ years)	Supports long-term social resilience
	Well-being	Quality of life and social outcomes	Slow recovery with long-term persistence (10+ years)	Indicates holistic recovery outcomes
Psychosocial Resilience	PTSD	Clinical assessment of post-traumatic stress	Long-lasting with delayed recovery patterns	Highlights persistent mental health burden
	Mental health	Longitudinal psychological recovery processes	Long-lasting with social and environmental	Reflects hidden but critical recovery dimension



			influence	
	Stress adaptation	Behavioral and emotional coping mechanisms	Long-term adaptation under changing conditions	Indicates individual-level resilience capacity
Spatial & Demographic Resilience	Relocation outcomes	Resettlement policies and spatial restructuring	Medium- to long-term transformation	Reshapes community structure and stability
	Migration patterns	Population mobility and redistribution	Medium- to long-term transformation	Influences labor dynamics and social networks
	Urban integration	Urbanization and community reorganization	Medium- to long-term transformation	Determines long-term settlement sustainability
Environmental Resilience	Hazard persistence	Landslide and debris flow dynamics	Evolving risk over time	Constrains reconstruction safety and planning
	Ecological restoration	Ecosystem recovery and environmental management	Medium- to long-term recovery	Supports sustainable reconstruction outcomes
	Risk exposure	Terrain evolution and hazard interaction	Evolving and dynamic over time	Defines long-term vulnerability and resilience

Long-term socioeconomic recovery indicators provide resilience and efficiency metrics to understand recovery. Economic resilience studies analyze how quickly and effectively afflicted regions recovered and which geographical settings recovered faster (Zhou et al., 2019, 2020). Xie et al. (2018) model “dynamic economic resilience” and relate it to recovery speed and loss reduction, showing resilience as a process driven by reconstruction paths. Long-term surveys demonstrate that disasters can affect health and well-being a decade later. Housing damage in rural areas is linked to long-term health outcomes 10 years after the Wenchuan earthquake, indicating that resilience depends on whether the shock's social and health effects fade or persist. Villagers' reconstruction satisfaction surveys 10 years after the earthquake reveal that socioeconomic recovery is judged by lived results, not aggregate progress (Ao et al., 2022). Migration, urbanization, and relocation are processes of disaster recovery. Rebuilding methods affect community social integration, livelihoods, and long-term stability (Chen et al., 2020). New Beichuan planning data show how off-site migration fostered diversity and integration, reflecting the long-term effort to build functioning communities in newly built sites (Zhang et al., 2020). Migration decisions affect social networks, place attachment, and the long-term stability of reconstructed communities, making population change a structural resilience aspect in this research. Public trust, governance satisfaction, and social stability are long-term indicators of rebuilding governance legitimacy and community security. After 10 years, villagers' satisfaction with the rebuilding shows that long-term stability rests on appraisal and acceptance rather than on physical completeness (Ao et al., 2022). Ten years after the



earthquake, generalized trust and media exposure predict post-traumatic stress symptoms, suggesting that social stability and psychological recovery remain linked to broader social conditions (He et al., 2018). Related research linking social capital to mental health shows that social resources and relational supports affect long-term well-being and recovery, supporting the idea that resilience is partly social and institutional rather than just infrastructural (Wang, 2022). Finally, the data consistently reveal unexpected long-term threats that hinder linear rehabilitation, especially in mountainous areas where the earthquake created persistent hazards. Post-earthquake debris flows show that heavy rainfall can revive hazards, generating catastrophic events long after the initial shock and harming communities and infrastructure throughout the recovery process (Tang et al., 2011). InSAR and terrain-change study of landslide dynamics and landscape development demonstrate a longer hazard tail, suggesting that slope deformation and secondary hazards might affect post-disaster risk. The included studies demonstrate how continuous hazards interact with settlement and infrastructure systems to define long-term resilience as the rebuilding outcomes' ability to remain safe and operate amid a persistent, changing risk landscape.

12 Challenges, Gaps, and Critical Failures Identified

The final Wenchuan earthquake literature depicts recovery and rebuilding as highly effective in mobilization and scale, but with chronic problems, structural gaps, and fundamental conflicts that affected short-term outcomes and long-term resilience. Governance, implementation, social rehabilitation, environmental risk, and assessment systems are linked. Coordination difficulty in multi-actor governance is a major issue in the literature. Centralized leadership and large-scale mobilization facilitated swift action, but studies of command structures and collaborative arrangements show that coordination between government levels, regions, and non-governmental players was not always smooth. Central government-led response mechanisms were functional and effective, but they struggled to connect decision-making with local conditions and ensure efficient cross-agency interaction (Zhu and Thanh, 2023). NGO participation and nonprofit collaboration research show that civil society actors contributed to recovery, but collaboration mechanisms were uneven and needed improvement to optimize resource use and coordination efficiency (Lu and Xu, 2015; Tang and Wang, 2020). These findings show that governance competence was strong in mobilization but inconsistent in integration and coordination among players.

Another gap is quick rebuilding vs. quality and sustainability. Several studies suggest that the rapid recovery in Wenchuan impeded planning, institutional learning, and sustainable integration. In resilience-based planning and “build back better” frameworks, rebuilding solutions must address long-term safety, environmental performance, and social acceptability, not only completion time (Shao and Xu, 2017; Zhou et al., 2022). The housing reconstruction study progressed from implementation tales to effectiveness evaluation, revealing that speedy delivery did not ensure long-term success (Kabilijiang et al., 2024; Qiang et al., 2019). Post-disaster governance must choose between reconstruction and lasting, context-sensitive, resilient results. Building on literature constraints and structural gaps, the evidence base provides a clear platform for future study. Integrative techniques that link governance, infrastructure, social systems, economic processes,



640 and environmental dynamics are needed for future studies. Table 4 synthesizes the major research directions from the 735-study corpus, identifies critical gaps, and generates specific research questions. These initiatives aim to elevate the discipline beyond fragmented analysis toward a dynamic, integrated understanding of post-disaster recovery.

Table 4: Research gaps and future directions in Wenchuan earthquake recovery literature

Research Directions	Future research gap	Research Questions
Integrated recovery pathways (governance→ delivery→ outcomes)	The evidence is strong in domain-specific studies (governance, infrastructure, social recovery, economy, environment) but weaker in studies that explicitly connect these domains into a single explanatory chain.	How do governance choices translate into infrastructure quality, livelihood recovery, and social outcomes? Where do linkages break across phases?
Paired-assistance (counterpart support) mechanism	Paired assistance is well documented as a signature policy model, but fewer studies systematically test which design features and boundary conditions produce stronger long-term outcomes and legitimacy.	What design features drive “success”? Why can public perception differ from implementation? Where does the model work less well (rural/relocation contexts)?
Command systems & coordination under multi-actor complexity	Centralized command is analyzed, and NGO roles are documented, but the corpus leaves limited integrated evidence on interoperability failures and how coordination performance shapes reconstruction outcomes across actors.	What coordination bottlenecks persist? What improves interoperability across agencies and NGOs?
Build Back Better (BBB) as measurable long-term performance	BBB and resilience-based planning are prominent, but there is a gap in standardized, testable indicators and comparative evidence on “speed vs quality” across reconstruction pathways	How to operationalize BBB beyond concept statements? What metrics capture durability, safety, sustainability, and legitimacy?
Long-term psychosocial recovery integrated with reconstruction policy	Mental health and social capital streams are mature, but psychosocial outcomes are often analyzed separately from governance arrangements, resettlement settings, and infrastructure delivery decisions.	How do PTSD/mental health, trust, and social capital evolve over time? How do policies and settlement choices shape these trajectories?
Uneven recovery and rural/urban	The evidence highlights rural vulnerability, the consequences of relocation, and the complexity of	Who benefits least and why? How do relocation and land



divergence	urban–rural reconstruction, but fewer studies fully explain distributional mechanisms (who benefits least and why) over time.	constraints shape livelihoods?
Persistent hazard tail and reconstruction under evolving risk	Secondary hazards are well documented, but there is a gap in studies that integrate hazard evolution with reconstruction siting, land-use governance, and long-term infrastructure maintenance decisions.	How do landslides/debris flows reshape long-term recovery risk? How should monitoring feed into planning and siting?
Technology-enabled recovery governance and decision support	Geospatial and decision-support tools are common, yet evidence is limited on their validated impacts on governance performance (e.g., prioritization quality, fairness, implementation efficiency).	When do GIS/RS/UAV tools improve real decisions (priorities, routing, siting)? How to validate tech-to-policy impact?
Economic resilience as a mechanism (not only an index)	The evidence includes resilience indices and IO/supply-chain analyses, but fewer studies connect these metrics to actionable policy levers and household- and community-level outcomes.	Which policy levers improve resilience and recovery efficiency? How do sectoral structures and interregional linkages shape recovery?

Uneven healing and social disparity are other issues, according to research. In relocation scenarios where reconstruction programs produced differing social and economic results, livelihood circumstances, land availability, and policy design affected recovery trajectories in rural and relocated populations (Chen et al., 2020). Social capital and community recovery studies show that pre-existing social structures affected recovery ability, resulting in uneven recovery experiences (Han, 2017; Wei and Han, 2018). Long-term survey-based research shows that satisfaction with reconstruction and perceived recovery success varied significantly among affected populations, highlighting that recovery is not uniform even with large-scale policy support (Ao et al., 2022). Final discoveries suggest a disconnect between macro-level reconstruction and micro-level lived healing.

The integration of psychosocial recovery into rebuilding frameworks is another major need. Early and long-term studies show significant mental health impacts, including post-traumatic stress and its persistence, but psychological recovery has not always been fully integrated into mainstream reconstruction planning and evaluation. Research relating social capital to mental health shows that psychosocial well-being is directly linked to community structure and social support systems, but policy-driven rebuilding procedures are lacking (Wang, 2022). This suggests a conceptual and practical gap in the approach to rehabilitation as a comprehensive process with material and psychological components. Environmental and geographical constraints are another key issue, especially in hilly and hazard-prone areas where dangers linger after an accident. Studies on debris flows and landslides show that post-earthquake landscapes remained unstable, with rainfall-triggered secondary hazards threatening infrastructure and residents years later (Tang et al., 2011). A monitoring-based study demonstrates that



terrain deformation and slope instability changed over time, indicating dynamic risk conditions (Zhang et al., 2021). Since rebuilding typically occurred under unknown or shifting hazard conditions, our findings reveal a crucial gap in the connection between reconstruction and long-term environmental risk management.

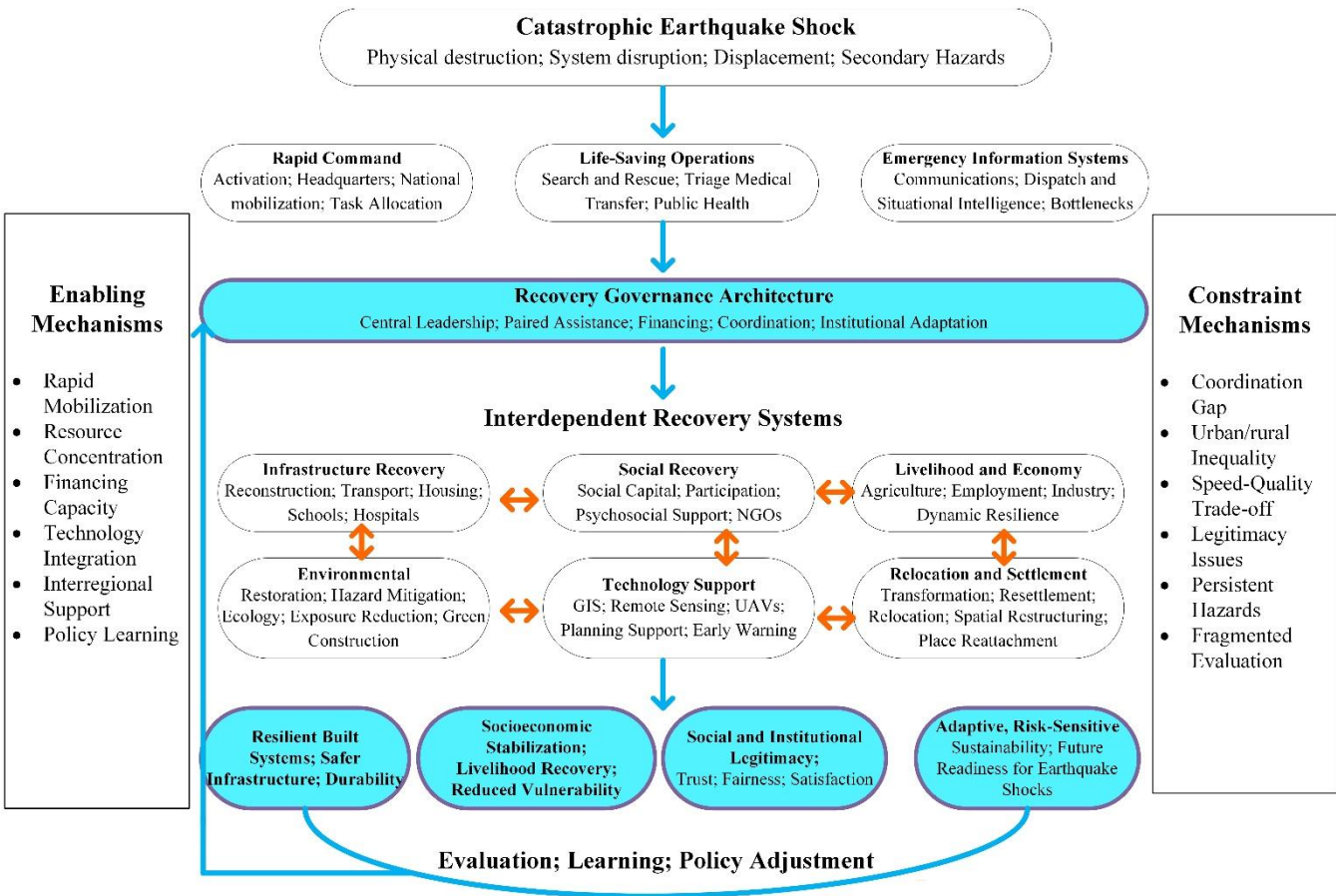


Figure 4: Integrated post-disaster recovery framework

An integrated post-disaster recovery framework is developed, offering several important contributions to the existing literature (See Figure 4). For example, it tackles knowledge fragmentation across disciplines, a major issue in disaster recovery research. Governance, infrastructure, social recovery, economic regeneration, and environmental restoration have been studied separately, making systemic recovery difficult to grasp. The paradigm allows academics to see recovery as a system rather than a collection of activities by combining information from these domains. Second, the framework advances theory by making governance architecture the key post-disaster coordination mechanism. Institutions have been studied before, but this model reveals how governance structures affect recovery-domain interactions and resilience. This adds to the literature by explaining complex and unpredictable recovery processes using governance theory, socio-ecological, and resilience perspectives. Third, infrastructure, social systems, livelihoods, environment, technical support, and spatial reconfiguration impact recovery. Such a systems-based strategy may reveal cross-domain linkages and leverage points, as



well as how recovery components support or constrain one another, in future empirical research. Fourth, the framework captures large-scale recovery conflicts by incorporating enabling factors and system constraints. Cooperation, inequality, legitimacy, and environmental risks impact recovery efficacy, resource availability, and policy design. Recovery studies deepen analysis and enable non-linear assessments of performance indicators. Finally, a monitoring, evaluation, and adaptive policy learning cycle explains healing as a continuous process. Modern resilience and adaptive governance ideas emphasize continuous learning and adaptation to heal. Academics examining long-term recovery trajectories, policy efficacy, and resilience-building in disaster-affected regions can apply the technique.

Current approaches for assessing recovery progress are flawed, according to a study. Economic resilience, recovery efficiency, and “build back better” frameworks organize evaluation, but research demonstrates that recovery assessment is fragmented across economic, social, and environmental dimensions (Zhou et al., 2020). Public opinion and policy evaluation research show that implementation success does not inevitably lead to perceived recovery success, underlining the importance of community perspectives in assessment frameworks (Bahmani et al., 2025). Technical or policy-based indicators don't align with the lived experiences of impacted populations, necessitating more integrated, multidimensional evaluation methodologies. Finally, reconstruction governance faces issues with institutional and structural property rights, resource allocation, and alignment with long-term development. Rebuilding may create new institutional issues due to the complex reconfiguration of property rights and governance changes during the post-disaster institutional transition (Deng, 2010). However, economic and industrial recovery studies reveal that reconstruction strategies and pre-existing economic systems affect recovery results by interacting with structural circumstances, including industry mix and interregional links. These findings demonstrate that recovery is embedded in institutional and economic systems with structural constraints on rebuilding. The final literature describes the Wenchuan earthquake recovery as a large-scale, effective rebuilding effort characterized by continuous coordination, equity, sustainability, psychosocial integration, environmental risk, and evaluation challenges. These structural concerns about complex post-disaster recovery processes suggest changes to future catastrophe management and rebuilding frameworks.

12 Conclusions

The present research synthesizes evidence on post-disaster recovery and rebuilding following the 2008 Wenchuan earthquake, drawing on a vast, interdisciplinary evidence base to assess recovery mechanisms over time. The findings show that recovery is a complex, adaptive system affected by governance structures, infrastructure reconstruction, social dynamics, economic regeneration, and environmental circumstances. The literature repeatedly links recovery effectiveness to institutions' capacity to deploy resources quickly, coordinate across players, and implement policy objectives. The research suggests that speed and size, while crucial in the immediate aftermath, do not ensure long-term resilience or social equity. A significant finding of this research is that governance organizes fragmented recovery domains. The Wenchuan instance shows how centrally planned processes, matched help, and large-scale finance can rebuild quickly and extensively. It also



shows that coordination, local adaptation, and legitimacy remain issues, especially when top-down techniques don't match community demands and lived experiences. The disputes show that the efficacy of rehabilitation depends on institutional capacity and on the interaction between the policy system and the local social context.

Organizations and populations exhibit different recovery patterns, according to the synthesis. Social recovery (particularly mental health, community cohesiveness, and long-term well-being) is slower and less included in official recovery planning than infrastructural and economic recovery. In unstable risk landscapes shaped by secondary hazards such as landslides and debris flows, environmental and biological constraints persist after rebuilding. Findings suggest that rehabilitation should be a long-term, complex process rather than a finite rebuilding phase. The suggested method considers recovery as a complex system influenced by governance, enabling factors, and structural constraints, enhancing current knowledge. This systems approach evaluates social, environmental, institutional, economic, and infrastructural performance holistically. It emphasizes adaptive learning, regular monitoring, and feedback to guide recovery. The Wenchuan earthquake provides a unique example of large-scale recovery under real-world restrictions. These findings imply that future catastrophe recovery plans should prioritize rapid mobilization, rebuilding capacity, coordination quality, social inclusion, integration of environmental risks.

Code and data availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author contributions

Conceptualization, Z.A.S. and A.Y.; methodology, Z.A.S.; software, Z.A.S.; validation, Z.A.S. and A.Y.; formal analysis, Z.A.S.; investigation, Z.A.S.; resources, A.Y.; data curation, Z.A.S. and A.Y.; writing—original draft preparation, Z.A.S.; writing—review and editing, Z.A.S., Z.J., P.P. and A.Y.; visualization, Z.A.S.; supervision, Z.J., P.P. and A.Y.; project administration, Z.A.S. and A.Y.; funding acquisition, A.Y. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare no conflicts of interest.

References

Ao, Y. B., Zhong, J. L., Zhang, Z. J., Han, L. L., Wang, Y., Chen, Y. F., and Wang, T.: Determinants of villagers' satisfaction with post-disaster reconstruction: Evidence from surveys ten years after the Wenchuan earthquake, *Front. Environ. Sci.*, 10, <https://doi.org/10.3389/fenvs.2022.952700>, 2022.

Bahmani, H., Ao, Y., Zhang, W., Xu, Q., Zhu, H., Ren, D., and Yu, H.: From policy implementation to public perception: A dual approach to assessing disaster recovery success in the Wenchuan and Bam earthquake recovery projects, *International Journal of Disaster Risk Reduction*, 117, 105162, 2025.



- Chang, Y., Wilkinson, S., Potangaroa, R., and Seville, E.: Resourcing challenges for post-disaster housing reconstruction: a
740 comparative analysis, *Building Research & Information*, 38, 247–264, 2010.
- Chang, Y., Wilkinson, S., Brunsdon, D., Seville, E., and Potangaroa, R.: An integrated approach: managing resources for
post-disaster reconstruction, *Disasters*, 35, 739–765, <https://doi.org/10.1111/j.1467-7717.2011.01240.x>, 2011a.
- Chang, Y., Wilkinson, S., Potangaroa, R., and Seville, E.: Resourcing for Post-Disaster Reconstruction: A Longitudinal Case
Study Following the 2008 Earthquake in China, *Post-Disaster Reconstruction of the Built Environment: Rebuilding for*
745 *Resilience*, 51–69, 2011b.
- Chang-Richards, A., Seville, E., Wilkinson, S., and Walker, B.: Effects of disasters on displaced workers, in: *Resettlement
challenges for displaced populations and refugees*, Springer, 185–195, 2018.
- Chen, L. and Zhu, Y.: Bridge Design Concept and Innovation of Chengdu-Dujiangyan Intercity Railway-Post Wenchuan
Earthquake Reconstruction Project in Sichuan, China, in: *Proceedings of the 1st International Workshop on High-Speed and*
750 *Intercity Railways: Volume 2*, 205–216, 2012.
- Chen, N., Zhang, Y., Tian, S., Deng, M., Wang, T., Liu, L., Liu, M., and Hu, G.: Effectiveness analysis of the prediction of
regional debris flow susceptibility in post-earthquake and drought site, *J. Mt. Sci.*, 17, 329–339, 2020.
- Deng, F.: Post-disaster reconfiguration of property rights in a transition economy, *Postcommunist Econ.*, 22, 193–206, 2010.
- Du, P., Chen, J., Chen, C., Liu, Y., Liu, J., Wang, H., and Zhang, X.: Environmental risk evaluation to minimize impacts
755 within the area affected by the Wenchuan earthquake, *Science of the total environment*, 419, 16–24, 2012.
- Duan, F., Gong, H., and Zhao, W.: Collapsed houses automatic identification based on texture changes of post-earthquake
aerial remote sensing image, in: *2010 18th International Conference on Geoinformatics*, 1–5, 2010.
- Fan, X. and Albuerne, A.: How Could Community Participation Help to Achieve Build-Back-Better, in: *Proceedings of the
International Conference on Natural Hazards and Infrastructure*, 147, 2022.
- 760 Gong, L., An, L., Liu, M., and Zhang, J.: Road damage detection from high-resolution RS image, in: *2012 IEEE
International Geoscience and Remote Sensing Symposium*, 990–993, <https://doi.org/10.1109/IGARSS.2012.6351235>, 2012.
- Guo, Y.: Urban resilience in post-disaster reconstruction: Towards a resilient development in Sichuan, China, *International
Journal of Disaster Risk Science*, 3, 45–55, 2012.
- Han, J. and Ji, Y.: Empirical analysis of charitable activities during the Wenchuan Earthquake: Telling the NGO story, *The*
765 *China Nonprofit Review*, 1, 173–202, 2009.
- Han, J., Zhang, P., and Song, Y.: The construction of emergency management whole process model based on the emergency
life-cycle: wenchuan case study, *Technology for Education and Learning*, 235–242, 2012.



- Han, Y., Wei, J., and Zhao, Y.: Long-term effects of housing damage on survivors' health in rural China: Evidence from a survey 10 Years after the 2008 Wenchuan earthquake, *Soc. Sci. Med.*, 270, 113641, 2021.
- 770 Han, Z.: Social capital and changes in post-disaster recovery process: Observations from China after the 2008 Wenchuan earthquake, 2017.
- He, L., Lai, K., Lin, Z., and Ma, Z.: Media exposure and general trust as predictors of post-traumatic stress disorder: ten years after the 5.12 Wenchuan earthquake in China, *Int. J. Environ. Res. Public Health*, 15, 2386, 2018.
- Huang, L., Zheng, Q., Yin, X., Luo, M., and Yang, Y.: "Double-edged sword": the effect of cultural distance on post-disaster
775 tourism destination recovery, *Tourism Review*, 77, 146–162, 2022.
- Jia, H., Chen, F., Pan, D., and Zhang, C.: The impact of earthquake on poverty: learning from the 12 May 2008 Wenchuan earthquake, *Sustainability*, 10, 4704, 2018.
- Jiang, W.: Breaking the Carbon Lock-In Effect in Post-disaster Rebuilding: A Case Study of a Wenchuan Earthquake-Stricken City in China, *Comparative Southeast European Studies*, 71, 48–73, 2023.
- 780 Jiang Wei, J. W., Yan Tao, Y. T., Liu Hui, L. H., Li YuanJian, L. Y., Tan Hong, T. H., Hu ZhuangLi, H. Z., and Wang Sen, W. Sen: Reconstruction of the hardest hit disaster area after Wenchuan earthquake greatly impacts on pre-hospital medical care in Deyang city., 2012.
- Kabilijiang, W., Wang, C., Zhu, P., Dong, W., and Hou, Y.: Study on the evaluation of the effectiveness of centralized post-disaster housing reconstruction in rural areas of Dujiangyan city after the Wenchuan earthquake, in: *IOP Conference Series: Earth and Environmental Science*, 012013, 2024.
- 785 Kun, P., Han, S., Chen, X., and Yao, L.: Prevalence and risk factors for posttraumatic stress disorder: a cross-sectional study among survivors of the Wenchuan 2008 earthquake in China, *Depress. Anxiety*, 26, 1134–1140, 2009.
- Lei, B. L., Zhou, Y., Zhu, Y., Huang, X. Y., Han, S. R., Ma, Q., He, J., and Li, Y. Q.: Emergency response and medical rescue in the worst hit Mianyang areas after the Wenchuan earthquake, *J. Evid. Based. Med.*, 1, 27–36, 2008.
- 790 Li, N., Wu, J. D., and Cui, W. J.: Simulation of post-disaster recovery and reconstruction period of Wenchuan earthquake based on adaptive regional input-output model, *Journal of Natural Disasters*, 21, 68–75, 2012.
- Li, Q., Umaier, K., Chen, Y., and Koide, O.: Comparative analysis of urban and rural housing reconstruction post 9.21 Chi-Chi and 5.12 Wenchuan earthquakes: complexity, challenges and policy exploration, *Disaster Prevention and Management: An International Journal*, 33, 406–424, 2024.
- 795 Liu, H., Zhang, D., Wei, Q., and Guo, Z.: Comparison study on two post-earthquake rehabilitation and reconstruction modes in China, *International journal of disaster risk reduction*, 23, 109–118, 2017.



- Liu, J., Lu, D., Wang, Y., and Shi, Z.: A measurement framework of community recovery to earthquake: a Wenchuan Earthquake case study, *Journal of Housing and the Built Environment*, 33, 877–892, 2018.
- Lu, Y. and Xu, J.: NGO collaboration in community post-disaster reconstruction: field research following the 2008 Wenchuan earthquake in China, *Disasters*, 39, 258–278, 2015.
- Lu, Y. and Xu, J.: Low-carbon Reconstruction: A Meta-Synthesis Approach for the Sustainable Development of a Post-Disaster Community, *Syst. Res. Behav. Sci.*, 33, 173–187, 2016.
- Ma, N., Ma, H., He, H., Yu, X., and Caine, E. D.: Characteristics of Wenchuan earthquake victims who remained in a government-supported transitional community, *ASIA-PACIFIC PSYCHIATRY*, 5, E73–E80, <https://doi.org/10.1111/appy.12074>, 2013.
- Ni, C., Chow, M. C. M., Jiang, X., Li, S., and Pang, S. M. C.: Factors Associated with Resilience of Adult Survivors Five Years after the 2008 Sichuan Earthquake in China, *PLoS One*, 10, e0121033-, 2015.
- Ou, J. P. and Li, H.: The regional engineering damage and reconstruction strategy in Wenchuan earthquake of China, *Journal of Earthquake and Tsunami*, 5, 189–216, 2011.
- Qian, L., Guo, J., Zheng, C., Wang, J., and Zhang, H.: Restoring residents' place attachment in long term post-disaster recovery: The role of residential environment, tourism, and social and cultural capital, *International Journal of Disaster Risk Reduction*, 117, 105174, 2025.
- Qiang, L. I., Zhang, J., Jiang, H., and Dan, G.: Analysis on ecological environment quality of Wenchuan county in the past 10 years after Wenchuan earthquake, in: *IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium*, 9585–9588, 2019.
- Sato, H. P. and Harp, E. L.: Interpretation of earthquake-induced landslides triggered by the 12 May 2008, M7. 9 Wenchuan earthquake in the Beichuan area, Sichuan Province, China using satellite imagery and Google Earth, *Landslides*, 6, 153–159, 2009.
- Shao, Y. and Xu, J.: Regulating post-disaster reconstruction planning in China: towards a resilience-based approach?, *Asian Geogr.*, 34, 71–89, 2017.
- Su, F., Cui, P., Zhang, J., and Xiang, L.: Susceptibility assessment of landslides caused by the wenchuan earthquake using a logistic regression model, *J. Mt. Sci.*, 7, 234–245, 2010.
- Sun, H. and Li, Q.: Research and development of seismic base isolation technique for civil engineering structures, in: *2010 International Conference on E-Product E-Service and E-Entertainment*, 1–5, 2010.
- Sun, M., Chen, B., Ren, J., and Chang, T.: Natural disaster's impact evaluation of rural households' vulnerability: The case of Wenchuan earthquake, *Agriculture and Agricultural Science Procedia*, 1, 52–61, 2010.



- Svirchev, L., Li, Y., Yan, L. A., Ma, B. L., and He, C. Y.: Preventing and limiting exposure to geo-hazards: Some lessons from two mountain villages destroyed by the Wenchuan earthquake, *J. Mt. Sci.*, 8, 190–199, <https://doi.org/10.1007/s11629-011-2095-6>, 2011.
- 830 Tang, C., Zhu, J., and Qi, X.: Landslide hazard assessment of the 2008 Wenchuan earthquake: a case study in Beichuan area, *Canadian Geotechnical Journal*, 48, 128–145, 2011.
- Tang, G. and Wang, F.: What factors contribute to nonprofit collaboration? An analysis of response and recovery efforts after the 2008 Wenchuan Earthquake, China, *Saf. Sci.*, 125, 104624, 2020.
- TianxueLIU, YingWANG, YuCHEN, and HaoCHANG: The Impact of Regional Industrial Structure on Resilience to Post-
835 disaster Recovery: A Case Study in Wenchuan and Beichuan Counties of China, *Journal of Catastrophology*, 39, 72–78, <https://doi.org/10.3969/j.issn.1000-811X.2024.03.012>, 2024.
- Ting, W.: Asset building and livelihood rebuilding in post-disaster Sichuan, China, *China Journal of Social Work*, 6, 190–207, <https://doi.org/10.1080/17525098.2013.797360>, 2013.
- Wang, D.: Effects of social capital on mental health of disaster victims: Evidence from the Wenchuan earthquake,
840 *International Journal of Disaster Risk Reduction*, 83, 103386, 2022.
- Wang, G. Z., Li, Y. M., and Liu, L. P.: Relief effort and reconstruction after Wenchuan Ms8. 0 earthquake, *Applied Mechanics and Materials*, 275, 2727–2734, 2013.
- Wang, L., Chang, M., Le, J., Xiang, L., and Ni, Z.: Two multi-temporal datasets to track debris flow after the 2008 Wenchuan earthquake, *Sci. Data*, 9, 525, 2022.
- 845 Wang, L., Bivona, E., Yan, H., and Qi, J.: Using a Hybrid Collaborative Crisis Management Framework to Foster Long-Term Growth in Post-Disaster Reconstruction: Findings From the Chinese Paired Assistance Policy, *Syst. Res. Behav. Sci.*, 43, 146–159, 2026.
- Wei, B. Y. and Su, G. W.: Assessment on indirect economic loss of Wenchuan earthquake disaster based on input-output analysis, *Seismology and Geology*, 38, 1082–1094, 2016.
- 850 Wei, J. and Han, Y.: Pre-disaster social capital and disaster recovery in Wenchuan earthquake-stricken rural communities, *Sustainability*, 10, 2046, 2018.
- Xiao, Y., Olshansky, R., Zhang, Y., Johnson, L. A., and Song, Y.: Financing rapid community reconstruction after catastrophic disaster: Lessons from the 2008 Wenchuan earthquake in China, *Natural Hazards*, 104, 5–30, 2020.
- Xiao-Yan, C., Li, C., and Fan, F.: Posttraumatic stress disorder symptoms in mothers and adolescents after the Wenchuan
855 earthquake: a cross-sectional and longitudinal network analysis, *J. Affect. Disord.*, 368, 555–563, 2025.



- Xie, W., Rose, A., Li, S., He, J., Li, N., and Ali, T.: Dynamic economic resilience and economic recovery from disasters: A quantitative assessment, *Risk analysis*, 38, 1306–1318, 2018.
- Xu, J. and Lu, Y.: A comparative study on the national counterpart aid model for post-disaster recovery and reconstruction: 2008 Wenchuan earthquake as a case, *Disaster Prev. Manag.*, 22, 75–93, 2013.
- 860 Xu, J., Xu, D., Lu, Y., and Wang, Q.: A bridged government–NGOs relationship in post-earthquake reconstruction: the Ya'an service center in Lushan earthquake, *Natural Hazards*, 90, 537–562, 2018.
- Zhang, H. and Tao, Z.: Evaluating China's paired-assistance policy (PAP) in response to the Wenchuan earthquake: A sustainability perspective, *Sustainability*, 10, 3732, 2018.
- Zhang, X., Tang, W., Huang, Y., Zhang, Q., Duffield, C. F., Li, J., and Wang, E.: Understanding the causes of vulnerabilities
865 for enhancing social-physical resilience: lessons from the Wenchuan earthquake, in: *Earthquake Disasters*, Routledge, 24–41, 2021.
- Zhang, Y., Yu, Y., Xu, W., and Hu, J.: Differentiation and integration: off-site resettlement planning practice in New Beichuan after 5.12 Wenchuan Earthquake, *Natural Hazards*, 104, 77–99, 2020.
- Zhang, Y. J., Duan, X. S., Wang, X. Y., Zhou, C. L., and Sun, Y.: Studies on Seismic Measures to Improve Masonry Infilled
870 Wall, *Applied Mechanics and Materials*, 580, 1746–1749, 2014.
- Zhao, G.-F., Yang, Y.-C., Zhang, S.-S., Deng, H., Zhu, Y., Ren, Z.-J., Zhang, W., Sun, X.-L., Li, H.-M., Liu, C.-X., Wang, M., Yue, L.-L., Liu, S.-M., Zhang, Z.-Q., Tao, Q.-L., Chen, Y., Xu, J.-J., Bi, J.-Q., and He, Y.-Y.: A cross-sectional study on the mental status of 780 survivors after Wenchuan earthquake, *Chinese Journal of Evidence-Based Medicine*, 8, 815–819, 2008.
- 875 Zhao, R., Zhong, S., and He, A.: Disaster impact, national aid, and economic growth: evidence from the 2008 Wenchuan earthquake, *Sustainability*, 10, 4409, 2018.
- Zhong, K. and Lu, X.: Exploring the administrative mechanism of China's Paired Assistance to Disaster Affected Areas programme, *Disasters*, 42, 590–612, 2018.
- Zhou, B., Zhang, H., and Evans, R.: Build back better: a framework for sustainable recovery assessment, *International
880 Journal of Disaster Risk Reduction*, 76, 102998, 2022.
- Zhou, K., Liu, B., and Fan, J.: Economic resilience and recovery efficiency in the severely affected area of Ms 8.0 Wenchuan earthquake, *Acta Geogr. Sin.*, 74, 2078–2091, 2019.
- Zhou, K., Liu, B., and Fan, J.: Post-earthquake economic resilience and recovery efficiency in the border areas of the Tibetan Plateau: A case study of areas affected by the Wenchuan M s 8.0 Earthquake in Sichuan, China in 2008, *Journal of
885 Geographical Sciences*, 30, 1363–1381, 2020.



Zhou, W., Mao, F., Liu, Z. E., Li, Q., and Fu, Q.: Research and application of planning support system based on 3S technique for post-disaster reconstruction after Wenchuan Earthquake in China, in: 2009 IEEE International Geoscience and Remote Sensing Symposium, II-666-II-669, <https://doi.org/10.1109/IGARSS.2009.5418174>, 2009.

890 Zhu, J. and Hu, M.: Pluralistic Governance: Reflecting on Participatory Development Theory in Post-disaster Community Reconstruction—a Case Study of the Post-Wenchuan Earthquake New Home Plan, in: Urban Chinese Governance, Contention, and Social Control in the New Millennium, Brill, 39–73, 2019.

Zhu, Y. and Thanh, L. B.: Functionality, Effectiveness, and Shortcomings of the Command Systems Employed in the Central Government-Led Response to the 2008 Wenchuan Earthquake, in: International Symposium on Disaster Resilience and Sustainable Development, 211–224, 2023.