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How Can Post-Disaster Recovery Plans Be Improved Based on Historical Learning? A Comparison of Wenchuan Earthquake and Lushan Earthquake Recovery Plans

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Abstract: Despite the emphasis on sustainability in post-disaster recovery plans (PDRPs), few studies have been conducted to investigate the information conveyed in disaster recovery plans in terms of sustainability. We aimed to investigate, in terms of sustainability, how post-disaster recovery plans can be improved from historical learning by examining local recovery plans that were developed and adopted after the Wenchuan and Lushan earthquakes, which are two representative post-disaster recovery cases in China. An evaluation protocol for sustainability issues was developed to analyze the recovery plans of the most severely affected counties and towns in Wenchuan (16 samples) and Lushan (7 samples). A comparative analysis was conducted to identify the similarities, differences, and evolution of sustainability considerations in these PDRPs. Semi-structured interviews with key informants were conducted to supplement the evaluation with qualitative data. The results show that the components and concepts of sustainability in PDRPs are conveyed and developed mostly by following the organization's existing patterns and regulations. In contrast, some components are retained across plans, thereby suggesting a substantial general structure of recovery plans. The underlying logic of this experience transfer across plans was discussed. The findings can help local governments and planners to effectively incorporate sustainability into PDRPs.

Keywords: Wenchuan earthquake; Lushan earthquake; post-disaster recovery plans (PDRPs); sustainability; plan evaluation; experience transfer

1. Introduction

After experiencing the Wenchuan earthquake in 2008 and the Lushan earthquake in 2013, the Chinese state and local governments established standard guidelines for conducting post-disaster recovery and reconstruction work. Two typical catastrophe response models were initially developed after the Wenchuan and Lushan earthquakes. After the Wenchuan earthquake, more than 200 post-disaster recovery and reconstruction policies were issued by the national and local governments in 2008, in which 19 provinces and municipalities participated in the paired assistance program. Then, the Lushan earthquake provided the opportunity for China to foster a new model of locally-led post-disaster reconstruction. This model has transformed the national assistance model into an

intra-provincial assistance model. The cities and counties in Sichuan province were paired to achieve the goal of reconstruction within three years.

Post-disaster recovery plans (PDRPs) now occupy a commanding position in reconstruction work. PDRPs are different from conventional plans and are developed in the special context of sudden disasters (i.e., disasters with short time duration, staggered tasks, and diversified demands). PDRPs are associated with recent construction plans and are consistent with the long-term development of disaster-affected areas. From a practical perspective, many studies have demonstrated that the urgency and high uncertainty of PDRPs may lead to various problems, such as secondary disasters after short-term decision-making, the ignorance of the root causes of regional vulnerability from a long-term perspective, and even the amplification of social, economic, and environmental weaknesses. Therefore, sustainability, which aims to realize the quality of being able to continue over a period of time, must be included as a key control dimension in the recovery process [1].

In the late 1970s, Haas et al. completed a pioneering study on post-disaster recovery [2] that continued into the 1980s. Post-disaster land use was the first application of the disaster recovery plan (DRP) [3]. Publications on post-disaster recovery and reconstruction plans were compiled by the United States Planning Bureau and filled the research gap regarding post-disaster recovery [4]. Empirical studies on post-disaster recovery have mainly focused on housing reconstruction [4–12], commercial recovery [13–16], urban planning [17–20], disaster sociology [21–23], and policy implementation [24–27]. The Handbook for Post-Disaster Recovery Practice proposed a "favorable" evaluation rule of post-disaster recovery and reconstruction plans [28]. This handbook set the basis for future post-disaster recovery and reconstruction research. Berke et al. used the assessment of 87 local PDRPs of eight states in the Southeast United States to integrate the plan quality principles into the anticipatory governance model and to build a new model for adaptive planning [20]. However, few studies have been conducted to investigate PDRPs in China. After the Wenchuan earthquake, studies have focused on reconstruction experience and summary [29,30], reconstruction policy analysis [12,27,31–34], reconstruction technology [35–37], reconstruction satisfaction surveys [38–40], and reconstruction plans [41–43]. The lack of incorporation of sustainability perspectives affects the plan quality and implementation. Thus, no definitive answer has been generated for determining the ideal PDRP.

The concept of sustainability started being applied in the field of post-disaster recovery and reconstruction in the 1990s [44,45]. The recovery process is highly time-constrained compared to the process of urban development [46]; thus, integrating sustainability into the recovery process presents a challenge. The importance of sustainable development in disaster prevention and mitigation has been established, but a comprehensive theory on sustainable post-disaster recovery and reconstruction has still not been proposed [18]. Therefore, PDRPs' documents provide guidelines for the proper implementation of sustainable development principles and reconstruction plans. A consensus has been reached on the core principles of plan quality (e.g., goals, fact base, policies, implementation, and inter-organizational coordination), as well as the measurable indicators that must be adapted in a particular planning domain [47–49]. Song et al. evaluated the quality of PDRPs after the Wenchuan earthquake and further explored the practicality of making these plans sustainable [1].

We aimed to evaluate PDRPs in China and to define the elements of sustainable planning in order to establish an evaluation framework that combines plan quality and sustainability. In the evaluation system, two representative examples of post-disaster recovery and reconstruction models were selected: (1) Wenchuan for state-led reconstruction and (2) Lushan for locally-led reconstruction. The similarities and differences between the two recovery plans were explored to compare their qualities. Semi-structured interview techniques were used to supplement our evaluation. Experiences and inspirations were summarized through a comparative analysis of the results. These findings can help local governments and planners to further integrate the concept of sustainability into the PDRPs, improve the quality of PDRPs in China, and promote sustainable development in the reconstruction areas.

2. Sustainability Evaluation Criteria in Post-Disaster Recovery Plans (PDRPs)

Baer [47] proposed a conceptual model called "plan evaluation" and established a set of criteria for the systematic evaluation of plans. Since then, scholars have conceptualized the composition and basic criteria for plan quality in multiple planning domains. Plans in Australia, Canada, the Netherlands, New Zealand, the United States, and the United Kingdom have been evaluated. Based on Baer [47] and Berke et al. [50], Berke and Godschalk [48] classified the evaluation of plan quality into two dimensions: (1) internal characteristics, including issue identification and vision, goals, fact base, policies, implementation, monitoring and evaluation, and internal consistency; and (2) external characteristics, such as organization and presentation, inter-organizational coordination, and compliance.

These evaluation principles are applicable to the assessment of plans for mitigating natural hazards, which are "time-and place-specific events that originate in the natural environment and the resulting disruption of the usual functions and behaviors of the exposed human population" [51]. The five main sections of Federal Emergency Management Agency's Blue Book for hazard mitigation plans are closely related to these principles. However, due to the high degree of uncertainty and short-term decision-making in PDRPs [52], Berke et al. integrated the established plan quality principles into the anticipatory governance model [20,53,54]. These researchers proposed six dimensions of recovery plan quality principles: goals, fact base, policies, inter-organizational coordination, participation, implementation, and monitoring. Few studies have evaluated sustainable development plans, but similar studies have been conducted for other types of urban plans. Berke critically and comprehensively studied the concept of sustainable development [55]; this author identified four characteristics of sustainable development: reproduction, balance, linking local to global concerns, and dynamic process, and proposed six principles of sustainable development: harmony with nature, livable built environments, place-based economy, equity, polluter pay, and responsible regionalism. Song et al. embedded sustainability into plan evaluation using the quality indicators proposed by Berke et al. and the six PDRP principles formulated by Berke and Horney [1,20].

In the present study, we established an evaluation system based on the aforementioned works. The short-term and complex nature of recovery planning and the characteristics and principles of sustainable development comprise our proposed system. We merged similar principles and ultimately used the five principles as evaluation criteria:

(1) Information base. Sufficient information is a prerequisite for sustainable development. The following information must be included to place sustainability as a basis for a good plan: (a) determining the degree of danger, such as the boundary and magnitude of the earthquake; (b) analyzing the degree of potential secondary disasters, such as earthquake-induced dammed lakes, floods, and landslides; (c) assessing ecosystems and their carrying capacity; (d) analyzing current and future scenarios of potential vulnerabilities, which are the inability of the social-economic system to withstand the effects of natural hazards [56,57]; and (e) assessing plan capacity, including a list of all relevant data sets, plans, and financial and technical capabilities.

(2) Vision, goals, and targets. We expect that the vision for a PDRP must include sustainability and resilience as the most basic and important goals. Resilience is a dimension of sustainability that is particularly important in post-disaster recovery. In our evaluation framework, resilience emphasizes the goal of increasing the capacity of an area to prevent risk and to aid recovery from subsequent disasters [58–60]. Sustainability goals must consider the environment, the economy, and equity as the three basic dimensions.

(3) Policy actions and strategies. In sustainable disaster recovery, returning to normality is not always the most satisfying outcome because people may re-embrace the vulnerability to future disasters. Therefore, we assume that sustainable recovery actions must include recovery and improvement actions and strategic compositions to promote further resilience. Policy measures and strategies must be fully sustainable. These strategies include considering risk mitigation, restoring ecosystems (including forests, wetlands, soil, and contours), strengthening infrastructure, a safe local economy and

housing construction, the strategic deployment of land use, implementing strict building regulations, and regulations that require the reconstruction of sustainable locations and patterns.

(4) Participation and coordination. Allowing the participation of stakeholder groups and the public helps to reduce conflicts and ensure high public support for the program. Participation ensures that the plan reflects local requirements, thereby increasing the likelihood that local stakeholders will support the plan. Coordination among government agencies is preferred to ensure that the plan is supported and will be implemented by the government. Several coordination strategies include the horizontal coordination of government departments at all levels, vertical coordination among government departments at all levels, and coordination across different types of plans.

(5) Implementation and monitoring. Implementation and monitoring are crucial for integrating sustainability into earthquake recovery procedures. The implementation of actions, organizational responsibilities, implementation schedules, funding sources, and methods of updating plans must be clearly stated in public documents to clarify the agenda. Indicators for tracking recovery results must be established to provide feedback during planning and to inform future planning actions. The receiving, recording, and managing of recovery funds from governmental and non-governmental organizations must be clarified in the recovery plan to establish public sector accountability and gain public support.

3. Research Method

In order to effectively compare the PDRPs of Wenchuan and Lushan earthquakes, this study takes a logic flow as shown in Figure 1. The analysis unit is the post-earthquake recovery plan at the county and township levels after the Wenchuan and Lushan earthquakes. This is because the recovery plans at the county and township levels obtained little attention in past research. In addition, it is extremely meaningful to examine local recovery plans as local actions play a great role in disaster recovery. A plan evaluation protocol based on existing studies is developed to examine and assign values for the selected PDRPs. Double coding is undertaken to ensure the reliability of the assessment results. Mean and standard deviation of samples for each indicator specified in the evaluation protocol are used to compare the performance of PDRPs at the county and township levels after Wenchuan and Lushan earthquakes. In-depth discussions and recommendations are also provided based on the findings. The following subsection will present the research process and findings in detail.

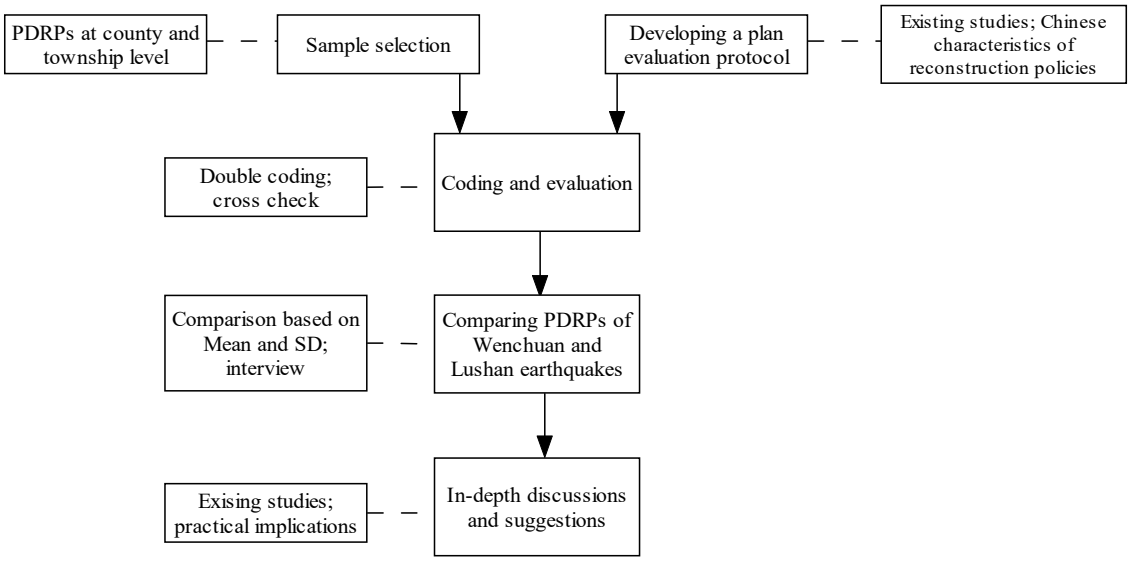

Figure 1. Research flow of this research.

3.1. Sample Selection

The units in this study mainly include the post-earthquake recovery plans at the county and township levels. We selected our sample from the most seriously affected areas in Lushan county and the areas in Baoxing and Tianquan counties where the earthquake hit the hardest. Four town-level recovery plans from Lushan were included. Based on previous research, recovery plan documents for eight of the most severely affected counties in Wenchuan and eight town-level recovery plans from the hardest-hit areas within Wenchuan and Beichuan counties were collected (Appendix A).

Our team had already evaluated the recovery plan for the Wenchuan earthquake. All planning documents used in the study were obtained from local governments and planning agencies responsible for drafting plans. Each plan was developed in an urgent way within 6 months of the disaster.

3.2. Developing a Plan Evaluation Protocol

To ensure the consistency of plan evaluation, we used the assessment framework from the Wenchuan recovery plan document. We critically analyzed 7 and 16 recovery plans for the Lushan and Wenchuan earthquakes, respectively. The evaluation system is based on the quality indicators from Berke's recovery plan and the local disaster recovery plan quality analysis tools created by Berke et al. [20]. We selected indicators that can be used to evaluate the sustainability of plans and added some indicators related to the Chinese characteristics of reconstruction policies. An example of an added indicator was "coordinate resources from 'paired assistance' program". The evaluation framework system based on the abovementioned evaluation indicators is displayed in Table 1.

Table 1. Description of indices and individual items used in plan coding.

Plan Components	Sub-Components	Coding Items
Information base	1.1 Hazard identification	1.1.1 Earthquake location/boundary identification
		1.1.2 Earthquake magnitude identification
		1.1.3 Secondary hazards (earthquake-induced dammed lakes, flash floods, landslides, etc.) identification
	1.2 Current vulnerability	1.2.1 Infrastructure vulnerability assessment
		1.2.2 Natural environment vulnerability assessment
		1.2.3 Population vulnerability assessment
		1.2.4 Housing vulnerability assessment
		1.2.5 Economy vulnerability assessment
	1.3 Ecological capacity	1.3.1 Ecological capacity assessment
	1.4 Future scenario(s) for vulnerability	1.4.1 Scenarios of future impacts
		1.4.2 Scenarios based on a range of future earthquake severities
		1.4.3 Scenarios based on alternative future growth patterns
	1.5 Capability assessment	1.5.1 Inventory of relevant plans
		1.5.2 Fiscal capability assessment
		1.5.3 Technical capability assessment
Vision, goals, and targets	2.1 Vision	2.1.1 Sustainability
		2.1.2 Resilience
	2.2 Goals and targets	2.2.1 Environment
		2.2.2 Economic development
		2.2.3 Equity
		2.2.4 Community rebuilding
		2.2.5 Public safety

Table 1. *Cont.*

Plan Components	Sub-Components	Coding Items
Policy actions and strategies	3.1 Secondary hazard solutions	3.1.1 Secondary hazard avoidance initiatives (e.g., flood discharge, slope stabilization)
	3.2 Forest restoration	3.2.1 Forestry system restoration (if applicable)
		3.2.2 Wildlife habitat restoration (if applicable)
	3.3 Wetland restoration	3.3.1 Wetland restoration (if applicable, for wetlands damaged in the earthquake)
		3.3.2 Wetland buffer preservation (if applicable)
	3.4 Soil and contour restoration	3.4.1 Natural soil restoration
		3.4.2 Natural drainage system preservation
		3.4.3 Re-vegetation for slope stabilization
	3.5 Infrastructure restoration	3.5.1 Repair/restoration
		3.5.2 Relocation to avoid hazard areas
		3.5.3 Target priority redevelopment areas
	3.6 Economic recovery	3.6.1 Sustainable principles in industrial layout (location, holding capacity, etc.)
		3.6.2 Sustainable industries (e.g., ecological industry)
	3.7 Housing regulations	3.7.1 Temporary housing: siting criteria (safe location, proximity to public services, holding capacity, etc.)
		3.7.2 Long-term housing: siting criteria (safe location, holding capacity, equity, etc.)
		3.7.3 Long-term housing: programs to transition people to permanent housing (rebuild, relocate, repair, etc.)
	3.8 Land-use regulations	3.8.1 Land use ordinances to ensure safety/compactness of urban land uses
		3.8.2 Site design requirement for hazard mitigation
	3.9 Building reconstruction standards	3.9.1 Structural strengthening for damaged buildings
		3.9.2 Strict seismic codes for new buildings (stricter for public buildings)
		3.9.3 Green building standards
	3.10 Redevelopment regulations	3.10.1 Sustainable patterns, including type, location, and the density of development
		3.10.2 Safe location for redevelopment (away from earthquake areas, floodplains, etc.)
		3.10.3 Requires dedication and/or preservation of open/green space (to host emergency shelters)
		3.10.4 Requires low impact development (i.e., preserving natural landscape features, minimizing effective imperviousness, etc.)
Participation and coordination	4.1 Description of the planning process	4.1 Provides a general narrative overview of how the recovery plan was prepared
	4.2 Public engagement techniques	4.2.1 Public comments/recommendations *
		4.2.2 Public meetings *
		4.2.3 Public notice *
		4.2.4 Website *
		4.2.5 Targeted outreach * (surveys, questionnaires, etc.)
	4.3 Horizontal coordination	4.3.1 In-house (within local government)
		4.3.2 With independent groups/stakeholders (within local jurisdictions)
		4.3.3 Across local jurisdictions
	4.4 Vertical coordination	4.4.1 Central government
		4.4.2 Provincial government
		4.4.3 City government
	4.5 Other post-disaster forms of coordination	4.5.1 Coordinate recovery volunteers through voluntary organizations or other means
		4.5.2 Coordinate resources from paired assistance program

Table 1. *Cont.*

Plan Components	Sub-Components	Coding Items
Implementation and monitoring	5.1 Implementation strategies	5.1.1 Implementation actions
		5.1.2 Organizational responsibility
		5.1.3 Implementation timeline
		5.1.4 Funding sources
		5.1.5 Method/schedule of updating
	5.2 Monitoring losses/recovery	5.2.1 Indicators that track losses
		5.2.2 Indicators that track recovery outcomes
		5.2.3 Organizational responsibility
	5.3 Financial monitoring and accountability	5.3.1 Processes to receive, record, and manage recovery funds from the central government and partner provincial/city governments
		5.3.2 Processes to monitor all recovery resources, including non-profit, private sector, and quasi-governmental organizations

Note: * is marked with a 0–1 binary code, other items are 0–2 ordinal codes.

Both the highlighted and overlooked factors in the current plan can be identified on the basis of the scores of the different code items. This framework system can be used to compare the recovery of different governments levels and recovery themes. The asterisk is marked with a 0–1 binary code (0 indicates that the item is excluded from the plan; 1 indicates a description associated with the item in the plan), whereas other items are 0–2 ordinal codes (0 indicates no mention in the plan, 1 indicates a general description in the plan, and 2 indicates detailed descriptions, including plans and tables, in the plan). Figure 2 presents three examples of applying the evaluation method to the collected recovery plan samples.

Example 1. For the coding of item 1.1.1, Earthquake location/boundary identification: In the first chapter of the Baoxing Post-Disaster Recovery Plan 2013–2020 (p. 133), the damage status and reconstruction conditions mentioned are: "In the 4.20 earthquake, Lingguan is close to Lushan County, which was the epicenter of the earthquake, and it was a serious disaster area in Baoxing County". Because the word "close" is not accurate, this item was assigned a score of 1. Comparatively, the Tianquan Post-Disaster Recovery Plan (p. 2) mentioned in the disaster situation and characteristics chapter: "On April 20, 2013, an earthquake of magnitude 7.0 occurred in Lushan County, Sichuan Province. Tianquan County, 15 kilometers from the epicenter of the earthquake, suffered a great loss of life, property, economy, and society of the people of the county." This description is accurate in terms of the distance, so it was assigned a score of 2.

Example 2. For the coding of item 3.1.1, Secondary hazard avoidance initiatives: In the Lushan Post-Disaster Recovery Plan 2013–2030 (p. 54–57), chapter 5.9.3 mentioned that : "the main measures include clearing danger, repairing retaining wall and rock retaining wall, strengthening anti-slide pile, sealing and supporting, drainage groove, active and passive protective net, etc." The main measures adopted are described in detail, so it was assigned a score of 2. *Tianquan Post-Disaster Recovery Plan* (p. 26) only summarizes in one sentence: "In view of the secondary disasters that may occur after the earthquake, attention should be paid to flood control facilities and the reinforcement of upstream reservoirs". It was assigned a score of 1.

Example 3. For the coding of item 2.2.2, Economic development: the Baoxing Post-Disaster Recovery Plan 2013–2020 (p. 26) only mentions in the planning principle "Inheriting culture and protecting ecology", but does not provide a description, so it was assigned a score of 1. In the Lushan Post-Disaster Recovery Plan 2013–2030 (p. 11), resources and environment as a sub-project are described in a whole paragraph, and the specific forest coverage and the number of days reaching the air quality standard are accurately described so it was assigned a score of 2.

Figure 2. Illustration of how to evaluate the post-disaster recovery plan (PDRP) documents.

During the analysis, we performed double coding to ensure the reliability of the results before computing the intercoder reliability scores. An overall intercoder reliability score of 76.3% was obtained. The Wenchuan earthquake had the same overall intercoder reliability score, whereas Lushan

earthquake had a score of 87.2%. As the reliability of plan quality assessment is 70–97%, the results of this study are within the acceptable range [48]. For easy comparison, the weights of the items were normalized by obtaining the index scores through the addition of the coded values for each item number and the division of the total number of coded items, in accordance with the method used to evaluate the previous plan. We doubled the coding values for all binary items to make them consistent with other coding weights.

3.3. Key Informant Interviews

We conducted semi-structured interviews with key people who were directly or indirectly involved in preparing recovery plans to comprehensively assess the recovery plan and obtain complementary information that was not mentioned in the collected documents. The qualitative data gathered from the interviews could help us to understand the reasons behind the scores. Ten of the interviewees were planners who participated in creating the recovery plans, and the other 10 interviewees were government officials from central, provincial, municipal, and local governments who were responsible for making recovery plans. The accuracy and authenticity of the content were ensured by recording all interviews and handling interview information anonymously.

The interview protocol (Appendix B) was developed in conjunction with the specific items of the planning document. A research assistant transcribed and used open coding for the results, and then inputted the results into the textual assessment system. Notably, interview data were only used as a supplement to explain the score (i.e., interviews did not affect the evaluation results).

4. Findings

The assessment results of the recovery plans for the Lushan and Wenchuan earthquakes are summarized in Table 2. The comparison results of the code scores were used as bases for the conclusions.

Table 2. Plan quality indices and evaluation results.

Principles	Indices	Mean		Standard deviation		Range		No. of Items
Information base	Hazard identification	CW = 1.33 TW = 0.75	CL = 1.61 TL = 0.83	CW = 0.88 TW = 0.68	CL = 0.35 TL = 0.43	CW = 0–2 TW = 0–2	CL = 1.33–2 TL = 0.33–1.33	3
	Current vulnerability	CW = 1.40 TW = 0.65	CL = 1.33 TL = 0.93	CW = 0.44 TW = 0.75	CL = 0.42 TL = 0.75	CW = 0.80–2 TW = 0–2	CL = 1–1.80 TL = 0.30–2	5
	Ecological capacity	CW = 1.13 TW = 0.38	CL = 1.33 TL = 0.63	CW = 0.78 TW = 0.70	CL = 1.15 TL = 0.95	CW = 0–2 TW = 0–2	CL = 0–2 TL = 0-2	1
	Future scenario(s) for vulnerability	CW = 0.08 TW = 0.13	CL = 0.00 TL = 0.00	CW = 0.14 TW = 0.23	CL = 0.00 TL = 0.00	CW = 0–0.33 TW = 0–0.67	CL = 0 TL = 0	3
	Capability assessment	CW = 0.42 TW = 0.67	CL = 0.94 TL = 0.67	CW = 0.28 TW = 0.33	CL = 0.48 TL = 0.00	CW = 0–0.67 TW = 0–1.33	CL = 0.67–1.50 TL = 0.67	3
	Overall mean	CW = 0.90 TW = 0.55	CL = 1.04 TL = 0.65	CW = 0.33 TW = 0.52	CL = 0.22 TL = 0.26	CW = 0.33–1.27 TW = 0.13–1.27	CL = 0.90–1.30 TL = 0.37–1	15
Vision, goals, and targets	Vision	CW = 0.94 TW = 0.38	CL = 1.08 TL = 0.81	CW = 0.39 TW = 0.41	CL = 0.14 TL = 0.85	CW = 0–1.50 TW = 0–2	CL = 1.00–1.25 TL = 0–2	2
	Goals and targets	CW = 1.23 TW = 0.78	CL = 1.33 TL = 0.78	CW = 0.44 TW = 0.52	CL = 0.12 TL = 0.26	CW = 0.60–1.60 TW = 0–1.80	CL = 1.20–1.40 TL = 0.4–1	5
	Overall mean	CW = 1.14 TW = 0.66	CL = 1.26 TL = 0.79	CW = 0.32 TW = 0.46	CL = 0.04 TL = 0.36	CW = 0.71–1.57 TW = 0–1.57	CL = 1.21–1.29 TL = 0.43–1.29	7
Policy actions and strategies	Secondary hazard solutions	CW = 2.00 TW = 1.38	CL = 1.50 TL = 0.88	CW = 0.00 TW = 0.86	CL = 0.00 TL = 0.75	CW = 2–2 TW = 0–2	CL = 1.50 TL = 0–1.50	1
	Forest restoration	CW = 0.81 TW = 0.31	CL = 0.83 TL = 0.31	CW = 0.70 TW = 0.66	CL = 0.76 TL = 0.24	CW = 0–2 TW = 0–2	CL = 0.00–1.50 TL = 0–0.50	2
	Wetland restoration	CW = 0.00 TW = 0.25	CL = 0.67 TL = 0.31	CW = 0.00 TW = 0.66	CL = 0.63 TL = 0.24	CW = 0–0 TW = 0–2	CL = 0.00–1.25 TL = 0–0.50	2
	Soil and contour restoration	CW = 0.04 TW = 0.25	CL = 0.94 TL = 0.17	CW = 0.11 TW = 0.46	CL = 0.51 TL = 0.19	CW = 0–0.33 TW = 0–1.33	CL = 0.50–1.50 TL = 0–0.33	3

Table 2. *Cont.*

Principles	Indices	Mean		Standard deviation		Range		No. of Items
	Infrastructure restoration	CW = 1.83 TW = 1.13	CL = 0.94 TL = 0.88	CW = 0.29 TW = 0.50	CL = 0.35 TL = 0.52	CW = 1.33–2 TW = 0.33–2	CL = 0.67–1.33 TL = 0.17–1.33	3
	Economic recovery	CW = 1.25 TW = 1.00	CL = 1.58 TL = 0.88	CW = 0.66 TW = 0.75	CL = 0.38 TL = 0.72	CW = 1.33–2 TW = 0–1.33	CL = 1.25–2.00 TL = 0–1.75	2
	Housing regulations	CW = 1.58 TW = 0.91	CL = 0.61 TL = 0.92	CW = 0.32 TW = 0.57	CL = 0.35 TL = 0.32	CW = 1.33–2 TW = 0–1.33	CL = 0.33–1.00 TL = 0.50–1.17	3
	Land use regulations	CW = 1.00 TW = 0.88	CL = 1.58 TL = 0.81	CW = 0.00 TW = 0.33	CL = 0.14 TL = 0.47	CW = 1–1 TW = 0–1	CL = 1.50–1.75 TL = 0.50–1.50	2
	Building reconstruction standards	CW = 0.88 TW = 0.63	CL = 1.06 TL = 0.83	CW = 0.55 TW = 0.51	CL = 0.10 TL = 0.24	CW = 0–1.33 TW = 1.33	CL = 1.00–1.17 TL = 0.67–1.17	3
	Redevelopment regulations	CW = 1.06 TW = 0.66	CL = 1.25 TL = 0.47	CW = 0.46 TW = 0.53	CL = 0.25 TL = 0.16	CW = 0.25–1.50 TW = 0–1.50	CL = 1.00–1.50 TL = 0.25–0.63	4
	Overall mean	CW = 1.02 TW = 0.71	CL = 1.06 TL = 0.63	CW = 0.16 TW = 0.40	CL = 0.23 TL = 0.14	CW = 0.64–1.16 TW = 0.16–1.44	CL = 0.80–1.22 TL = 0.44–0.74	25
Participation and coordination	Planning process	CW = 0.13 TW = 0.13	CL = 0.67 TL = 1.33	CW = 0.33 TW = 0.33	CL = 1.15 TL = 0.85	CW = 0–1 TW = 0–1	CL = 0.00–0.67 TL = 0–2	1
	Public engagement techniques	CW = 0.70 TW = 0.25	CL = 1.20 TL = 0.75	CW = 0.84 TW = 0.19	CL = 0.00 TL = 0.70	CW = 0–2.40 TW = 0–0.40	CL = 1.20 TL = 0.40–1.80	5
	Horizontal coordination	CW = 0.25 TW = 0.33	CL = 0.72 TL = 0.46	CW = 0.46 TW = 0.44	CL = 0.10 TL = 0.25	CW = 0–1.33 TW = 0–1	CL = 0.67–0.83 TL = 0.33–0.83	3
	Vertical coordination	CW = 1.25 TW = 0.96	CL = 1.11 TL = 0.42	CW = 0.40 TW = 0.63	CL = 0.77 TL = 0.17	CW = 0.67–2 TW = 0–2	CL = 0.67–2.00 TL = 0.33–0.67	3
	Other post-disaster forms of coordination	CW = 0.88 TW = 0.81	CL = 1.00 TL = 0.63	CW = 0.22 TW = 0.24	CL = 0.00 TL = 0.25	CW = 0.50–1 TW = 0.50–1	CL = 1.00 TL = 0.50–1.00	2
	Overall mean	CW = 0.58 TW = 0.49	CL = 1.01 TL = 0.63	CW = 0.29 TW = 0.28	CL = 0.24 TL = 0.40	CW = 0.21–1.07 TW = 0.14–0.93	CL = 0.86–1.29 TL = 0.36–1.21	14
Implementation and monitoring	Implementation strategies	CW = 1.20 TW = 1.23	CL = 1.33 TL = 1.23	CW = 0.45 TW = 0.47	CL = 0.23 TL = 0.26	CW = 0.40–1.60 TW = 0.20–1.60	CL = 1.20–1.60 TL = 1–1.60	5
	Monitoring losses/recovery	CW = 0.00 TW = 0.00	CL = 0.22 TL = 0.17	CW = 0.00 TW = 0.00	CL = 0.25 TL = 0.19	CW = 0–0 TW = 0–0	CL = 0.00–0.50 TL = 0–0.33	3
	Financial monitoring and accountability	CW = 0.50 TW = 0.06	CL = 0.67 TL = 0.50	CW = 0.35 TW = 0.17	CL = 0.29 TL = 0.00	CW = 0–1 TW = 0–0.50	CL = 0.50–1.00 TL = 0.50	2
	Overall mean	CW = 0.70 TW = 0.63	CL = 0.87 TL = 0.76	CW = 0.19 TW = 0.25	CL = 0.25 TL = 0.16	CW = 0.30–0.90 TW = 0.10–0.90	CL = 0.70–1.15 TL = 0.65–1	10

Note: CW = County in Wenchuan earthquake; TW = Town in Wenchuan earthquake; CL = County in Lushan earthquake; TL = Town in Lushan earthquake; the same below.

4.1. Information Base

The specific encoding values of the information bases are plotted in Figure 3. The overall trends of the evaluation of the recovery plan are nearly the same for hazard identification, current vulnerability, ecological capacity, and capacity assessment. The basic information is insufficient to understand the relevant issues regarding the disaster, especially at the township level. The scores of the items closely related to sustainability, particularly ecological capacity and future scenarios for vulnerability, are extremely low.

The quality is slightly better in the Lushan earthquake's information base than in that of the Wenchuan earthquake. According to the interviews, the Lushan earthquake had less of an impact and less damage-related data than the Wenchuan earthquake. Local governments have a reserve for data collection and have considerable experience in data collection after earthquakes. Before the experts entered the site, relevant assessment reports had already been completed.

Hazard identification and current vulnerability have the highest relative scores. The understanding of the basic disaster situation is thorough. Secondary disasters are more accurately identified in the Lushan earthquake information base than in that of the Wenchuan earthquake; the current vulnerability is slightly lower in the former than in the latter. This result is mainly reflected in the results of the economic vulnerability assessment. No digital description of direct economic losses was found in

the Lushan earthquake documents. The data and interviews revealed that, in contrast to Wenchuan, the country did not disclose the direct economic losses of the Lushan earthquake. Economic losses due to the disaster in Lushan were estimated, but no accurate value was given. In terms of ecological carrying capacity, we found that many key chapters or paragraphs in the national- and county-level recovery plans seldom involve townships. Similarly, relevant reports on ecological carrying capacity at the national level seldom involve townships.

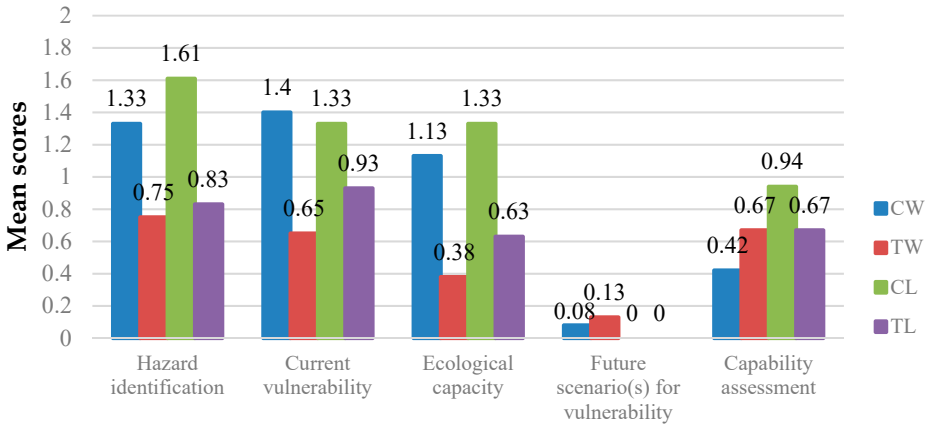

Figure 3. Indices mean scores of the information base.

Among the five indices, future vulnerability scenario (s) scored the lowest. The PDRPs of the Lushan earthquake rarely included a relevant description of these indices. The interviewees indicated that the future vulnerabilities, such as site selection, infrastructure, traffic, and green space system, have been considered in the recovery plans, but the specific scenarios and alternatives are frequently not indicated in the document. Based on the capacity assessment, nearly all plans have planning lists. Technical assessments have clearer technical routes and more advanced reconstruction techniques for the Lushan earthquake than for the Wenchuan earthquake. Provincial paired assistance counties supported the rebuilding. The recovery plans of the three counties involved in the Lushan earthquake were directly supported by the top Chinese planning institutes, and the local design institute assisted throughout the process. Thus, the contents of these plans were integral.

4.2. Visions, Goals, and Targets

Figure 4 shows that the score of goals and targets is higher than that of the vision. The scores are higher for the Lushan than in the Wenchuan earthquake. This result is due to the target of the plan for Shuangshi Town being simple and empty, thus resulting in a low score.

In terms of planning visions, sustainability and resilience were thoroughly included. The reconstruction policy documents of both earthquakes state that "we should base on the present and focus on the future". Therefore, sustainability is regarded as a default item that must be mentioned in the documents' objectives.

The issues identified in the present study are the gaps in a specific implementation plan. These gaps can be caused by different levels of governmental planning. Resilience is rarely mentioned in the plan for the Wenchuan earthquake, and it only appears as a concept and lacks specific measures in the plan for the Lushan earthquake. Chinese academia only began to apply the concept of resilience to the planning field after 2010. Considering the goals and targets, the equity in both earthquake recovery plans is weak. A planner indicated that "equity is not a goal, but a basic planning principle". For example, the pursuit of equity in housing reconstruction is a consensus. Therefore, emphasizing these basic principles in the plan is unnecessary. The interviewees were generally dissatisfied with the vision and goals of the recovery plans for the two earthquakes. A PDRP is an emergency plan,

and long-term planning vision is also a necessary component of the planning documents. However, the long-term planning vision is not the focus of the actual implementation. Specific planning vision must be further clarified by statutory plans. Long-term sustainability is frequently weakened by the requirements of economic development or policy changes, and the specific effect depends on the follow-up.

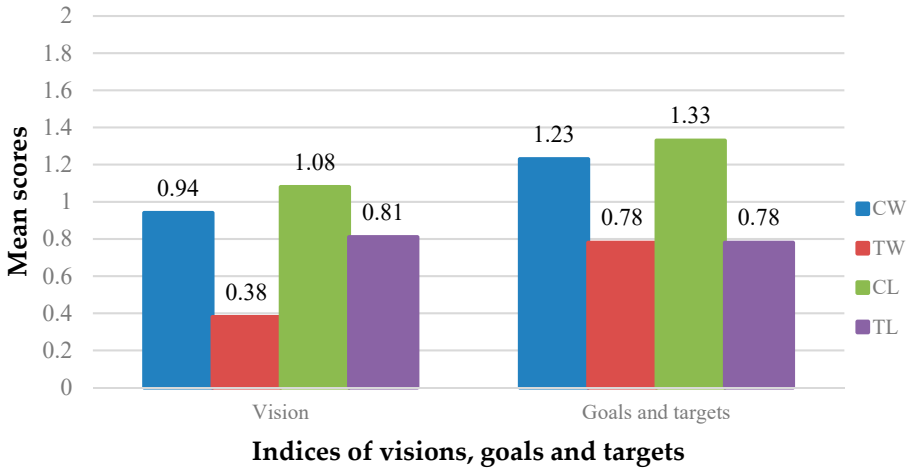

Figure 4. Indices mean scores of visions, goals and targets.

4.3. Policy Actions and Strategies

The policy actions and strategies of the two earthquake recovery plans have large contrasts at the country level, whereas the evaluation results at the township level are the same, as shown in Figure 5. In terms of secondary disaster prevention, the Wenchuan earthquake recovery plans have higher overall scores than for Lushan. Given that the magnitude of the Lushan earthquake was 7.0 Ms, which is far less than the magnitude 8.0 Ms in Wenchuan earthquake, 97% of secondary disasters were small- and medium-sized. Therefore, secondary hazard solutions are not a priority in the Lushan earthquake recovery plans. The recovery plans for the two earthquakes have the same low scores for forest restoration. The county level is near 0.8, whereas the town level is near 0.3 for forest restoration.

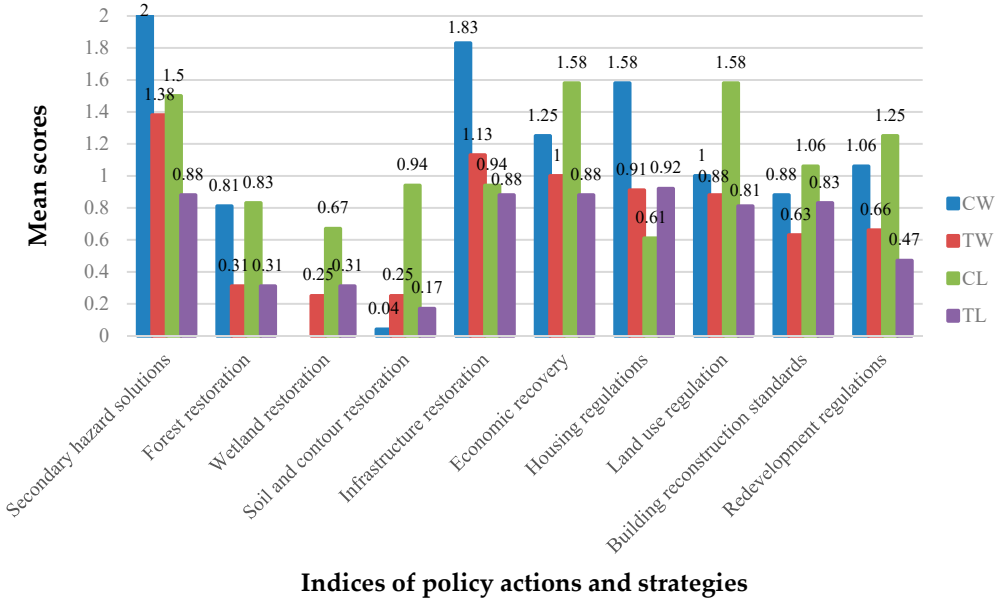

Figure 5. Indices mean scores of policy actions and strategies.

The county level in the Lushan earthquake was significantly better in contrast to the Wenchuan earthquake in terms of wetland restoration and soil and contour restoration. Ecological restoration policies, such as wetland and soil restoration, are reflected in the plans for Lushan. The location of the Lushan earthquake, which is in the area of the Panda Reserve and requires considerable ecological protection, is favorable. This change also reflects the transformation in the recovery goals of local governments and planners. The interviewees agreed that the national government mentions many sustainable processes that are mostly committed to economic development in the Wenchuan earthquake recovery plan. The plan for the Lushan earthquake is based on local subjects. In the locally owned process, local governments consider the comprehensiveness of development rather than the economy. However, specific measures for ecological protection are relatively limited, and no factual measures are available for low-impact development (LID), which is emphasized in local development planning by the central government.

The score for infrastructure restoration and house reconstruction is lower in the Lushan earthquake plan at the county level than in the Wenchuan earthquake plan. Both plans underrate the risk of infrastructure relocation and temporary housing. Prefabricated houses were proposed for the Wenchuan earthquake, whereas the temporary refuge in the Lushan earthquake plans is tented areas, located mainly in school playgrounds, small squares in front of the village committee, and in the edges of the village. Economic recovery and land-use regulations are emphasized in the Lushan earthquake plans.

During the interviews, the interviewees stated that in addition to safety provision, cultural inheritance is a focus of the recovery plans. According to the current situation observed after reconstruction, spatial reconstruction has favorable effects on future development. In addition to the humanitarian perspective, revitalization policies and strategies have provided the affected areas with many opportunities to use their external resources and enhance their own improvement opportunities.

4.4. Participation and Coordination

The scores for participation and coordination were generally low for both earthquake recovery plans. The lowest scores were found in the Wenchuan earthquake plans, as shown in Figure 6. At the county level, the overall situation of participation and coordination in the Lushan earthquake plan (overall mean = 1.01) is higher than for Wenchuan (overall mean = 0.58). However, at the township level, the Wenchuan earthquake incorporates additional vertical cooperation and other post-disaster coordination.

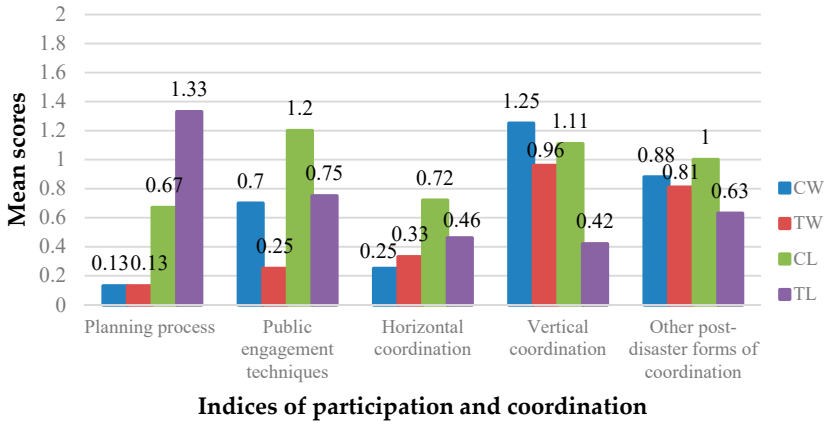

Figure 6. Indices mean scores of participation and coordination.

The planning process is described in the documents of the Lushan earthquake, and the compilation is more detailed at the township level than at the county level. An important principle for restoration and reconstruction in the Lushan earthquake is "extensive participation of the people in the disaster area", which is also reflected in the planning documents. The indexed item of public engagement

techniques scored higher in the Lushan earthquake than in the Wenchuan earthquake at the county and township levels.

Public participation in the Wenchuan earthquake is poor; our informants admitted that public participation in the planning process for the Wenchuan earthquake is insufficient. The demands and preferences of the public, such as resettlement sites and styles of rebuilt houses, are directly reflected in the relevant planning contents. By contrast, in the Lushan earthquake, from the Appendix B of the text, the interview records or related questionnaires on household investigation can be intuitively observed, and the public will is directly reflected in the relevant planning content, such as the selection of resettlement sites and the style of rebuilding houses. In the coordination category, in contrast to the Wenchuan earthquake, the Lushan earthquake is a locally led disaster relief system. Counterpart support is present within the province. Therefore, the Lushan earthquake plans adopted horizontal coordination, which is more closely tied with local stakeholders and neighboring regions than in the plans for the Wenchuan earthquake. In the two earthquake plans, vertical coordination has high scores, and the national and provincial recovery planning lead the actions and executions. However, although the Lushan earthquake plan has more horizontal coordination, it still cannot exceed the vertical coordination score. Some interviewees stated that implementing horizontal coordination has many challenges. Cross-government departments require further integration and coordination in docking planning. "Guazhi" (which denotes that some people serve other organizations for a period while retaining their positions in the previous organizations) may be a special form of communication that establishes a link between institutions, and between institutions and governments.

Paired assistance is frequently mentioned in the recovery plans, while other voluntary or non-governmental organizations (NGOs) are seldom mentioned. Some interviewees simply commented that certain NGOs (e.g., the Self-inspection Committee of Baihuo New Village in the Longmen township of Lushan county) have emerged during reconstruction and have increased the public's participation in reconstruction. We found that a social organization and volunteer service center was established after the Lushan earthquake. To train local talent for paired assistance, the center was divided into three levels: city, county, and township.

4.5. Implementation and Monitoring

The evaluation scores of both earthquakes for implementation and monitoring have a high degree of similarity, as shown in Figure 7. The implementation strategies are the highest scored, with most of the plans including implementation actions, organizational responsibility, and an implementation timeline. However, references to funding sources and methods of updating are scarce. The method for monitoring losses and recovery and financial monitoring have low scores. The interviewees recommended strengthening the dynamic recovery process but they do not have the personnel and technical capabilities to accomplish this task.

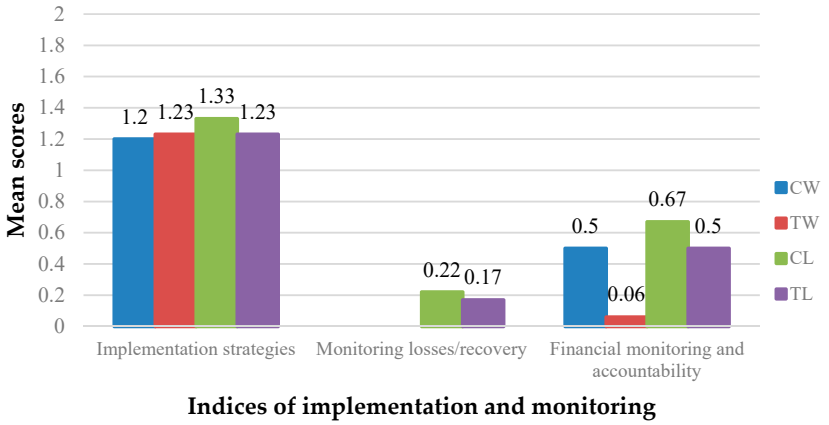

Figure 7. Indices mean scores of implementation and monitoring.

Some interviewees stated that the recovery plan is formulated within a relatively short period. Therefore, real-time monitoring and feedback are necessary. Many projects must be dynamically coordinated. Specifically, reconstruction plans must provide a dynamic planning process that incorporates implementation, monitoring, evaluation, and revision.

4.6. Summary

The recovery plans analyzed in this study did not fully reflect the principles and concepts of sustainability in any of the five components, although progress in sustainable penetration from the Wenchuan to Lushan earthquakes was observed. From the overall trend, the scores are slightly better in the Lushan earthquake plans than in the Wenchuan earthquake plans at the county and town levels.

In summary, the overall quality is generally better in county-level recovery plans than in town-level plans. County-level planning is likely to include an information base, vision, goals and targets, and policy actions and strategies. As shown in Figure 8, for the information base, the county-level recovery planning (overall mean score = 0.90) scored higher than the town-level planning (overall mean score = 0.55). Similarly, for the vision, goals, and targets, the score (overall mean score = 1.14) is higher for county-level than for town-level planning (overall mean score = 0.66). A significant score gap was found for policy actions and strategies. The overall mean score for the county-level planning is 1.02, whereas the overall average for the town-level planning is 0.71. However, for other planning principles, no evident gap was identified between county and township planning. For example, county- and town-level planning are both closely related in terms of implementation and monitoring; thus, the scores are similar.

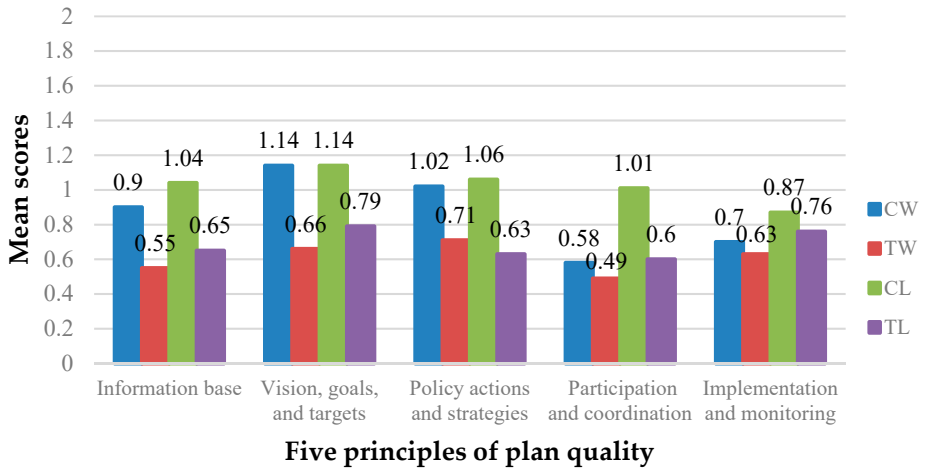

Figure 8. Overall mean scores of the five principles.

5. Discussion

Based on the aforementioned findings, we found that considerable attention should be paid to some important issues.

5.1. Sustainable Implementation in the Recovery Plan

The continuous evolution and improvement of data collection, as well as the transformation of recovery goals at different stages, can be observed in the PDRPs for Lushan and Wenchuan. The goals are increasingly balanced; the economy is not the only concern but the ecological goal has also become more prominent. Reconstruction planning requires a long-term perspective. The idea of sustainable development in planning is formulated to be invisibly incorporated into the design of site selection, housing reconstruction, road traffic, and municipal administration. The change of goals and visions between PDRPs after Lushan earthquake and Wenchuan earthquake generally reflects the increasing

emphasis on sustainable development. This shift is not an isolated change within the disaster context. Since 2013, ecological factors have obtained increasing attention as President Xijinping proposed "Green mountains and clear water are equal to mountains of gold and silver". The change in the PDRPs echoes with the change of national development strategy under the normal development condition. However, the key task of recovery plans lies in their short-term emergency response, which will set a specific advance table for three to five years. Therefore, based on the long-term perspective, the planners must focus more on actual enforceability. The characteristics of the recovery plan indicate that the main function of the document is not to depict a vision. The recovery plan is not statutory, and implementing the goals and targets is optional. Specifically, completing post-disaster recovery work must rely on statutory planning to further define the direction of local development, but this will weaken the vision function of the recovery plan. The present study also confirms that the implementation effect of the recovery plan will be influenced by many policies in the later period. On the one hand, political and socio-economic changes may later hinder the implementation of sustainable principles and actions specified in the PDRPs. On the other hand, the rapid change and urbanization process sometimes presents unpredictable challenges specified in the PDRPs. Sustainable development should be realized based on the unpredictable challenges rather than the prediction in the PDRPs. Considering the lack of effective bottom-up planning, flexibility and suggested measures should be considered for long-term sustainable development.

5.2. Recovery Planning Capabilities in the Recovery Plan

The analysis of the PDRPs of both earthquakes shows that the technology for recovery plans remains in the exploration phase. No paradigm for a unified and high-standard planning document exists. Although future disaster scenarios have been considered during planning, they still lack the exact description of specific alternative models to simulate the scenarios. This is partly resulting from the difficulty of complete and precise investigation and forecasting of the secondary and future disasters. Advanced technologies need to be developed to rapidly collect and analyze the multi-attribute data after earthquake. Suitable models, which should be validated before making PDRPs, are needed to simulate the scenarios of future disasters. During the interviews, the interviewees referred to the lessons learned from Japan's disaster prevention experience in preparing recovery plans. Unlike Japan, where earthquake frequently occur, there is generally a lack of effective experience summary and lessons transferring between disasters in China. The planning institutions focus more on planning under normal development conditions rather than planning after disasters. The evaluation of recovery planning capacity in China is insufficient. New technologies, such as low-impact development and green buildings, must be included in the plan to further promote flexibility of future development. In terms of temporary housing selection, some contradictions occur because the establishment of a recovery plan is a systematic process that requires extensive time, and temporary housing requires the shortest possible time. Therefore, the reconstruction plan must be separated first to rapidly guide the site selection while leaving space for long-term development.

5.3. Participation and Coordination in the Recovery Plan

The recovery and reconstruction plan for the Lushan earthquake have drawn considerable experience from Wenchuan. These processes further emphasize the need for precision in disaster relief. The words of the document have been written carefully and focus on practical results. According to the interview results, public participation in the process continues to increase. In the investigation stage, afflicted people, government organizations, and enterprises will discuss how to reconstruct intensively. Planning can include the victims' preferences for the site selection, layout, and functional design of the housing through public participation while satisfying the basic needs such as safety and sufficient carrying capacity. Guazhi, known as job swaps, has become an important hub for horizontal and vertical coordination in China. In this study, the vertical coordination is better than the horizontal coordination for both earthquakes, but some differences are observed in the cross-sectoral cooperation

among various local government departments. Relevant policies and measures of sustainability generally score higher at the county level than in the township-level recovery plans, indicating that lower-level planning cannot achieve higher-level goals. The decentralization of sustainability to local areas is an important issue that must be resolved in the future.

5.4. Strategic Recommendations on Improving PDRPs

First, the plan must enhance the information base. Data backup in disaster-prone areas must be strengthened to transfer data immediately after the disaster and share these data among agencies. Adequate attention must be paid to combining the evaluation system to form the paradigm of recovery plans, to increase the emphasis on future disaster scenes and ecology, and to enhance planning technology. Second, sustainability must be integrated into visions, goals, and targets. The positioning of the recovery plan and its connection and division with the statutory plans must be defined to analyze the vision accurately. The visions of recovery plans must be refined into smaller targets that can be measured and tracked, thus making achieving sustainability intuitive and feasible. Third, policy actions and strategies must be emphasized in PDRPs. In China, top-down control frequently plays a major role in guiding planning. Therefore, the top-level design of sustainable development tools and policy actions is particularly important. Our study found some weaknesses in implementing the objectives at the township level. Thus, bottom-up control must be used to strengthen local support and sustainability policy formulation. The plan must increase local cross-sectoral collaboration. We conclude that the locally-led disaster relief model adopted in the Lushan earthquake has better internal coordination than the national-led disaster relief of the Wenchuan earthquake. We recommend that local governments adopt the Guazhi approach to form a working team that will coordinate and supervise the concepts and implementations of sustainability in recovery plans. Finally, considering the changeability and time urgency of a recovery plan, the model must be a dynamic planning process from a sustainable perspective, requiring timely dynamic assessment and updating within a few years after the disaster.

6. Conclusions

We aimed to evaluate the planning documents of two earthquake recovery plans to determine their methods for transferring, preserving, developing, and applying the concept of sustainability, and to propose an improved planning method. Through thorough analysis and comparison of the two earthquake response plans, the results show undeniable progress in the sustainability of the planning documents. However, the total scores range from the middle to low levels, indicating that the principle of sustainability is not well integrated into the PDRP documents. Numerous problems and challenges must still be addressed to properly incorporate sustainability into the planning process.

This study improves the elements, framework, and content of the sustainable recovery plan and explored the influencing factors and mechanism of its implementation. Some suggestions have been presented in accordance with the actual situation in China for improving our theoretical understanding and practical operation level of PDRPs. The gap between the theory and practice of sustainable recovery planning must be further narrowed in the future. We think that planners must surpass the symbolic use of the concept of sustainable development and adopt a comprehensive development guidance strategy.

However, this study has certain limitations caused by applying a qualitative examination approach with limited samples. Would the findings be supported by other research methods? Would the findings be the same if we compare PDRPs of earthquakes in different countries? Future studies can take text mining to examine the similarities and differences of PDRPs with more samples in a quantitative and objective way. In addition, cross-culture comparison of PDRPs is also necessary to provide more insights on how to deliver the sustainability vision in PDRPs.

Author Contributions: L.H. proposed and designed the research; Z.X. collected the data, analyzed the data and revised the paper; L.H. and Z.X. are co-first authors as they contribute equally in the process. Y.P. conducted discussions and proofread the manuscript; Y.S.; S.D. provided some comments and helped to edit the manuscript. All authors reviewed and approved the final manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of evaluated earthquake recovery plans.

Plan Title	Locality Level
Longmen township post-disaster comprehensive plan and design	Township (L)
Baosheng township post-disaster recovery plan and reconstruction site plan	Township (L)
Shuangshi township post-disaster recovery plan	Township (L)
Qingren township post-disaster site plan	Township (L)
Weizhou town post-disaster comprehensive recovery plan 2008–2020	Township (W)
Yinxing township post-disaster recovery plan	Township (W)
Sanjiang township earthquake recovery plan	Township (W)
Shuimo town post-disaster recovery plan	Township (W)
Xuankou town post-disaster recovery plan	Township (W)
Tongkou town post-disaster recovery plan	Township (W)
Chenjiaba township post-disaster comprehensive recovery plan 2008–2020	Township (W)
Baishi township post-disaster recovery plan	Township (W)
Lushan post-disaster recovery plan 2013–2030	County (L)
Baoxing post-disaster recovery plan 2013–2020	County L)
Tianquan post-disaster recovery plan	County (L)
Beichuan post-disaster recovery plan	County (W)
Maoxian post-disaster recovery plan	County (W)
Anxian post-disaster recovery implementation plan	County (W)
Pingwu Wenchuan earthquake comprehensive recovery plan 2008–2020	County (W)
Mianzhu Wenchuan earthquake comprehensive recovery plan	County (W)
Shifang post-disaster recovery plan	County (W)
Dujiangyan post-disaster comprehensive recovery plan 2008–2020	County (W)
Pengzhou post-disaster recovery comprehensive plan	County (W)

Note: L = Lushan earthquake; W = Wenchuan earthquake.

Appendix B Interview Protocol

Overarching research question: How well have the recovery plans in the aftermath of the Wenchuan earthquake incorporated sustainability?

Part 1: Questions regarding information base of plans

- What types of technical resources, particularly databases and information systems, such as geographic information systems (GIS), did you use or collaborate with another agency to use? In your opinion, what were some of the key data/information products that helped facilitate recovery? How (by whom and for what) were they used?
- Did your agency perform post-disaster assessments of damage and economic losses? When? Using what methods? For what regions or sectors (i.e., infrastructure, housing, economy)?

- What portion of your pre-disaster resources (funds, staff, access to other data or technical resources, etc.) were redirected to post-disaster recovery management responsibilities? What types of additional resources (funds, staff, access to other data or technical resources, etc.) were available to your agency after the disaster?

Part 2: Questions regarding visions, goals, and targets

- In your view, to what extent did your locality develop plans that include visions of sustainability and resilience? How effective were these? Do you think that the plans have a balanced set of goals covering the environment, the economy, and equity?

Part 3: Questions regarding policies and actions

- To what extent were your agency's policies and actions connected with sustainability and resilience visions and goals (i.e., secondary hazard mitigation, restoration of forestry, wetlands, soil, contour, infrastructure, land uses, housing reconstruction, building standards, and redevelopment)? How effective were these?
- What policies and procedures do you believe facilitated hazard mitigation and improvement? How successful were these? What impeded your ability to provide improvement? In what ways did the speed of reconstruction perhaps result in lost opportunities to provide quality or improvement?

Part 4: Questions regarding participation and coordination

- To what degree did you communicate recovery policies and updates with affected groups, non-governmental organizations, and other governmental organizations? What methods and mechanisms did you use for these communications (i.e., individual or group meetings, Internet, emails, public notices in newspapers or public places, or communications through third parties or other agencies)? To what degree did you seek input into the recovery policies, programs and projects from affected groups, non-governmental organizations, and other governmental organizations?
- How useful is the institutional and planning framework constructed for the earthquake by the national government to implement the recovery plans? In what ways did the institutional framework that the national government constructed for recovery management provide the necessary resources, vision, and leadership required to address the unique characteristics of catastrophic disasters? To what extent was the national level planning framework helpful to recovery plans and to what extent do you think it was harmful? How so?
- How did the communication for inter-agency coordination take place (i.e., meetings, letters/emails, directives)? For which policies?

Part 5: Questions regarding implementation and monitoring

- To what extent did the policies and actions include timeline targets and milestones? How effective were these? What additional funds and staff were received to ensure the implementation of plans? Did most localities complete the recovery and reconstruction responsibilities in the expected timeframes?
- Did the localities develop both reconstruction and fiscal indicators to track implementation progress? If so, how were the indicators developed?
- Were the tracking results recorded and used to inform the planning process? In your view, are the plans dynamic and available for adjustments based on progress assessment?

Note: A portion of our interview protocol is not included since it is unrelated to the results of this paper.

References

1. Song, Y.; Li, C.; Olshansky, R.; Zhang, Y.; Xiao, Y. Are we planning for sustainable disaster recovery? Evaluating recovery plans after the Wenchuan earthquake. *J. Environ. Plan. Manag.* **2017**, *60*, 2192–2216. [CrossRef]
2. Haas, J.E.; Kates, R.W.; Bowden, M.J. (Eds.) *Reconstruction Following Disaster*; MIT University Press: Cambridge, UK, 1977.
3. Mader, G.G.; Spangle, W.E.; Blair, M.L. *Land Use Planning after Earthquakes*; William Spangle and Associates: Portola Valley, CA, USA, 1980.
4. Zhang, J.; Fu, Y.Q. Research on post-disaster recovery and reconstruction abroad. *J. Liaocheng Univ.* **2013**, *4*, 78–86.
5. Peng, Y.; Shen, L.Y.; Tan, C.; Tan, D.L.; Wang, H. Critical determinant factors (CDFs) for developing concentrated rural settlement in post disaster reconstruction: A China study. *Nat. Hazards* **2013**, *66*, 355–373. [CrossRef]
6. Bates, F.L.; Peacock, W.G. *Living Conditions, Disasters, and Development: An Approach to Cross-Cultural Comparisons*; University of Georgia Press: Athens, GA, USA, 1982.
7. Rubin, C.B.; Popkin, R. *Disaster Recovery After Hurricane Hugo in South Carolina*; Working Paper No. 69; Natural Hazards, Institute of Behavioral Science, University of Colorado: Boulder, CO, USA, 1990.
8. Bolin, R. *Household and Community Recovery After Earthquakes*; Institute of Behavioral Science, University of Colorado: Boulder, CO, USA, 1993.
9. Bolin, R.; Stanford, L. *The Northridge Earthquake: Vulnerability and Disaster*; Routledge: New York, NY, USA, 1998.
10. Comerio, M.C.; Landis, J.D.; Rofe, Y. *Post-Disaster Residential Rebuilding*; Working Paper 608; Institute of Urban and Regional Development, University of California: Berkeley, CA, USA, 1994.
11. Hirayama, Y. Collapse and reconstruction: Housing recovery policy in Kobe after the Hanshin great earthquake. *Hous. Stud.* **2000**, *15*, 111–128. [CrossRef]
12. Peng, Y.; Shen, Q.P.; Shen, L.Y.; Lu, C.; Yuan, Z. A generic decision model for developing concentrated rural settlement in post-disaster reconstruction: A China study. *Nat. Hazards* **2014**, *71*, 611–637. [CrossRef]
13. Kroll, C.A.; Landis, J.D.; Shen, Q.; Stryker, S. *Economic Impacts of the Loma Prieta Earthquake: A Focus on Small Businesses*; Working Paper 91–187; University of California at Berkeley Transportation Center and Center For Real Estate and Urban Economics: Berkeley, CA, USA, 1991.
14. Webb, G.R.; Tierney, K.J.; Dahlhamer, J.M. Businesses and disasters: empirical patterns and unanswered questions. *Nat. Hazards Rev.* **2000**, *1*, 83–90. [CrossRef]
15. Alesch, D.J.; Holly, J.N.; Mittler, E.; Nagy, R. *Organizations at Risk: What Happens When Small Businesses and Not-for-Profits Encounter Natural Disasters*; Public Entity Risk Institute: Fairfax, VA, USA, 2001.
16. Chang, S.E.; Falit-Baiamonte, A. Disaster vulnerability of businesses in the 2001 Nisqually earthquake. *Environ. Hazards* **2002**, *4*, 59–71.
17. Olshansky, R.B. Planning after hurricane Katrina. *J. Am. Plan. Assoc.* **2006**, *72*, 147–153. [CrossRef]
18. Smith, G.P.; Wenger, D. *Sustainable Disaster Recovery: Operationalizing an Existing Agenda. Handbook of Disaster Relief Research*; Springer: New York, NY, USA, 2007; pp. 234–257.
19. Olshansky, R.B.; Johnson, L.A.; Horne, J.; Nee, B. Planning for the rebuilding of New Orleans. *J. Am. Plan. Assoc.* **2008**, *74*, 273–287. [CrossRef]
20. Berke, P.; Cooper, J.; Aminto, M.; Grabich, S.; Horney, J. Adaptive planning for disaster recovery and resiliency: An evaluation of 87 local recovery plans in eight states. *J. Am. Plan. Assoc.* **2014**, *80*, 310–323. [CrossRef]
21. Nigg, J. Awareness and behavior: Public response to prediction awareness. In *Perspectives on Increasing Hazard Awareness*; Saarinen, T.F., Ed.; Institute of Behavioral Science, University of Colorado: Boulder, CO, USA, 1982; pp. 71–96.
22. Peacock, W.G.; Morrow, B.H.; Gladwin, H. *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters*; Routledge: New York, NY, USA, 1997.
23. Lu, X. Online communication behavior at the onset of a catastrophe: An exploratory study of the 2008 Wenchuan earthquake in China. *Nat. Hazards* **2018**, *91*, 785–802. [CrossRef]

24. May, P.J. FEMA's role in emergency management: Examining recent experience. *Public Adm. Rev.* **1985**, *45*, 40–48. [CrossRef]
25. May, P.J.; Williams, W. Disaster policy in perspective. In *Disaster Policy Implementation*; Springer: Boston, MA, USA, 1986; pp. 1–17.
26. Olson, M. *From Communism to a Market Democracy*; Center for Institutional Reform and the Informal Sector: College Park, MD, USA, 1993.
27. Peng, Y. A comparison of two approaches to develop concentrated rural settlements after the Wenchuan earthquake in China. *Habitat Int.* **2015**, *49*, 230–242. [CrossRef]
28. University of Colorado Natural Disaster Center. *Handbook for Post Disaster Recovery Practice*; University of Colorado Natural Disaster Center: Boulder, CO, USA, 2001.
29. Hu, Y.Z. Theory and practice of post-disaster reconstruction planning: Taking the reconstruction of new orleans as an example, and concerning the reference to Wenchuan earthquake reconstruction. *Int. Urban Plan.* **2008**, *4*, 66–70.
30. Chen, Y.; Li, H.X.; Wu, Y. Review of the post-disaster reconstruction of Wenchuan earthquake. *Urban Dev. Res.* **2011**, *18*, 105–111.
31. Song, X.G.; Pang, M.C.; Wang, X.L.; Yan, S.B.; Lu, H.T.; Wan, C.Y.; Liu, C.; Guo, X.D.; Liu, D.D. Policy framework and policy system for post-disaster reconstruction of major natural disasters: Taking Wenchuan earthquake as an example. *Res. Financ. Econ. Issues* **2008**, *9*, 10–18. (In Chinese)
32. Liu, T. On the establishment of long-term mechanism for counterpart support—From the perspective of the development of the Wenchuan post-quake reconstruction counterpart support. *J. Southwest Univ. Natl.* **2010**, *31*, 98–101.
33. Peng, Y.; Shen, L.Y.; Zhang, X.L.; Ochoa, J.J. The feasibility of concentrated rural settlement in a context of post-disaster reconstruction: A study of China. *Disasters* **2014**, *38*, 108–124. [CrossRef]
34. Peng, Y.; Li, X.; Huang, L.; Jiang, S.; Xu, Y.; Lai, Y. Risks of developing concentrated rural settlement after the Wenchuan earthquake in China. *Sustainability* **2018**, *10*, 1569. [CrossRef]
35. Huang, R.Q. The basic characteristics of the "5.12" Wenchuan earthquake and its impact on post-disaster reconstruction. *Chin. Geol. Educ.* **2008**, *2*, 21–24.
36. Wang, L.; Zhang, B.; Wang, L.Y.; Chen, L.H. Investigation and study on earthquake damage of villages and towns in Hanzhong city of Wenchuan earthquake. *J. Shaanxi Univ. Technol.* **2010**, *26*, 41–45.
37. Wu, Y.; Zhang, W.; Shen, J.; Mo, Z.; Peng, Y. Smart city with Chinese characteristics against the background of big data: Idea, action and risk. *J. Clean. Prod.* **2018**, *173*, 60–66. [CrossRef]
38. Yang, H.; Dietz, T.; Yang, W.; Zhang, J.; Liu, J. Changes in human well-being and rural livelihoods under natural disasters. *Ecol. Econ.* **2018**, *151*, 184–194. [CrossRef]
39. Peng, Y.; Zhang, F.; Jiang, S.; Huang, L.; Wang, Z.; Xu, Y. Analysis of farmers' satisfaction towards concentrated rural settlement development after the Wenchuan earthquake. *Int. J. Dis. Risk Reduct.* **2018**, *31*, 160–169. [CrossRef]
40. Peng, Y.; Zhu, X.; Zhang, F.; Huang, L.; Xue, J.; Xu, Y. Farmers' risk perception of concentrated rural settlement development after the 5.12 Sichuan earthquake. *Habitat Int.* **2018**, *71*, 169–176. [CrossRef]
41. Jin, L. Study on the planning strategy of post-disaster reconstruction of Wenchuan, Sichuan Province. *Archit. Creat.* **2008**, *6*, 113–119.
42. Yin, Q. Reflections on the Wenchuan earthquake and reflections on reconstruction planning. *Urban Plan.* **2008**, *7*, 24–27.
43. Qiu, J.; Jiang, R. Discussion on constructing post-earthquake restoration and reconstruction planning system: Taking Wenchuan earthquake as an example. *Urban Plan.* **2009**, *33*, 11–15.
44. Oliver-Smith, A. Post-disaster housing reconstruction and social inequality: A challenge to policy and practice. *Disasters* **1990**, *14*, 7–19. [CrossRef]
45. Berke, P.R.; Kartez, J.; Wenger, D. Recovery after disaster—Achieving sustainable development, mitigation and equity. *Disasters* **1993**, *17*, 93–109. [CrossRef]
46. Olshansky, R.B.; Hopkins, L.D.; Johnson, L.A. Disaster and recovery: Processes compressed in time. *Nat. Hazards Rev.* **2015**, *13*, 173–178. [CrossRef]
47. Baer, W.C. General plan evaluation criteria: An approach to making better plans. *J. Am. Plan. Assoc.* **1997**, *63*, 329–344. [CrossRef]

48. Berke, P.; Godschalk, D. Searching for the good plan: A meta-analysis of plan quality studies. *J. Plan. Lit.* **2009**, *23*, 227–240. [CrossRef]
49. Stevens, M.R.; Lyles, W.; Berke, P.R. Measuring and reporting intercoder reliability in plan quality evaluation research. *J. Plan. Edu. Res.* **2014**, *34*, 77–93. [CrossRef]
50. Berke, P.R.; Godschalk, D.R.; Kaiser, E.J.; Rodriguez, D.A. *Urban Land Use Planning*, 5th ed.; University of Illinois Press: Urbana, IL, USA, 2006.
51. Combs, D.L.; Quenemoen, L.E.; Parrish, R.G.; Davis, J.H. Assessing disaster-attributed mortality: Development and application of a definition and classification matrix. *Int. J. Epidemiol.* **1999**, *28*, 1124–1129. [CrossRef] [PubMed]
52. Olshansky, R.B.; Johnson, L. *Clear as Mud: Planning for the Rebuilding of New Orleans*; Routledge: London, UK, 2010.
53. Lyles, L.W.; Berke, P.; Smith, G. Do planners matter? Examining factors driving incorporation of land use approaches into hazard mitigation plans. *J. Environ. Plan. Manag.* **2014**, *57*, 792–811. [CrossRef]
54. Quay, R. Anticipatory governance: A tool for climate change adaptation. *J. Am. Plan. Assoc.* **2010**, *76*, 496–511. [CrossRef]
55. Berke, P.R.; Conroy, M.M. Are we planning for sustainable development? An evaluation of 30 comprehensive plans. *J. Am. Plan. Assoc.* **2000**, *66*, 21–33. [CrossRef]
56. Bankoff, G.; Frerks, G. *Mapping Vulnerability: Disasters, Development and People*; Routledge: London, UK, 2013.
57. Smith, B.; Wandel, J. Adaptation, adaptive capacity and vulnerability. *Glob. Environ. Chang.* **1996**, *3*, 65–67. [CrossRef]
58. Paton, D.; Johnston, D. *Disaster Resilience: An Integrated Approach*; Charles C Thomas Publisher: Springfield, IL, USA, 2017.
59. Holling, C.S. Resilience and stability of ecological systems. *Annu. Rev. Ecol. Syst.* **1973**, *4*, 1–23. [CrossRef]
60. Bruneau, M.; Chang, S.E.; Eguchi, R.T.; Lee, G.C.; O'Rourke, T.D.; Reinhorn, A.M.; Shinozuka, M.; Tierney, K.; Wallace, W.A.; Von Winterfeldt, D. A framework to quantitatively assess and enhance the seismic resilience of communities. *Earthq. Spectra* **2003**, *19*, 733–752. [CrossRef]