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Regular article

Research on post-Wenchuan earthquake recovery and reconstruction implementation: A case study of housing reconstruction of Dujiangyan City

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ABSTRACT

This paper is a systematic study on the reconstruction planning and policy implementation of the Wenchuan earthquake. It mainly summarizes the whole process of reconstruction from the perspective of post-disaster housing reconstruction. From both macro and micro scales, it carries out an in-depth analysis of the emergency response and reconstruction mechanisms adopted by the central and local governments after the earthquake occurred. The content mainly includes housing disaster assessment, housing reconstruction process management, and housing reconstruction particular policies, which are the key factors affecting post-disaster reconstruction benefits. To better explain the great success of the Wenchuan earthquake recovery and reconstruction policy for housing reconstruction, this paper conducts a detailed investigation of the reconstruction planning, policies, implementation and results of the housing reconstruction in Dujiangyan central city. The study found that the diversification of the Dujiangyan housing reconstruction development model has mostly met the different needs of the victims. The participation of multiple entities such as the market and social institutions has accelerated the economic recovery of post-disaster reconstruction and promoted the early completion of housing work; The unique system introduced during the reconstruction process not only protected the interests of the victims, but also effectively solved the complex property rights problem in rural areas, achieved the goal of saving land and integrating resources, and replaced a large number of land resources for the government.

1. Research background and objective

The Wenchuan earthquake occurred on May 12, 2008. Measuring at 8.0 Ms. Over 69,226 people lost their lives in the quake. 374,643 were reported injured, with 17,923 listed as missing as of July 2008 and 440,000 km^2 affected. The earthquake directly resulted in an economic loss of 845.14 billion Yuan. National Bureau of Statistics categorizes economic loss into Casualties, Economic loss, and Environment Devastation. Measured by the three indicators, housing damage takes up the most part in which the loss of urban and rural houses accounts for 27.4% of the total number, with damaged schools, hospitals and other non-residential housing taking up another 20.4%. The difference between housing and other infrastructures or public facilities is that it directly concerns to interests and losses of victims, the first priority of issues waiting to be tackled. Therefore, it is urgent to resettle victims, repair, and consolidate houses in the process of post-disaster emergency handling and recovering effort.

There are remarkable predecessors dedicated to post-disaster research. The earliest post-disaster recovering research mainly accentuates the profiling operation process in the recovering period, and behaviors and reactions of victims and reconstruction parties [5,6,12]. Barton (1969) maintains that the conflicts between victims and government reach acme in the recovering stage, far more serious than the emergency or reconstruction finalizing stage. His argument laid some theoretical ground for policy-makers [2]. Rubin (1991) analyzed the positive influence on reconstruction with the support of the local government, such as a case that special policies tailoring to various needs could prevent collisions in the reconstruction process [24]. Pearce [23], from the perspective of sustainable development, asserts that the period of public participation does have a direct impact on reconstruction results [22]. Public participation shall be included in the decision-making process if there is a prospect for a successful reconstruction. From the view on capacity after recovering, Alesch argues that the recovering should further the development of the disaster-stricken area [1]. Developing countries, especially, should precipitate relevant people to work on increasing the resilience, social and economic development to a higher standard by firstly recognizing urban vulnerabilities and ameliorating those shortcomings [3,4,14,15]. ***To conclude, there are many studies focusing on the whole process of reconstruction rather than a specific reconstruction project. Currently, studies focusing on government-led housing reconstruction are relatively in inadequacy.***

Housing is the basis for living and social development. The reconstruction of housing will significantly impact on overall benefits in the recovery

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planning. It is far from infrastructures like roads, is of high complexity in that it is directly connected to victims, subject to various factors, and requiring a long-term working cycle and considerable investment [9,10,29,33]. Wenchuan Earthquake is the most disastrous one since the foundation of PRC (http://www.gov.cn/). Among the calamitous loss, residential housing takes up a quarter. The process of housing reconstruction involves not only bodies such as government, victims, and developers but also construction contractors, banks, and other agencies and organizations. Previous studies on such matters in international context reveals three major issues, i.e., financing, housing reconstruction central bodies, principles of compensation and distribution [19,25,30]. Among which the financing of reconstruction is the prerequisite of fast recovering, and reasonable compensation and funds distribution is not only the critical reference to evaluate the housing reconstruction, but also the cornerstone to maintaining the order in the real estate market. ***Compared with the major earthquake disasters in the past, the reconstruction of Wenchuan Earthquake is faced with three main problems:***

(1) **Large housing demand in the short term**

According to statistics, in rural area, there are 1,668,600 households of victims of disaster-stricken areas need to be strengthened, in a total of 2,187,700 families' houses need to new build (accounting for 6,656,100 unit), in terms of urban area, about 599,100 sets of houses need to be strengthened, and about 720.3 million new houses need to be built, he urban and rural housing reconstruction involves an area of about 10,202,800m^2 [13]. Recent temporary resettlement, mid-term transitional resettlement, and long-term permanent resettlement of the victims after the earthquake are enormous challenges for the disaster recovery and reconstruction work.

(2) **Complex property rights issues**

Due to the particularity of China's urban-rural duality, the land ownership of many cities, especially in the central and western counties, is still unclear. Determining land property rights and state-owned land use rights belonging to different entities after a considerable earthquake disaster is a complex and arduous task. Besides, the reconstruction process involves not only the large-scale adjustment of the residential structure but also the reversal of land functions, which will inevitably bring new influences on the original land ownership relationship.

(3) **Development issues after rehabilitation and reconstruction**

Post-disaster rehabilitation and reconstruction involve not only the change of residents' living style but also the optimization and construction of public facilities. Reconstruction planning does not simply restore the original state before the disaster but is better than the original state, which necessarily puts forward higher requirements for post-disaster reconstruction planning [21,29]. It is an essential problem in the overall planning of post-disaster reconstruction to draw up the recovery and reconstruction plan and the construction and development plan in a short time.

In this paper, Dujiangyan City housing reconstruction as the research carrier, through the analysis of housing reconstruction planning and process of implementations of management to summarize the solutions to the above three problems. The housing reconstruction sequence in Dujiangyan City can be divided into three phases: temporary housing, transitional housing, and permanent housing (Fig. 1). ***The research content includes four parts: housing damage assessment process, housing reconstruction implementation mechanism, housing reconstruction support policy, and a case study detailing the entire process of housing reconstruction after the Wenchuan earthquake. Research methods include field survey, questionnaire survey, Symposium, and discussion.***

1.1. Field investigation

The University of Tokyo had conducted >20 investigations, the Chinese Embassy to Japan, the City Planning Institute of Japan, and relevant associations. Investigation panel dealt with experts on planning in Chengdu and Dujiangyan, as well as professors of Peking University, Renmin University of China, Sichuan University, Southwest Jiaotong University, and the group of victims. Also, the panel acquired valuable records and documents relating to the reconstruction process.

1.2. Questionnaire

The author, together with a contingent from Southwest Jiaotong University, a part of the group of Dujiangyan conceptual planning, conducted an investigation on community and social reconstruction via questionnaire study, and achieved results after proper review on government sources on July 2008.

1.3. Symposium and discussion

Professor Mikiko Ishikawa participated a three-year reconstruction work, including conceptual planning for Dujiangyan City, strategic research, Source of Tianfu planning, and so forth. We have discussed relevant issues with local government, universities and organizations on various occasions.

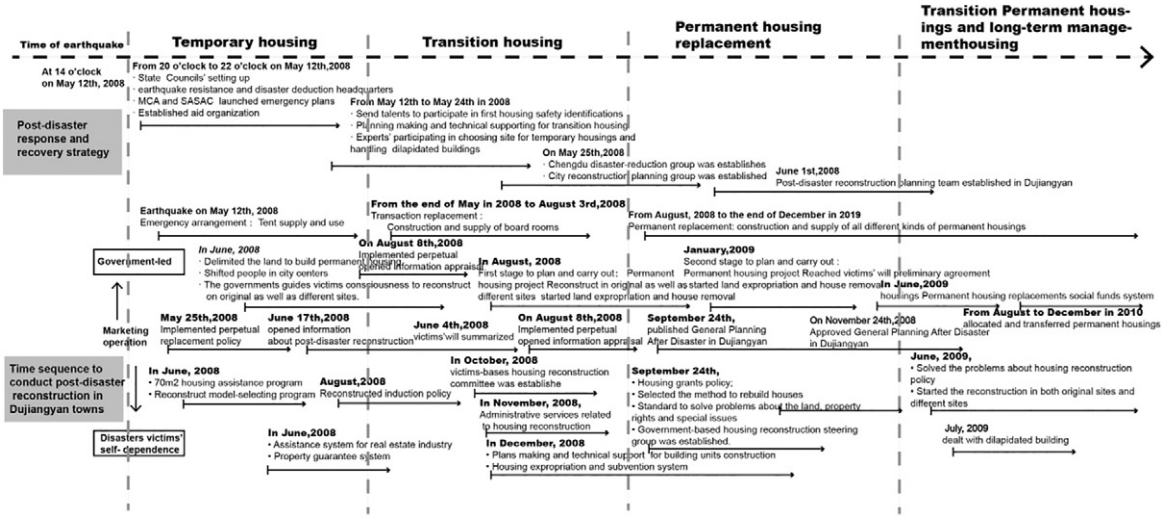

Fig. 1. Chronological order of housing reconstruction in Dujiangyan City.
(Source: http://www.china.com.cn/news/2008-09/04/content_16386369.htm)

2. Research area

Dujiangyan City is located in the northwest of Sichuan Plain and adjacent to the Longmenshan fault zone. The distance from the Wenchuan earthquake source is about 58 km. When the earthquake occurred, there was a strong earthquake in the Dujiangyan city area. The seismic intensity in most areas was as high as 10 degrees or more. Dujiangyan City covers an area of about 1208 km^2, with a total of 5 streets (central city), 12 towns, and one township (Fig. 2). In 2008, the Wenchuan earthquake caused a total of 3091 deaths in Dujiangyan City, 203 missing and 10,560 injured; urban and rural housing collapsed 4.61 million square meters, damaged 41.26 million square meters; road damage totaled 766 km, 208 bridges collapsed; 92 schools and 27 hospitals were also damaged to varying degrees. Among them, the direct economic loss caused by housing was about 30.4 billion yuan, accounting for 56% of the total direct economic losses in Dujiangyan City.

3. Housing reconstruction management process

3.1. Disaster assessment

After the earthquake, the central government and experts' team developed disaster assessment standards. The housing safety appraisal process is shown in Fig. 3. It is mainly divided into three parts: housing damage assessment, safety appraisal, and treatment. Firstly, the housing damage situation is divided into five categories through the safety emergency evaluation process: ***collapse, severe damage, moderate damage, mild damage, and basically intact;*** secondly, based on the damage evaluation, the house is divided into five categories: collapse, destruction and unusable, damage and repairable use, no need for safety appraisal and habitability [17].

3.2. Process management

According to the "Regulations on the Recovery and Reconstruction of Wenchuan Earthquake," [7] the housing reconstruction in Dujiangyan city mainly includes five processes: ***planning induction, victim reconstruction support, housing assistance, reconstruction mechanism, and implementation system***. As shown in Fig. 4, although the overall plan is a top-down reconstruction plan, in the implementation process, the participation of the victims has been increased, especially in the process of self-reconstruction support, the establishment of the reconstruction organization has shared the central government's Stress, on the other hand, from the reconstruction of life to a greater extent to meet the wishes of the victims.

3.3. Reconstruction of special systems

After the Wenchuan earthquake, the central government and local governments have formulated many systems to support and promote post-disaster recovery and reconstruction. These systems have primarily solved the problems of post-earthquake recovery and reconstruction, especially in terms of improving reconstruction efficiency (time, quality, and resident satisfaction) and meeting multi-stakeholders.

3.3.1. Victims, government, and market collaboration system

- Housing
  a. Housing reconstruction is a major regional development project and is the result of the government's response to national laws and regulations;
  b. Housing as the basis for the victims to live and work, the victims can be obtained through self-construction of the victims, government construction, purchase of commercial housing, and rental of houses;
  c. Housing reconstruction is an important way for developers to profit. Through the construction of commercial housing and other products, developers can obtain benefits from the real estate industry.

- Victims
  a. Participate in the reconstruction planning and implementation of the victims, and obtain housing through self-construction or replacement;
  b. The victims participate in and organize reconstruction under the guidance of the government and obtain support and assistance

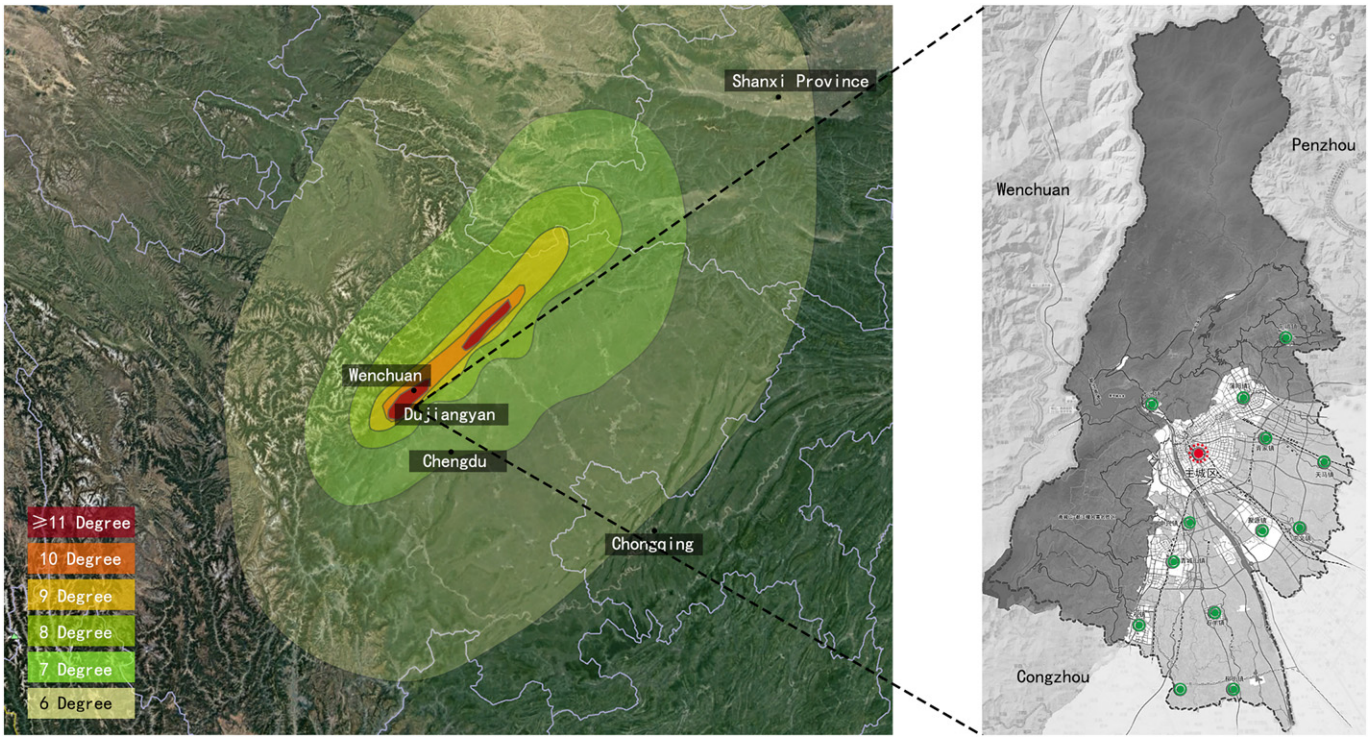

Fig. 2. Seismic intensity distribution map and study area.

from the government;

c. The victims provide human resources and other resources to the market, and obtain income from the market. They are also important customers of real estate developers.

- Government

a. The government guides the victims to achieve housing reconstruction and provide certain support and assistance to the victims;

b. The government provides services such as management, approval, property rights management, and relief for housing reconstruction. Provide funds to build, rebuild or participate in housing construction, and in turn realize the concentration of land property rights;

c. The government realizes land reserve and utilization by means of land allocation, land transfer or collective land replacement. The government has reached a certain cooperative relationship with the market through bidding to achieve economic development and obtain government revenue.

- Developer

a. Obtaining land resources from the government and reaching cooperation with the government to promote the people's employment and wealth through the development of the economy, and then benefit from it;

b. Participate in the construction of commercial housing, which can directly benefit from the real estate industry;

c. Provide disaster victims with a variety of housing options such as commercial housing to meet the needs of the victims.

3.3.2. The system to ensure property right

The categories of land ownerships in Dujiangyan are complicatedly various. Subsequent planning and adjustment bring changes to the ownership, causing land value change. According to the Property Law of the People's Republic of China, the property right enjoyed by Chinese residents covers the sum of all interests of a house, including possession, use, disposal. The property is composed of two elements, house ownership and the right of land use. Residents enjoy continual use of a house, whereas that of land is 40, 50, or 70 years. The mechanism automatically renews the lease with the fee of 1–10%.

According to the "Land Management Law" and the "Regulations on Land Administration," the land ownership of Dujiangyan central city is owned by the state, and the land use department or individuals can obtain land use rights through allocation and transfer by the state and the government. The rights owned by urban victims mainly include housing property rights and land property rights. Housing property rights include the right to possess, use, income and dispose of housing; land property rights refer to land use rights, lease rights, mortgage rights, inheritance rights, easements, etc. in addition to land ownership. According to the different types of housing reconstruction and resettlement, urban residents adopt different reconstruction methods, and their property rights are organized as shown in Table 1.

Based on the rights of the victims, such as the right to use, mortgage, etc., the victims can register the property rights and pledge. The benefits of this system can be summarized as follows: (1) For the problem of land redrafting involved in housing reconstruction, property rights registration can be used to protect the legitimate rights and interests of the victims; (2) mortgage application for loans with property rights or replacement of government-provided property rights Economic housing can help the victims solve or alleviate the reconstruction funds and the economic burden of life in reconstruction.

3.3.3. Housing reconstruction method selection system

In the process of urban housing reconstruction, the government proposed a multi-purpose housing development model and housing acquisition plan based on the overall planning of post-disaster reconstruction to allow the victims (citizens) to choose voluntarily. For example, the housing reconstruction provided by the government can take various measures such as strengthening the housing, rebuilding the original site, replacing the land to build a house, renting a house, and purchasing a commercial house (see 4.3 for details). Besides, according to Document No. 38 (2008) issued by the Chengdu Municipal Government, access to housing can be carried out in three ways: housing replacement, currency termination, and renting and direct management of public housing. For the victims of urban homes damaged by the disaster, the original owner of the house can continue to hold the corresponding legal land-use rights. However, in order to speed up the implementation of the post-disaster urban renewal plan, the

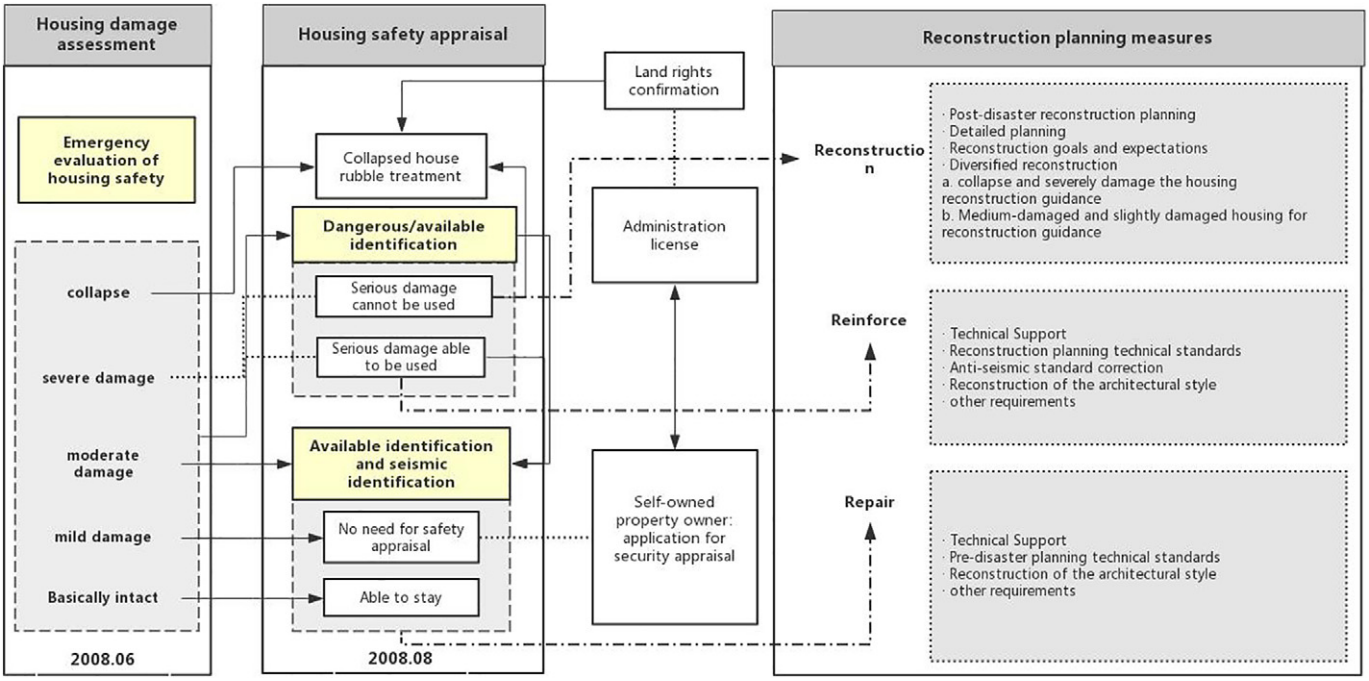

Fig. 3. Housing safety appraisal flow chart.

government stipulates that the owner of the land use right should dispose of the land in time during the three-year reconstruction period.

3.3.4. Housing reconstruction subsidy system

The housing reconstruction assistance policy is divided into **financial support and in-kind** (Tables 2, 3). The financial subsidy policy is a cash subsidy for urban damaged housing for victims who with private property rights. The property rights owned by the victims include **land use rights and housing ownership**. The support for the in-kind subsidy policy is mainly for the "three no" and "three orphans" people and no private property rights. In rural areas, financial assistance is implemented based on the family population (Table 4).

4. Case study

4.1. Housing reconstruction disaster assessment and demand analysis

4.1.1. Safety identification

The results of Dujiangyan urban housing safety appraisal are shown in Table 5. A total of about 96,739 housing units need to be reconstructed or reinforced, of which reconstruction housing accounts for 36.42% of the total damage. In the reconstruction of housing, about 6373 households collapsed, accounting for 15% of the total. It is only necessary to repair 10,260 houses that can be inhabited slightly, and 9.3% of the total urban housing.

4.1.2. Reconstruction requirements

As shown in Table 6, about 130,000 sets of houses (including new construction and reinforcement) were rebuilt, with a total construction area of about 12.68 million m^2. According to the actual situation, 20,000 of them need to be realized through land consolidation. The newly built housing area of the town is about 5.06 million square meters, of which 87% will be built in the urban area, about 51,000 sets.

4.2. Housing reconstruction planning and resettlement measures

4.2.1. Reconstruction planning

- **Spatial planning**

Dujiangyan City government designated the belt area (zone II) as its major housing reconstruction planning area, allocating victims the reconstruction lands. The new area (zone III and zone V) has the corresponding administrative center, communication center, financial center, and new features such as the planning for road system and public facilities. Considering the employment environment, the newly-built community combines industrial and industrial zones, with 20 low-income housing projects, 74,258 households. The living space is heterogeneous as it is comprised of grouped low-income houses, relocation houses, commercial real estate, and low-rent houses. While implementing low-income housing construction, there is a parallel effort to transfer massive residents from the disaster-stricken area to a new area. The compensatory fund of housing reconstruction is similar to that of farmland appropriation [32]. In order to ensure the reconstruction of land resources in urban areas, the Dujiangyan Municipal Government adopted a mechanism for increasing the urban construction land and reducing the rural construction land, thus achieving the 29 km^2 land intensive use target. The relocation in the urban area is similar to that of rural areas, which turns the remainder of collectively-owned land resources into nationalized construction land. On the other hand, to cope with issues as decreasing arable land, multiple packages of housing settlement have been carried out. Such measures not only dealt with pressing land resource issues but also achieved specific goals.

- **Population planning**

The spatial reconstruction planning for Duajingyan city proper is composed of original spatial adjustment and space regeneration. According to the assessment of land applicability in Dujiangyan City, multiple places are not suitable for on-site reconstruction. Spatial distribution pattern of a high-density population of Old Town (zone I) proper is considered as a potentially hazardous factor. After the risk assessment, the Dujiangyan Municipal Government decided to

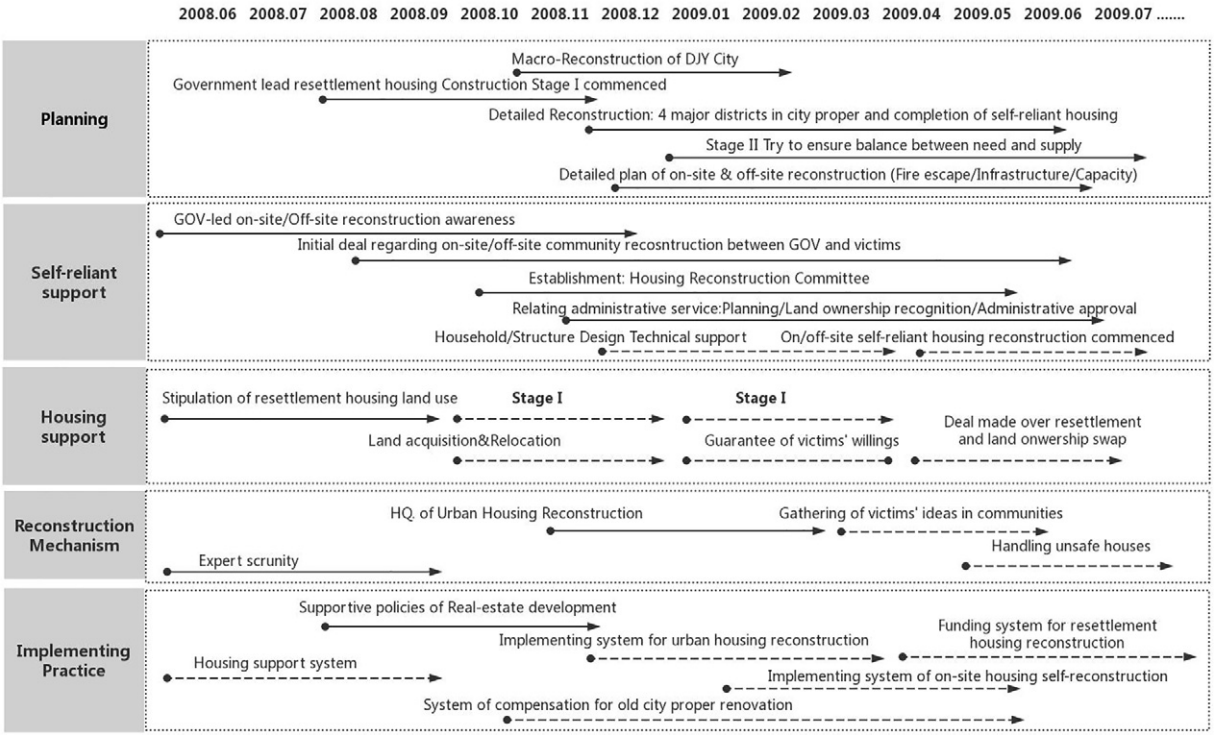

Fig. 4. Schematic diagram of housing reconstruction process management.

Table 1
Housing reconstruction model and its property rights determination.

Reconstruction mode		Planning system		Main part			Housing property			Social class				Ownership
		Reconstruction planning	Planning adjustment	Government	Group	Individual	Secure housing	Self-built housing	Rescue housing	General income and above	Low income	Minimum living security income	Diversified income	
Original site reconstruction	Self-built	√	√			√		√					√	√
	Joint construction	√	√			√		√					√	√
Replacement land reconstruction	Offsite	√	√			√		√					√	Have altogether
	Self-built													
	Social funded	√	√			√		√					√	Have altogether
Rental housing	Low-cost housing	√	√	√					√			√		
	Rental subsidy	√	√	√					√			√		
	Affordable housing	√	√	√					√		√			
Buying housing	Affordable housing	√	√	√			√						√	√
	Commercial housing	√								√			√	√
Combined reconstruction	Original site reconstruction (house reform)	√			√			√		√				√
	Original site construction (state-owned)	√			√			√			√			
	Purchasing/leasing low-cost housing	√		√					√				√	Have altogether
	Replacement land reconstruction housing		√		√			√					√	Have altogether
Affordable housing replacement		√		√			√			√				√
Fund subsidy housing		√				√		√		√				√
Continuous lease of state-owned housing		√		√					√		√			

Table 2
Implementation standards for urban housing reconstruction fund subsidy policy.

Subsidy standard (million yuan/household)					Subsidy					Subsidy condition		
Class	Family population/income level	1–2 person	3 person	>4 person	Household	Funds demand	Disbursement funds	Dispatch rate (%)	Proportion (%)	Property	Household registration	Safety identification
Housing reconstruction	Lowest	2.7–2.9	3.0–3.23	3.3–3.5	33,980	8.5	8.1	95.3	62	Private	Urban	Safety certification
	Low	2.4–2.6	2.7–2.9	3.0–3.2								
	High	0.5	0.7	1								
	Average		2.5									
Housing reinforcement	Damage level		Subsidy standard		74,925	5.2	5.2	100	38	Private	Urban	Safety certification
	Mild damage		0.1–0.3									
	Moderate damage		0.4–0.5									
	Severe damage		0.6–0.8		Total	13.7	13.2	/	/			

Table 3
Implementation standards for urban housing reconstruction physical subsidy policy.

Subsidy object			Subsidy attribute	Subsidy standard	Funds sources	Subsidy condition	
Region	Class	Description				Property	Safety identification
Urban	Three-no	No labor, no source of life, no dependents	Rescue	40m^2 housing free of charge	Government	No private property rights	Safety certification
	Three solitary	Lonely old person, lonely child, lonely disabled person	Social well-being	Welfare home	Earthquake financial subsidy (35,000/person)		

adjust the administrative area and expand based on the original urban area to evacuate the population and develop new housing land. For instance, the original area of Old Town is 5.55 km^2, with 150,000 populations. However, the Old Town proper contains a few shortcomings: the per capita area is <20 m^2, and the area is close to Longmenshan fault so that it is not suitable for comprehensive and intensive construction. The adjustment is mainly on updating and population scattering. First of all, based on preserving the intact spatial structure of the Old Town, the area will be gradually transformed into commercial and residential dual-function land. Secondly, the severely damaged administrative areas and residential areas were converted into commercial facilities, thereby migrating 50% of the old city population to Zone II, the Zone III, and the Zone V. The construction of the new urban area is mainly used for the migration of the population of the

Table 4
Implementation standards for rural housing reconstruction subsidy policies.

Subsidy object	Family population (person)	Subsidy (yuan/household)	Condition		Administrative procedures
			Disaster level	Household registration	
General farmers	1–3	16,000	House damage	Local villagers	Safety identification
	4–5	19,000			Village and group required subsidy publicity
	≥6	22,000			Township government's instructions
Hard farmers	1–3	20,000	House damage	Local villagers	Dangerous house handling procedures
	4–5	23,000			Subsidized blonde
	≥6	26,000			Subsidized blonde

Table 5
Damage and safety assessment of urban housing in Dujiangyan.

Urban housing damage (June 2008)				Safety appraisal housing reconstruction classification (August 2008)			
Region	Damage grade	Num. of household	Percentage (%)	Recovery method	Damage grade	Num. of household	Percentage (%)
City	Collapsed	4375	4.69%	Housing reconstruction	• Collapse • Severely damage cannot be repaired	40,167	36.42%
	Severely damaged	28,994	31.09%				
	Moderately damaged	24,776	26.57%				
	Mildly damaged	23,217	24.90%				
	Basically intact	11,894	12.75%				
	Total	93,256	100.00%				
Town	Collapsed	1998	11.73%	Housing reinforcement	• Moderately damaged • Mildly damaged	56,572	51.29%
	Severely damaged	4810	28.23%				
	Moderately damaged	5137	30.15%				
	Mildly damaged	3442	20.20%				
	Basically intact	1650	9.68%				
	Total	17,037	100.00%				
Total	110,293 (household)			Minor repair	•Basically intact	10,260	9.30%

Table 6
Statistics on housing reconstruction needs in Dujiangyan towns.

Class	Reconstruction scale (unit: 10,000m^2, 1000 sets)							Investment demand (unit: 100 million yuan)				
	Housing reinforcement		New build housing				Public construction	Housing reinforcement	New build housing	Low-cost housing	Public construction	Total
	Area	Set	Area	Set	Low-cost housing							
					Area	Set	Area					
City	342.52	2.83	441	5.1	10	0.2	30	45.74	76.03	1.5	53.3	175
Town	420	4.67	66	0.49	/	/	/					
Total	762.52	7.5	506	5.59	10	0.2	30					
City proportion	44.90%	37.70%	87.20%	91.20%								
Town proportion	55.10%	62.30%	13.00%	8.80%	/	/	/					

Old Town and the housing of the future urban population. According to calculations, after the reconstruction, roughly 200,000 people will be moved into the above areas, including farmers and farmers whose land is occupied.

4.2.2. Resettlement measures

Based on the comprehensive analysis of geological assessment, ecological assessment, and traffic accessibility assessment, the evaluation of suitable construction land in Dujiangyan City was decided. Coupled with the analysis of the damage to the building in Dujiangyan urban spaces, is shown in Fig. 5. The reconstruction method and planning implementation arrangement are shown in Table 7. Region A and C belong to the full reconstruction mode and have priority. During the reconstruction process, the residents of the two places were first resettled in the temporary resettlement sites planned by the government and then transferred from the temporary resettlement areas to the over-relocation areas and permanent resettlement areas according to the housing reconstruction process. The rehabilitation and reconstruction project in region B is complicated; systematic planning should be carried out before reconstruction, including the old town landscape protection planning and reconstruction development planning, etc., in consideration of the resettlement of the victims, it is also necessary to consider the business problems of historical blocks and tourist attractions. The D and E regions belong to the original repair and reinforcement project. The government and the victims jointly work as the main body for reconstruction. Among them, the regional E housing is basically intact, and most of the slightly damaged housing can be used after repairing, so it has the priority to exercise the right to resettle.

4.3. Housing reconstruction selection and supply

On May 25, 2008, the Dujiangyan government proposed that the victims voluntarily choose to rebuild the housing model system, that is, the general housing development model, the multi-dimension housing reconstruction model and the supply plan based on the overall planning of the central urban area allow the victims (citizens) to choose voluntarily. Residential supply systems fall into two categories: demolition and damage. The scale of supply is about 12,000 due to the earthquake-damaged houses on the land. Affordable housing is a typical government-led reconstruction model [18]. During the reconstruction process, the victims showed a high degree of reliance on the government. The main reason can be thought that the victims (>80%) do not have enough funds to cover the cost of housing reconstruction. According to the survey conducted in June 2008 (200 copies), >63% of the victims are expected to rebuild in situ, and >22% of the victims are expected to build new houses in the suburbs of Dujiangyan, while the number of victims expecting new housing in Juyuan New District is <8%. Affected by reconstruction, the large-scale concentration of the victims is tough for the government (government visit record, August 2008). During the reconstruction process, the Dujiangyan Municipal Government adopted the Property Law to guide and improve the sense of ownership of the victims, thus promoting the implementation of in-situ

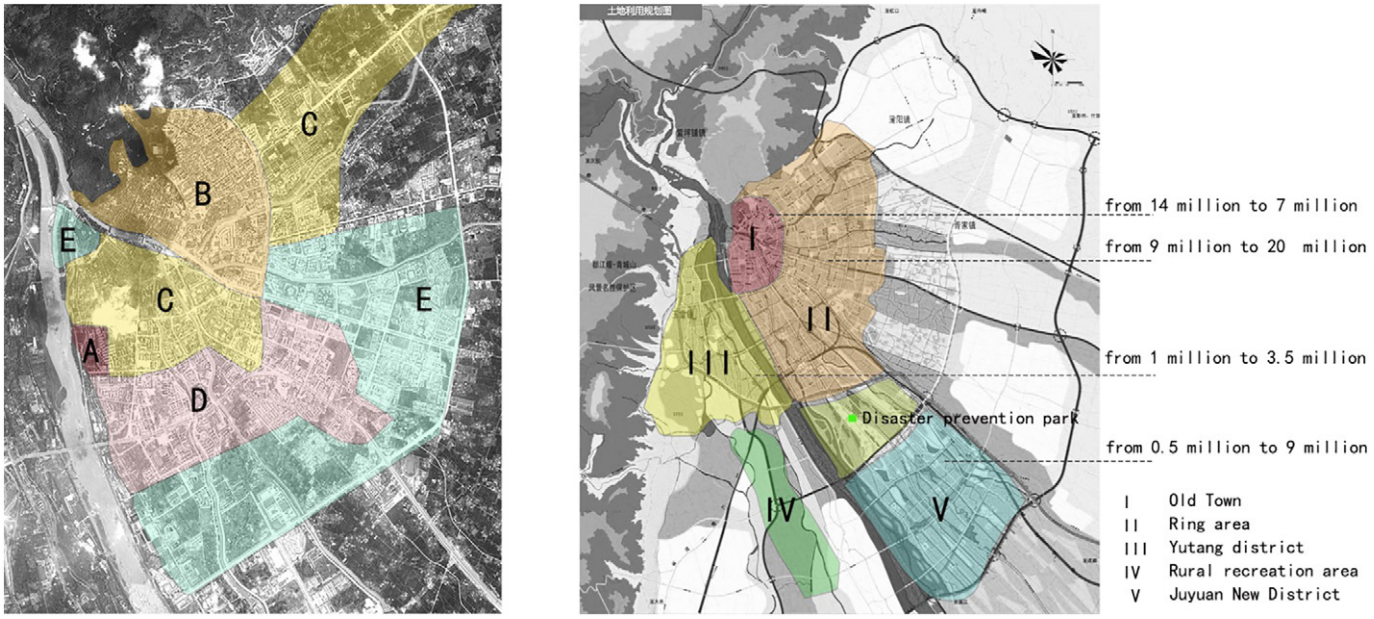

Fig. 5. Schematic diagram of spatial adjustment of housing reconstruction planning.

Table 7
Spatial division and reconstruction methods of resettlement measures.

No.	Degree of housing damage	Reconstruction method	Implementation party	Compensation method	Property rights replacement	Order
A	Not suitable for construction area: complete damage and severely damage	Relocation	Government	70% residential compensation area	Shared property	Priority
B	Not suitable for construction area: moderately damaged and slightly damaged	On-situ reconstruction + repair + change function + reduce density	Victims	Monetary compensation construction cost	Private property	–
			Government	70% residential compensation area	Shared property	–
C	Suitable construction area: complete damage and severely damage	On-situ reconstruction	Government	70% residential compensation area	Shared property	Priority
D	Suitable construction area: moderately and slightly damaged	On-situ repair and reinforcement	Government + Victims	Monetary compensation construction cost	Private property	–
E	Suitable construction area: basically intact	On-situ repair and reinforcement	Government + Victims	Monetary compensation construction cost	Private property	Priority

reconstruction on a large scale. Affordable housing is similar to traditional economic housing and is a new post-disaster reconstruction housing supply system. According to the diverse needs of the victims, affordable housing also provides different types of housing for victims (areas outside the 70 square meters are paid at market prices). As of October 2009, the total size of government-led urban housing reconstruction reached >46,000, the number of resettlement victims was about 34,000, and the number of non-disaster resettlement households was about 12,000. Affordable housing is the most significant proportion of housing reconstruction, accounting for about 56% of the total housing construction area. About 20,380 victims signed a housing replacement agreement, and more than half of the victims (60%) chose 70 square meters of housing, 85 square meters, 105 square meters, 120 square meters and 20% of market-based housing. It is at 5%. At 1% and 10%, the proportion of victims who choose to settle by currency is 3%. Due to various reconstruction methods and the scattered sample layout of self-built houses, this article does not do statistics. However, self-built housing is more flexible than the government's uniformly planned housing, such as original site reconstruction, community reconstruction, and cross-community combination reconstruction, which not only meets the demand but also replaces a large number of land resources.

5. Conclusion and prospect

According to historical records, the reasons drew from housing reconstruction failure can be concluded as: little or invalid public participation, lack of co-support of social organization and expert, incomplete legal basis, deficiency in reconstruction funds, hasty reconstruction, ignorance over the vulnerable, and issues regarding land property rights [11,14,31,34,35]. Significant reconstruction cases share commonalities such as full support from local government and social groups, sound reconstruction plan, emphasis on local culture, and exchanges among shareholders [8,11,22,26].

Through the analysis of the housing reconstruction in Dujiangyan central city, it can be found that the housing reconstruction of Dujiangyan is under the guidance of the central government, while the local government as an aid to ensure the effective implementation of reconstruction. Besides, the feedback mechanism between the central government and local governments is conducive to providing solutions to unforeseen problems and contradictions in reconstruction. According to the investigation of the reconstruction intention of the victims, the government proposed that the reconstruction plan, which is mainly based on residential housing and supplemented by self-built housing, largely satisfies the needs of different individuals. Among them, housing supply methods such as property rights replacement, currency termination, and renting of public housing, especially for special programs set up for low-income people, effectively solved the complex property rights issues involved in post-disaster housing reconstruction and the shortage of funds for the reconstruction of affected people. In addition, under the guidance of the government-led housing construction policy, some residents whose housing have been damaged and cannot be reconstructed in situ will be transferred from their original place of residence to the residential area around the city. The space concentration of residential housing has maintained the original social relationship of the residents to a certain extent. On this basis, the in-kind support system not only protects the interests of the owners, but also achieves the goal of saving the land and integrating resources, and has replaced a large number of land resources for the government. The development of residential housing, using the role of the market economy to attract social funds to participate in the reconstruction, effectively stimulated the operation of the post-disaster market economy. In urban housing reconstruction, problems such as land redrawing are usually involved. The government of Dujiangyan City has established a property rights protection system to protect the rights and interests of victims in the period of post-disaster recovery based on the rights of housing use rights and mortgages owned by the victims. At the same time, the victims can also apply for loans to purchase housing or replace their housing with their property rights. The replacement model of property rights and housing has realized the transformation of the original land nature and function, providing a space for development after the earthquake recovery and reconstruction, and the intensive use of new urban land.

Compared with the previous post-disaster reconstruction projects, the housing reconstruction of Dujiangyan Municipality is based on the idea of “government-led, victim participation, and external assistance” to form a reconstruction model in which multiple entities participate together. In the process of building affordable housing, the government, as the core strength of reconstruction, comprehensively plans and implements various aspects of housing reconstruction, infrastructure, public services, market services, and leads other forces to participate in the reconstruction work. Meanwhile, in order to fully mobilize multi-agent participation in reconstruction, Dujiangyan Municipality established a council composed of representatives and experts of the victims and implemented a system of separation of decision-making power and executive power to maximize the role of the victims. Through the mutual restraint between powers, the implementation of the post-disaster housing reconstruction mechanism is ensured. In the process of reconstruction and implementation, the decentralization and balance of rights will undoubtedly form a better supervision mechanism, and to a certain extent avoid the one-right housing reconstruction plan and ensure the quality of housing reconstruction.

In general, after the Wenchuan earthquake, the characteristics of Dujiangyan housing reconstruction can be summarized as the multi-level parallel reconstruction mode of the central government's guidance, local government cooperation, civil institution cooperation, and social participation. Based on the disaster-stricken housing, through the participation of the victims to establish direct contact with the leading organizations, and then based on the assistance of professional teams to jointly explore to achieve maximum satisfaction with the reconstruction needs of the disaster areas (such as homes, environment, industry, culture, etc.) and The process and results of the action.

Declaration of competing interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled.

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