A generic decision model for developing concentrated rural settlement in post-disaster reconstruction: A China study

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Abstract: The increasing impacts of natural disasters on disadvantaged rural areas, especially in developing countries, have led to concerns regarding post-disaster rural settlement reconstruction. Various approaches, including resettlement and in-situ reconstruction, have been adopted, both of which disregard changing the pattern of dispersed settlement in villages. Against a pattern of dispersed settlement, developing a concentrated rural settlement (CRS) within a village is argued to enable the resilience of rural villages and provide a basis for sustainable development after a disaster. Nevertheless, this has received little attention when determining a plan of actions for post-disaster reconstruction. No specific guidelines can be referenced when developing CRS in post-disaster reconstruction due to the lack of a generic decision model. Therefore, this study examines the process of developing CRS in post-disaster reconstruction by mapping four cases selected in Dujiangyan, China, after the 5.12 Sichuan Earthquake in 2008. The examination leads to establishing a generic decision model for developing CRS in post-disaster reconstruction, which incorporates all the proficiencies embodied in the existing practices. This model provides

an alternative tool for planning CRS in post-disaster reconstruction. It can also serve as a vehicle for identifying both effective practices and weak areas by comparing varying cases.

Keywords: Concentrated rural settlement (CRS), post-disaster reconstruction, generic decision model, mapping, 5.12 Sichuan Earthquake, China

1 Introduction

Housing reconstruction plays an important role in restoring society to its former level, especially for rural areas in developing countries where disasters usually result in extreme disadvantages (Al-Nammari and Lindell 2009; Wu and Lindell 2004). In rural areas, two approaches – in-situ reconstruction and resettlement – are usually taken to rebuild houses. In-situ reconstruction is an approach to replace damaged houses with new ones onsite, in their original location (Jha et al., 2010). The resettlement approach, on the other hand, refers to building new houses on a new site where natural disaster is less likely (Badri et al., 2006). Both approaches have their inherent merits; for example, in-situ reconstruction requires little mobilization, requires no land acquisition, and would not bring about much social tensions (Jha et al., 2010). Resettlement provides opportunities for victims to improve their livelihoods via better access to employment and public services (Badri et al., 2006). However, without emphasis on a suitable concentration of rural settlements, these traditional approaches would either continue several disadvantages, such as land resource waste, poor living conditions and environmental degradation; or bring new disadvantages, like undermining livelihoods and disrupting social networks. In regard to the pattern of dispersed settlements in developing countries, neither approach is consistent with the appeal of achieving sustainable post-disaster reconstruction, especially now.

Developing concentrated rural settlements (CRS) within a village is a feasible approach to achieving sustainable development and increasing a village's resilience after disasters. CRS is considered as an effective means to utilize rural land, improve infrastructure and public services, and better living conditions in the countryside (Turnock, 1991). CRS not only reduces the rural disadvantages and alleviates the imbalance of welfare distribution between urban and rural areas, but also contributes to achieving sustainable development by saving land consumption and serving as growth-engines and stabilizers of urbanization through linking rural and urban areas (Alaci, 2010; Qadeer, 2004). In addition, these benefits would help rural areas confront their

vulnerabilities while facing fewer disadvantages led by a high population concentration as found in urban areas (Peng et al., 2013).

Few studies have been conducted in developing CRS for post-disaster reconstruction in China. How to effectively develop CRS during post-disaster reconstruction therefore remains unknown. In theory, a number of studies have been conducted to investigate the process of reconstruction at the national/regional level without special referral to CRS. For example, the pioneering research by Haas et al. (1977) provides a conceptual framework in which urban reconstruction proceeds in four sequential stages: emergency response involving debris removal, restoration of public services, replacement or reconstruction of capital stock to pre-disaster levels, and commemorative/betterment/developmental reconstruction. Following studies have provides other models like the three peaks model by Rubin and Popkin (1990), and five key stages model by Brunsdon and Smith (2004). The three peaks model addresses concerns for physical recovery, societal recovery, and community betterment. The five key stages model considers reconstruction as a mega project, which can be managed from impact assessment, restoration proposal, funding arrangements, regulatory process and physical construction. Quarantelli (1995) developed a four-stage shelter model-emergency shelter, temporary shelter, temporary housing, and permanent housing-to illustrate the housing reconstruction process. However, later research found that the four stages are not necessarily sequential, but can occur simultaneously or in different sequences (Rubin, 1991; Berke et al., 1993; Bolin 1993). Recent research has moved beyond physical reconstruction, laying out the concerns for social progress and sustainable post-disaster reconstruction (Nigg, 1995; Mileti, 1999; Miles and Chang, 2006). These studies have enriched this research's sources on housing reconstruction and provided useful references for future study. Nevertheless, it appears that existing research pays less attention to post-disaster rural settlement reconstruction at the village level, although it emphasizes the importance of community participation and local actions for sustainable post-disaster reconstruction. On the other hand,

existing standard project management may also provide a reference on how to effectively develop CRS in post-disaster reconstruction. However, when compared to a construction project under normal conditions (where no natural disaster occurs), the post-disaster reconstruction environment is chaotic, dynamic, and complex (Alexander, 2004; Berke et al., 1993; Birkland, 2006; Davidson et al., 2007). The decision model of a construction project developed under normal conditions might not be applicable in post-disaster reconstruction.

In practice, the existing decision system of rural housing reconstruction in China lends a useful tool to investigate how to effectively develop CRS in post-disaster reconstruction. The current operational mechanism of rural housing reconstruction in China can be summarized as: “unified leadership, graded response and functional division, based on local government and supplemented by central government” (Yi et al., 2012: 296). The general principles of rural housing reconstruction are specified through the formulated laws and regulations concerning a specific disaster event. Four main steps would be followed in rural housing reconstruction including: determining the households needing reconstruction, rural housing planning, rebuilding the rural housing, and checking the delivery of rural housing (State Council’s Earthquake Relief Headquarter, 2008). However, the existing decision system provides merely general guidelines and cannot be directly used in CRS development due to various problems. For example, there is no specific pre-disaster planning at the village level, which usually results in unreasonable reconstruction and thus sustainability is difficult to ensure. In addition, the current decision system only emphasizes building emergency management systems from the aspect of government while excluding individuals’ role in disaster mitigation and prevention. Education should be given to improve individuals’ abilities to prevent and respond to natural disasters (Barakat et al., 2013). Most importantly, CRS is a new form different from both the traditional dispersed rural settlement and the urban community. Many new problems such as how to adapt to the new lifestyle would be generated as a result. An appropriate management approach should be put forward to deal with

these problems, which are not included in existing decision systems of rural housing reconstruction.

There is no decision model available for guiding CRS development in post-disaster reconstruction in China although CRS is considered to be a sustainable approach. Therefore, this study aims to establish a generic decision model for implementing CRS in post-disaster reconstruction, using the 2008 Sichuan Earthquake in China as an example. In order to fulfill this research aim, Section 2 will specify the methods adopted in this study to map the process of implementing CRS in post-disaster reconstruction. Section 3 will present the cases and findings of the mapping approach. Section 4 will discuss the mapping results, put forward a generic decision model, and section 5 presents the results of model validation. Finally, Section 6 will conclude the research with suggestions on future study.

2 Research Methods

This paper aims to establish a decision model for utilizing CRS in post-disaster reconstruction with an emphasis on the implementation process. However few studies have been conducted on this issue and an explorative investigation on the real cases is necessary. For this purpose, the implementation of CRS in four villages in Dujiangyan, Chengdu City, China was mapped. Cases were identified through a web search, and interviews were conducted with the local officials, planners and rural victims of the four villages to collect additional information on implementing CRS. The free-flow mapping technique was adopted to map the process of developing CRS in post-disaster reconstruction, the result of which was confirmed by the local officials. Finally, the problems and experiences in the mapped processes were discussed. A generic decision model for developing CRS in post-disaster reconstruction was established based on the experiences and problems found in current reconstruction practices and the traditional model's principles. Model validation was also conducted to ensure its practicability. The generic decision model was put

forward as a guideline for future CRS development in post-disaster reconstruction in China.

3 Mapping the implementation process of CRS in post-disaster reconstruction projects

A web search was conducted to find villages that have developed CRS after the devastation of the 5.12 Sichuan Earthquake in 2008. Seven villages of Dujiangyan City were able to successfully implement CRS in its reconstruction plans. These seven villages were identified as case study candidates in this research. A field study in Dujiangyan City, Sichuan Province, was therefore conducted in September, 2011. The research team was able to reach and successfully interview the local officials of four villages, namely Xiangrong, Shiqiao, Qingjiang, and Luchi Villages. The data from each of the four villages is specified in Figure 1 and Table 1.

<Please Insert Figure 1 here>

<Please insert Table 1 here>

The free-flow mapping presentation technique was adopted in this study for investigating the process of developing CRS in post-disaster reconstruction. This technique has been considered advantageous in presenting a logical, clear flow of the process (Fisher and Shen, 1992). An interview with relevant experts and a field study was adopted to collect the information of reconstruction process, and to find any relevant problems and experiences. As shown in Table 2, the interviewees were qualified to comment on CRS development in post-disaster reconstruction. The interview was conducted in Chinese, given that it is the dominant language in the targeted population. Due to political sensitivity, inhabitants of the disaster-hit areas are known for rejecting interviews conducted in other languages. But the researchers speak the province's native dialect, and this helped to reduce many barriers that would have otherwise been present. Careful attention was paid to minimizing the chance that information would be lost in the translation from

Chinese to English.

<Please insert Table 2 here>

The process of developing these mappings allows the research team to understand the problems and experiences of each practice, which forms the basis for developing an effective decision model. It is necessary to note that this study seeks to present an alternative method for examining developing CRS in post-disaster reconstruction. Although the data used is not from a comprehensive survey, it provides a level of indication about the current practice of developing CRS in post-disaster reconstruction in China. In order to conduct comparative analysis between the four cases, consistent terminologies are used for presenting the mappings.

- Damage assessment: The earthquake relief headquarters established expert groups to assess the extent of damage of the rural houses.

- Determining the reconstruction approach: Whether to develop CRS or to reconstruct in-situ; if to develop CRS, whether adopting unified-planning-self-reconstruction or unified-planning-unified-reconstruction was discussed and determined[*].

- Site selection: Select the sites for developing CRS within the village.

- Project application: Proposal of developing CRS post-disaster was submitted to the Construction Committee and Standing Committee of Dujiangyan for endorsement.

- Housing planning and design: Respective design company/institutions were hired to plan a course of action in order for the reconstruction to remain reasonable.

- Building CRS: The rural victims respectively selected a construction team and signed the contract to build houses.

- Infrastructure planning: The village planning council of Dujiangyan made infrastructure planning for CRS, which acquired the village committee's comments and final confirmation.

- Building infrastructure: The construction committee of Dujiangyan entrusted construction teams to build the infrastructure.

- Allocating the houses for unified-planning-unified-reconstruction: The houses were allocated by a lottery draw with official oversight.

- Moving into the CRS: The rural victims moved into the constructed houses in the reconstruction site after completing housing, building infrastructure, and final decorations and beautification.

- Demolish the former houses and consolidate the former rural residential land: According to China's regulation, the rural victims moving into the CRS must demolish their former houses and consolidate the former rural residential land, which must be used as cultivated land.

- Issue the property right certificate: Property right certificate of the housing and rural residential land in the reconstruction site was issued after the rural victims confirmed the results of survey.

- Daily management: The residents of the concentrated site elected the members of the management committee for the site. The management committee conducted daily management practices accordingly.

- Economic development: Various measures such as land circulation, eco-agriculture, and tourism were considered to promote economic development after concentrating the population

<Please insert Figure 2 here>

<Please insert Figure 3 here>

It was found that the process of developing CRS was similar between the villages of Xiangrong and Qingjiang, while the village of Shiqiao was similar with Luchi. These were mapped and presented in Figures 2-3 separately. The field study and discussions on these practices led to the formulation of a list of problems and experiences in developing CRS in post-disaster reconstruction:

Problem:

P_1=no pre-disaster planning

P_2=undetermined property rights of cultivated land generated from consolidating former rural residential land

P_3=no geographical survey in site selection

P_4=incapability of completing project application before reconstruction

P_5=little supervision on the housing quality

P_6= inadequate assessment due to rush of progress

P_7=inadequate infrastructure

P_8=insufficient financial support on daily management for CRS

P_9=insufficient coordination between industrial planning and developing CRS

P_{10}=weak basis for future development

P_{11}=little attention to environmental impacts

P_{12}=little attention to psychological recovery

P_{13}=few risk-coping mechanisms for CRS

P_{14}=little education for disaster reduction

Experience:

E_1=transparent and consistent policies

E_2=many matched policies to support CRS

E_3=sufficient promotions of CRS to the rural victims

E_4=establishing special village affairs board and special supervision board

E_5=regional coordination of the external features of CRS

E_6=mobilizing the farmers themselves to conduct daily management for CRS

E_7=assessment on damage degree rather than the economic values of the houses

E_8=CRS suiting local production and living ways

E_9=suitable degree of concentration

E_{10}=using the local or nearby materials and construction teams

E_{11}=adjustable housing and infrastructure planning

E_{12}=considering future needs of urbanization

The analysis of the problems and experiences of the surveyed practices was comparatively conducted between the four cases, and the results are given in Tables 3 and 4.

<Please insert Table 3 here>

<Please insert Table 4 here>

The most important issues for each case mainly lie in available matched policies, successful organization, involving rural victims in decision-making, and satisfying rural victims' needs for CRS, which were also included in the generic decision model. As explained by Peng et al. (2013), governmental guidance, economic development and victims' willingness are three important concerns to be considered in CRS development. These measures were therefore the key for the local government to successfully initiate and organize the concentration scheme. For example, the policy of rural residential land exchange, which implies the land use right of the saved areas of construction land in rural areas could be transferred to urban areas, was available for the rural victims to gain extra income for reconstruction (Peng et al., 2013). Also, rural victims were involved in decision-making during CRS development. All case villages established the Special

village affair board (SVAB) and Special Supervision Board (SSB) to discuss and supervise the implementation of relevant issues, such as reconstruction approach, site selection, layout, housing design (Peng et al., 2013). Moreover, as a result of involvement in decision-making, it was easy to satisfy rural victims' needs for CRS such as sufficient space for agricultural needs, short cultivation radius and suitable degree of concentration. Therefore, the rural victims were willing to support CRS development as they can envisage what they can get after concentration.

The typical problems existing in most of the surveyed cases included: no pre-disaster planning, incapability of completing project application before reconstruction, little supervision on the housing quality, insufficient financial support on daily management for CRS, insufficient coordination between industrial planning and developing CRS, little attention to environmental impacts, little attention to psychological recovery, and little education for disaster reduction. The reasons for these identified problems above are multiple. Typically, some critical activities of developing CRS in post-disaster reconstruction are missing. For example, although there were some emergency measures of responding to natural disasters, no pre-disaster planning was available. As a result, no specific guidelines can be provided to instruct the process of developing CRS. The local officials had to explore developing CRS with the rural victims in a rush while listening to the directives of the upper government. The rush of developing CRS without critical guidelines inevitably led to some problems. This problem might be resolved by expanding the pool of systematic studies on decision model for developing CRS in post-disaster reconstruction, which is precisely the aim of this research. In addition, some activities are not so well-designed due to the rush of the project. For instance, there is little supervision on the quality of housing and very little assessment on the reconstruction process. This may lead to critical issues if another disaster occurs. Relevant activities should be fine-tuned in the generic decision model for developing CRS. Moreover, some important features of sustainable development have been given insufficient consideration, including: balancing reconstruction efforts with economic, social and

environmental benefits; mobilizing the available financial resources and participants; and recycling resources in the reconstruction process. Therefore, the basis for future development may be somewhat weak for some villages. Disaster reduction education and psychology recovery were not included sufficiently as participants in the reconstruction project; for example, NGOs were not present especially in the stage of post-disaster community management. Also, the environmental impacts were given little consideration as resource recycling was overlooked.

4 The generic decision model for developing CRS in post-disaster reconstruction

By examining the problems and experiences in developing CRS in the four surveyed villages, we may obtain valuable references for proposing a more effective decision model. By incorporating the experiences embodied in these practices, the decision framework of developing CRS in post-disaster reconstruction is shown in Figure 4. The main part in this framework is optimizing the process of developing CRS in post-disaster reconstruction (sub-model A); while balancing reconstruction with social, environmental, and economic considerations (sub-model B); then mobilizing the participants and financial resources (sub-model C); and finally recycling resources in post-disaster reconstruction (sub-model D). All are important components in ensuring the sustainability of a post-disaster reconstruction. The following sections briefly introduce these four parts.

<Please insert Figure 4 here>

4.1 Optimizing the process of developing CRS in post-disaster reconstruction

As the critical part, sub-model A aims to optimize the process of reconstruction and provide references to the critical activities in each step. As shown in Figure 5, there are four sub-stages, namely reconstruction preparedness of CRS (A-1), planning of CRS (A-2), building CRS (A-3),

and post-disaster community management of CRS (A-4) in the reconstruction process. Meanwhile a GIS support system (A-5) is introduced to coordinate the efforts of the village-level government and the regional-level government, and record any relevant information.

<Please insert Figure 5 here>

Reconstruction preparedness of concentrated rural settlement (CRS) (A-1)

Reconstruction preparedness of CRS shall be put on agenda while the emergency relief and temporary housing are undertaken. In this stage, four most important activities namely damage assessment, reviewing pre-disaster planning, determining whether to concentrate the victims and establishing the Special village affair board (SVAB) and Special Supervision Board (SSB) should be led by the local officials as shown in Figure 6-1. The activities of this stage would target whether concentration and who shall be in responsible for organizing and supervising the whole process.

Damage assessment is the basis when determining the proper approach to reconstruction. The principles applied in this step include people orientation and assessment on damage rather than on the economic values of the houses. As disaster brings a great shock to farmers, people orientation is useful to reduce the resistance in the following reconstruction process. The assessment on damages is a response to how national subsidies are allocated, based on the degree of damage, and can reduce the suspicion of unfairness. As well, the study found that the higher the percentage of collapsed and severely damaged households, the higher the ratio of moving to a concentrated rural settlement (Peng et al., 2013).

Reviewing pre-disaster planning is a key for timely housing reconstruction, as the timeframe of a disaster offers insufficient time to make proactive plans and hold stakeholder consultations (Wu and Lindell, 2004; Badri et al., 2006). Various critical elements, such as organization, land use,

regional coordination, building standards, household preparation, and construction-sector preparation, should be specified in the planning (Wu and Lindell, 2004). In addition, drawing on local resources, meeting local living standards and culture, and selecting a proper location are also necessary (Johnson, 2007). Furthermore, in order to achieve sustainable development, a plan that is flexible, uses minimal energy consumption, is supported by community participation, and produces long-term effects, should be emphasized (Arslan, 2007; Davidson et al., 2007). The biggest benefit of pre-disaster planning lies in the planning process—not in the written plan itself (Wu and Lindell, 2004). This generic decision model is a good reference for local governments when designing a pre-disaster plan for CRS.

Determining whether to concentrate the victims is a precondition for developing CRS. Critical factors such as availability of favorable policies, local government organization capacity, economic development conditions, and rural victims' willingness should be considered (Peng et al., 2013). If the geographical location and economic development both provide the basis for concentration and the local government has the capacities of introducing the pros and cons of CRS and attaining sufficient numbers of rural victims to participate in this scheme, it is possible to develop CRS after disaster strikes. Otherwise, the rural victims can choose reconstruction in-situ. However, even so, the government should also pay attention to guaranteeing the quality of reconstruction.

Establishing the Special village affair board (SVAB) and Special Supervision Board (SSB) is a means to involve rural victims in the decision-making process. Members within SVAB and SSB are elected by both the rural victims participating in CRS and the local officials. Participation empowers the rural victims to reach consensus on reconstruction and attain community capabilities for further development, which is critical for sustainable post-disaster reconstruction (Pearce, 2003; Davidson et al., 2007). The first issue on the agenda of SVAB is to choose whether to engage in self-reconstruction or unified-reconstruction, since unified planning is necessary for

CRS. The most important principle, no matter what they elect, is in following the rural victims' preferences. The practical criterion is that if some partner is interested in providing financial support to conduct unified-reconstruction, and the village has the potential of suburbanization or mainly relies on non-primary economic activities, unified-reconstruction is acceptable. A contract is needed to determine the distribution of benefits between the village and the financial backer. Meanwhile, self-reconstruction is suitable for remote villages, which have little potential of suburbanization and still relies on primary economic activities. In addition, SVAB must be responsible for organizing the discussions on site selection, housing allocation, demolishing former rural houses and reclaiming the former rural residential land. SSB must be responsible for supervising the implementation of every decision made by SVAB, supervising the quality of the houses during reconstruction, and reviewing the timeframe of the CRS project.

<Please insert Figure 6-1 here>

Planning of CRS (A-2)

After the preparedness, planning of CRS would be started as shown in Figure 6-2. Site selection, housing design and planning, and recording the proposals of developing CRS are three main steps to ensure the reasonableness of developing CRS. The activities in this stage shall result in determined sites for concentration, housing planning schemes, and proposals of developing CRS submitted to upper governmental departments. Each step should be paid enough attention as follows:

Site selection is critical for developing CRS after a disaster strikes. The principles for this activity include: (a) safety—no secondary and future disasters; (b) capacity—enough ecological carrying capacity for CRS and relevant infrastructure; (c) proximity to transportation; (d) proximity to the contracted land, especially for those self-reconstruction projects in which the victims prefer maintaining the rural lifestyle. Several sites can be selected to ensure that all rural victims can

easily carry on farm work; (e) proximity to urban areas, especially for victims who selected the unified-reconstruction project, and want to abandon the rural life; and (f) occupying farmland as little as possible. By following these principles, the rural victims can usually put forward some clear proposals. By combining the initial options and the experts' professional advice, several sites can be selected as a result. A geographical survey is necessary to finalize the selection.

Housing design and planning the layout of the settlement make up the basis for delivering an acceptable CRS. Professional experts/institutions should be employed to design the houses. It is better to have them stay in the villages, where they would be in charge of collecting materials, seeking advice, and following the whole process closely in order to provide flexible revisions. The principles taken into consideration include: accommodation to the local living and production ways, leaving room for future demands—like garages, and using the local materials as efficiently as possible.

Recording the proposals of developing CRS in the GIS support system is a response to the embarrassing fact that many projects had begun even before the project was endorsed. Many project applications are usually made simultaneously, which is beyond the processing capacity of China's upper government. Therefore, a simplified procedure should be made to confront the chaotic conditions and time constraints after a disaster. A robust GIS support system can be used to judge whether the site selection is feasible or not. Conditional permission can be given to the village to proceed with the reconstruction project after the check. Key points of the project application must be kept in the support system for further review in the construction quality. All the relevant certificates can be prepared in the process of reconstruction and issued after checking the delivery of CRS.

<Please insert Figure 6-2 here>

Building CRS (A-3)

After obtaining the conditional permission, building CRS can be proceeded as shown in Figure 6-3. While building CRS, infrastructure planning and design can be undertaken in order to save the building duration. Quality check of CRS finally can be used to ensure the safety. The activities in this stage mainly result in good quality of CRS and infrastructure.

Building CRS can begin after attaining the conditional permission. For self-reconstruction, the rural victims sign a contract with the local or external construction teams. The houses must be built according to the selected housing design schemes separately, and both the SVAB and SSB must conduct quality checks throughout the construction process. The financial source for each household would be the income from rural residential land exchange, self-owned capital, and credit. For unified-reconstruction, the whole project would be funded by the partner, who could sign a contract with a professional construction company. The concentrated settlements can be constructed according to the determined planning in the abovementioned step. The financial source would be the income from rural residential land exchange and the partner-owned capital. As the whole construction project is taken on by the partner, the rural victims shall get no income from rural residential land exchange.

Infrastructure planning and design can be carried out while the CRS is developed, since the construction of the houses takes a longer time. This is useful to reduce the duration of the project. The secret formula is to leave room for infrastructure while construction is in progress. The planning should satisfy the local needs and leave flexibility for future improvement. After the construction committee confirms the infrastructure planning, local construction teams or construction companies can be hired to construct the infrastructure. It is better to use local materials. However, the supply chain of the relevant materials should be robust to ensure consistent progress. The cost of the infrastructure can be assumed by the local government, and the reconstruction support partner.

Quality control of the development of CRS is critical to ensure the safety of those involved in its construction. Although SSB supervises the construction progress and quality now and then, the certification system of commercial houses in the urban areas should be referenced to ensure the quality of houses before the rural victims move in. SVAB could invite the relevant experts (or relevant NGOs) to assume this professional work. The rural victims must confirm the check results. For self-reconstruction, the rural victims can move into the CRS after they complete the interior decorating. For unified-reconstruction, the house should be allocated first. All the houses can be numbered, based on the types of rooms, floors and street block for a lucky draw. The first lucky draw can be used to determine the sequence of lucky draws to place the victims into the newly constructed houses. Then the second lucky draw can be used to choose the house according to the chosen drawing sequence. No matter what method is implemented, the detailed rules and procedures should be discussed among the rural victims so that they may reach a consensus and announce it in advance. The official notary should be invited to supervise the whole process in order to ensure equality and fairness. The feeling of equality and fairness is critical for the rural victims to accept the results and complete reconstruction smoothly.

<Please insert Figure 6-3 here>

Post-disaster community management of CRS (A-4)

Post-disaster community management of CRS aims to help the farmers adapt to the new life-style, find their own way to support the living, and learn to response to future disasters. Six important activities including demolishing former houses and consolidation, issuing the property rights certificate, daily management of CRS, economic development, and disaster preparedness should be conducted as shown in Figure 6-4. The key points of each step are listed as follows:

Demolishing former houses and consolidating the former rural residential land is necessary to complete the scheme of exchanging rural residential land. According to the requirements of

‘increasing versus decreasing’ policy, the former rural houses should be demolished and the relevant rural residential land should be consolidated to return the construction land back to farmable land. SVAB can hire a professional team to bear all the work. The SSB should encourage and supervise the implementation process. The financial source for this activity is the income from rural residential land exchanges. The allocation of the income for these rural residential land exchanges after consolidation can be used as an incentive to promote this activity. Finally, the land management departments should check and confirm the consolidation.

Issuing the property rights certificate is an indispensible step in confirming the results of the newly developed CRS. After a check on the consolidation of former rural houses is performed, a new property rights certificate of the CRS should be issued by the housing department from the upper government. For the property rights of farmland generated from consolidation, the upper government is better to issue a standard rule. As the right to use the construction has been transferred to urban areas, the contract rights of the farmland can be attributed to the corresponding rural victims while the ownership is still attributed to the rural collectives.

Daily management of CRS is important to achieve social sustainability after reconstruction. A new rural community, different from the traditional rural organization and the urban community, would be formed after concentrating the population. Corresponding measures should be made to support the new rural community. The residents can be mobilized to manage the public affairs by themselves, which is helpful to build social capital. Budgetary allocations from the upper government should be allocated to support daily management. In addition, NGOs can be mobilized to help the residents achieve psychological recovery, deal with the problems that may inflict the old and the young, promote the education of reducing disaster devastation, and accommodate to a new concentrated lifestyle.

Economic development is an important pillar to achieve economic sustainability after

concentrating the farmers. Characteristic agriculture, eco-tourism and eco-agriculture can be promoted by concentrating the farmland, and vocational training should be organized to provide laborers with enough skills to earn income to support their families after they've moved into their new houses in the CRS.

Disaster preparedness is an important measure to take, so that fewer lives will be at stake during the next potential disaster. Pre-disaster planning can be reviewed and improved after the reconstruction project has concluded. For the villages that have no pre-disaster planning experience, this is the chance to start by following the generic decision model and incorporating their own experiences in developing a CRS after a disaster.

<Please insert Figure 6-4 here>

The GIS support system (A-5)

The GIS support system is a tool used to record data of geography, demographic, economic and social development, disaster damage, reconstruction proposals, assessment results during reconstruction process, to conduct relevant analysis, and to manage a developing a CRS in the post-disaster reconstruction at the regional level. The functions of GIS support systems (A-5) are shown in Figure 6-5. Two important analysis components are to assess the resources around the new CRS and its environment carrying capacity, and the safety of the geological environment in establishing a concentrated rural settlement. These critical components are beneficial because they allow a project manager to easily judge whether the site for concentration is feasible. This in-depth analysis can also reduce the project's duration, allowing the victims to reenter society quickly. When supervising the progress and quality of a CRS, the recorded information of a CRS project can be used to check whether the CRS satisfies the objectives in the project application. In addition, the GIS support system can be used to check whether the former houses have been demolished and consolidated in the final stage and be used to help issue the relevant property

rights certificate. Moreover, the GIS support system can be used to coordinate industry planning and CRS development while coordinating the external features of the CRS, which could be diversified at the regional level while unified at the village level.

<Please insert Figure 6-5 here>

4.2 Balancing reconstruction with economic, environmental, and social considerations (B)

In order to achieve sustainable development, balancing reconstruction with economic, environmental, and social considerations should be closely monitored in the reconstruction process of a CRS. As shown in Figure 7, planning coordination, regional coordination, and victims-experts coordination are three critical pillars to support the project's successful completion. Through planning coordination, the construction of the CRS would be connected with industry development after a disaster. On the one hand, the site selection, architecture, and housing design of CRS should favor the industry development such as the eco-tourism and eco-agriculture industries. On the other hand, industry planning should provide non-primary work opportunities for the farmers, which is essential to support livelihoods after concentrating the population into the CRS. Via regional coordination, industry planning and any relevant CRS planning can be matched with the local environmental resources at the regional level. In addition, the external features of the CRS could be diversified at the regional level while unified at the village level. Furthermore, coordination between the victims and the experts offers the chance for the victims to make the site selection, decide the housing design, and fulfill the objectives of environmental protection, safety, and economy, while satisfying the culture and psychological requirements of the rural victims.

<Please insert Figure 7 here>

4.3 Mobilizing participants and financial resources (C)

The most involved participants in the development of post-disaster CRS should be: the rural victims, the village-level government, NGOs, the regional-level government, experts, and a reconstruction support partner. Their internal relationships are shown in Figure 8 (a). In the central stage of CRS reconstruction, the village-level government should disseminate the schemes of developing CRS by referring to pre-disaster planning, introducing the advantages and disadvantages of concentration, and responding to the rural victims' concerns. This is important to attract rural victims' participation, and the voluntary principle should be followed in this process. On the other hand, the willing victims must be able to participate in the decision-making process when developing a CRS, such as the site selection, housing design, and quality oversight. The rural victims can provide their needs and any relevant information about the CRS development to NGOs and experts, thus allowing NGOs to provide any necessary emergency aid, along with psychological support and disaster preparedness education after completion of the reconstruction project. This will also enable experts to provide any pertinent professional advice.

The village-level government should welcome the NGOs and provide information for facilitating recovery. The village-level government should also communicate with the regional-level government, provide feedback about the reconstruction process, conduct a project application for the development of the CRS, and accept their supervision. The regional-level government should enact appropriate policies to support developing CRS, coordinate different planning schemes for different villages at the regional level, and supervise the critical nodes of the reconstruction process, such as: project records, housing allocation, and issuing property rights certificates. The regional-level government should also actively communicate with the reconstruction support partner and acquire the financial and technological support for post-disaster reconstruction. Most importantly, the regional government should seek the opportunities to establish long-term cooperation with the reconstruction support partner and push forward the

economic/social/environmental development for the region.

Specifying the financial sources of developing a sustainable CRS is important, especially when funds are limited after a disaster. As shown in Figure 8(b), there are five financial sources, including national subsidies, income from the “increasing versus decreasing balance” policy, self-financing, partner support, and the local government. The national subsidy should be allocated according to the results of the damage assessment, which prioritizes the most severely damaged households. The income from the “increasing versus decreasing balance” policy should be allocated according to the consensus of SVAB. The existing practices include allocation according to the saved rural residential land, and even allocation among the participants. The most important principle is to reach a consensus and provide a clear dissemination of benefits, thus establishing fairness among the rural victims. Self-financing includes self-owned financial resources, and loans from a bank, or from relatives (low interest rate). Financing from the local government and a reconstruction support partner would mainly focus on building the relevant infrastructure and provide daily management funding for the site.

<Please insert Figure 8 here>

4.4 Recycling resources in post-disaster reconstruction (D)

Recycling resources is important to achieving the sustainability of a post-disaster reconstruction, especially within the constraints after a disaster. Centered on the CRS development process, recycling efforts should be spent on a temporary housing site (at Stage 1 and 2 of the CRS development), a concentrated rural settlement (Stage 3), and a former dispersed housing site (Stage 4). Temporary housing units can be sorted first, followed by dumping all useless and destroyed articles, directly reusing and decomposing construction components such as paneling and walls. For those decomposed parts, some can be reused, some can be recycled, and others can be dumped. If the temporary housing land is suitable for concentration and the rural victims agree

to use this site, it can be used for concentrating the victims in the subsequent steps. Otherwise, the temporary housing land should be reclaimed as cultivated land. Correspondingly, the temporary infrastructure can be integrated into the concentration site; otherwise, it should be reclaimed as cultivated land or used for the agricultural infrastructure.

With regard to the CRS, the construction waste in the building process and the domestic waste in the living process should be collected and sorted, and finally they should be dumped, recycled and reused. As for the former dispersed housing site, the housing units can be reused or recycled for construction in other villages, or be dumped if useless. The housing land should be reclaimed as cultivated land if the “increasing versus decreasing balance” policy is adopted. Meanwhile, it can also be used as construction land (e.g. rural hotels) if the “increasing versus decreasing balance” policy is not adopted. Correspondingly, infrastructure such as road and transportation systems should be reclaimed as cultivated land or be kept for agricultural infrastructure. If possible, they can also be integrated into the construction.

<Please insert Figure 9 here>

5 Model Validation

An expert’s review was adopted to validate the generic decision model. In this research, it was determined that the experts who are relevant to evaluate this model are those who would use it and participate in post-disaster reconstruction: village-level officials, experts of housing planning, officials of land management, and academic leaders in post-disaster reconstruction, who have participated in such reconstruction projects after the 5.12 Sichuan Earthquake.

After the model was developed, it was shown to six experts who had not previously been involved in developing the generic decision model. As shown in Table 5, the six experts were qualified to comment on the generic decision model. After being introduced to the model and the

relevant methodology, the experts were asked a series of questions concerning its utility, benefits, and shortcomings. The first question was whether or not the model was understandable (including the objective, assumption, activities, and process). If the expert could not follow the logic presented to them, the model failed to meet the key performance objective. Next, the experts were asked if the model could be applied in other regions of China under a disaster condition, or under normal conditions as well. The third question asked if the model was a better process than the one they had experienced. In the final two questions the experts were asked to identify the advantages and disadvantages in using the proposed model and methodology.

<Please insert Table 5 here>

Reaction to the model was positive overall. All the experts responded that they could understand the model. The flow of the information was reasonable and reflected real-world processes. There was interest in the key points throughout the process and paying special attention to balancing the reconstruction with social/economic/environmental considerations, mobilizing participants and financial resources, and recycling resources. There was an agreement that the model provided specific guidelines that were not previously available, and that the process was at least as good as the existing practices. Most thought it was an improvement over existing conditions.

The key points in each step of CRS development, the GIS support system, the balancing model, and the resource recycling model were the functions they thought very useful. Having a process model with key points allows the local officials to identify any necessary precautions in each step. The framework of the GIS support system provides a tool to manage the reconstruction information at the regional level, conduct regional coordination and balance, and speed up the reconstruction progress accordingly. The balancing model and the resource recycling model specify the important concerns and offer detailed measures to achieve progress during reconstruction. It was also agreed that the model would lend a tool for them to prepare a pre-

disaster planning, making the local officials' job easier, and avoiding some disadvantages of the process.

Although the functions of the model are well-designed, there were also some reservations about the implementation of the model. Potential problems lie in the fact that some criteria are qualitative without a specific threshold to make decisions. This is resulted by difficulty in gaining enough data to develop a quantitative model. However, this was somewhat offset by the fact that the decision in reality usually depends on several critical qualitative criteria listed in the model.

The overall impression was that the model would be beneficial as a decision tool. It would allow the local government to improve the effectiveness and efficiency of developing CRS in post-disaster reconstruction by providing specific guidelines. This would also help the local government prepare a pre-disaster plan for developing CRS by following the decision model and involving local farmers. Finally, the introduction of the GIS support system would help the regional government manage and coordinate post-disaster reconstruction at the regional level.

6 Conclusion

Housing reconstruction after a disaster occurs is a top priority in rural areas, especially in developing countries. Against the dispersed settlement pattern in developing countries, such as China, implementing CRS is argued to be more resilient and sustainable. However, few studies have investigated how to develop CRS in post-disaster reconstruction. Although existing studies on housing reconstruction at the regional level provide good references, few guidelines are made for developing CRS at the village level. In addition, the common approach of construction management at the village level is useless as the post-disaster reconstruction environment is chaotic, dynamic, and complex and quite different from regular construction projects. As well, the existing decision system of rural housing reconstruction in China provides merely general guidelines and cannot be directly used in CRS development due to various problems. Therefore,

this study developed a generic decision model for developing CRS in post-disaster reconstruction based on the practices of four case villages in Dujiangyan, China.

Emphasizing the optimization of the process, this study identifies four stages in the successful development of CRS, outlining specified critical issues at each step. Meanwhile, balancing a reconstruction project with social/economic/environmental considerations, mobilizing participants and financial resources, and recycling resources should be paid enough attention to ensure the sustainability of the CRS. The model allows the local government to improve the effectiveness and efficiency of developing CRS in post-disaster reconstruction by providing specific guidelines. This would also help the local government prepare a pre-disaster plan for developing CRS by following the decision model and involving the local farmers. Moreover, the introduction of a GIS support system would help the regional government manage and coordinate post-disaster reconstruction at the regional level. However, some criteria are qualitative without a specific threshold to make decisions. This is resulted by difficulties of gaining enough data to develop a quantitative model. Future efforts should be spent to collect enough data and quantify the relevant criteria in the decision model.

*Remark:

There were two means, namely unified-planning-self-reconstruction and unified-planning-unified-reconstruction adopted in the case study. Unified planning was adopted for finding the suitable sites for building concentrated rural settlements, ensuring the scientific layout, housing design and construction of the settlements, and maintaining the harmonious relationship with other settlements. For self reconstruction, the victims consolidated their former rural residence land and rebuilt the houses with less residence land by themselves in the selected sites. As the area of the rural residence land in the concentration site is smaller than before, many areas of rural construction land was transformed into cultivated land. According to the policy ‘increasing

versus decreasing balance', the land use right of the saved areas of construction land in rural areas could be transferred to urban areas, which generated income and supplement the reconstruction finance. The victims reconstructed the houses by themselves according to the overall planning with governmental subsidies, own funds, loans and the income from transferring the land use right of saved rural residence land. Under this context, single house was preferred in the concentration site. Compared to self-reconstruction, unified-reconstruction granted all the generated income from transferring the land use right of saved rural residence land to the collaborative party. The collaborative party was in charge of building the concentrated rural settlements while the rural victims got the settlements for free. Under this context, multi-storey house was preferred in the concentration site as the collaborative wanted to save more areas of rural residence land and thus got more incomes

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Table 1 Involved Cases in this research (Source: from interviews)

Case	A: Xiangrong Village	B: Shiqiao Village	C: Qingjiang Village	D: Luchi Village
Topography	Plain areas	Hilly areas	Plain areas	Hilly areas
Areas of land/cultivated land (Unit: hectare)	315/115.9	537/183.2	352/148.5	328/51
Population/households	1767/635	2354 /817	2776/767	702/220
Labors	1200	1000	1800	540
Percentage of Migrant workers to labors	62%	50%	56%	50%
Per capita income before disaster (Unit: Yuan/person/year) (end of 2007)	5300	3000	5200	4800
Supporting industry	Vegetable cultivation	farm tourism, cash crops	Mushrooms, vegetable cultivation	actinidia chinensis, tea, and bamboos
collapsed and severely damaged households	433	635	370	210
Planning and Financial source	Unified planning, self reconstruction	Unified planning, unified reconstruction	Unified planning, self reconstruction	Unified planning, unified reconstruction
Areas of the concentration site(Unit: hectare)	5.81	18.67	9.07	2.17
percentage of households moving to concentrated rural settlement after disaster	32%	90%	43%	93%
Per capita income after disaster (Yuan/person/year) (end of 2011)	7000	8900	7781	6200
Increased living cost after concentration (Yuan/person/year) (end of 2011)	1000	1200	1100	1000

Table 2 Background information of the interviewees in developing decision model (Source: from interviews)

Village	Interviewee	Work unit	Job title	Years of relevant work experience	Education level	Major responsibility
Xiangrong	X1	Village level government	Branch secretary	20	Middle school	Organization and management in the whole process
	X2	Village level government	Assistant village head	3	Bachelor	Organization and management in the whole process
	X3	Planning institution	Senior Planner	10	Master	Planning
Qingjiang	Q1	Village level government	Village head	16	High school	Organization and management in the whole process
	Q2	Village level government	Accountant	10	Bachelor	Organization and management in the whole process
	Q3	Planning institution	Senior Planner	8	PhD	Planning
	Q4	Others	Farmer	1	High school	Participating in site selection, housing design and building
Shiqiao	S1	Village level government	Branch secretary	20	High school	Organization and management in the whole process
	S2	Village level government	Assistant village head	3	Bachelor	Organization and management in the whole process
	S3	Planning institution	Senior Planner	12	Master	Planning
	S4	Others	Farmer	1	Middle school	Participating in site selection, housing design, housing allocation
Luchi	L1	Village	Branch	15	High school	Organization

		level government	secretary			and management in the whole process
	L2	Village level government	Village head	11	Bachelor	Organization and management in the whole process
	L3	Planning institution	Senior Planner	13	Master	Planning
	L4	Others	Farmer	1	High school	Participating in site selection, housing design, housing allocation, and community management

Table 3 The problems existed in the four case villages

Problems	Xiangrong	Shiqiao	Qingjiang	Luchi
P1	M	M	M	M
P2	H	H	H	H
P3	H			
P4	H	H	H	H
P5	M	L	M	L
P6	M		M	
P7	M			M
P8	H	H	H	H
P9				M
P10		L	L	M
P11				M
P12	H	H	H	H
P13		H		H
P14			M	L

Note: L: insignificant, M: significant, H: strongly significant, and blank: not mentioned

Table 4 The experiences existed in the four case villages

Experiences	Xiangrong	Shiqiao	Qingjiang	Luchi
E1	H	H	H	H
E2	H	H	H	H
E3	H	H	H	H
E4	H	H	H	H
E5	H	H	H	H
E6		M		H
E7	H	H	H	H
E8	H		M	L
E9	H	L	H	L
E10	H	H	H	H
E11	H		H	
E12		H		

Note: L: insignificant, M: significant, H: strongly significant, and blank: not mentioned

Table 5 Background information of the interviewees in model validation (Source: from interviews)

Interviewee	Work unit	Job title	Years of relevant work experience	Education level	Major responsibility
Int1	Village level government	Branch secretary	20	High School	Organization and management in the whole process
Int 2	Village level government	Village head	12	Bachelor	Organization and management in the whole process
Int 3	Planning institution	Senior Planner	13	Master	Planning
Int 4	Provincial government department	Senior professional	16	Master	Land management and transfer
Int5	Municipal government department	Middle level professional	10	Bachelor	Land management and transfer
Int6	Planning institution	Senior professional	8	PhD	Research

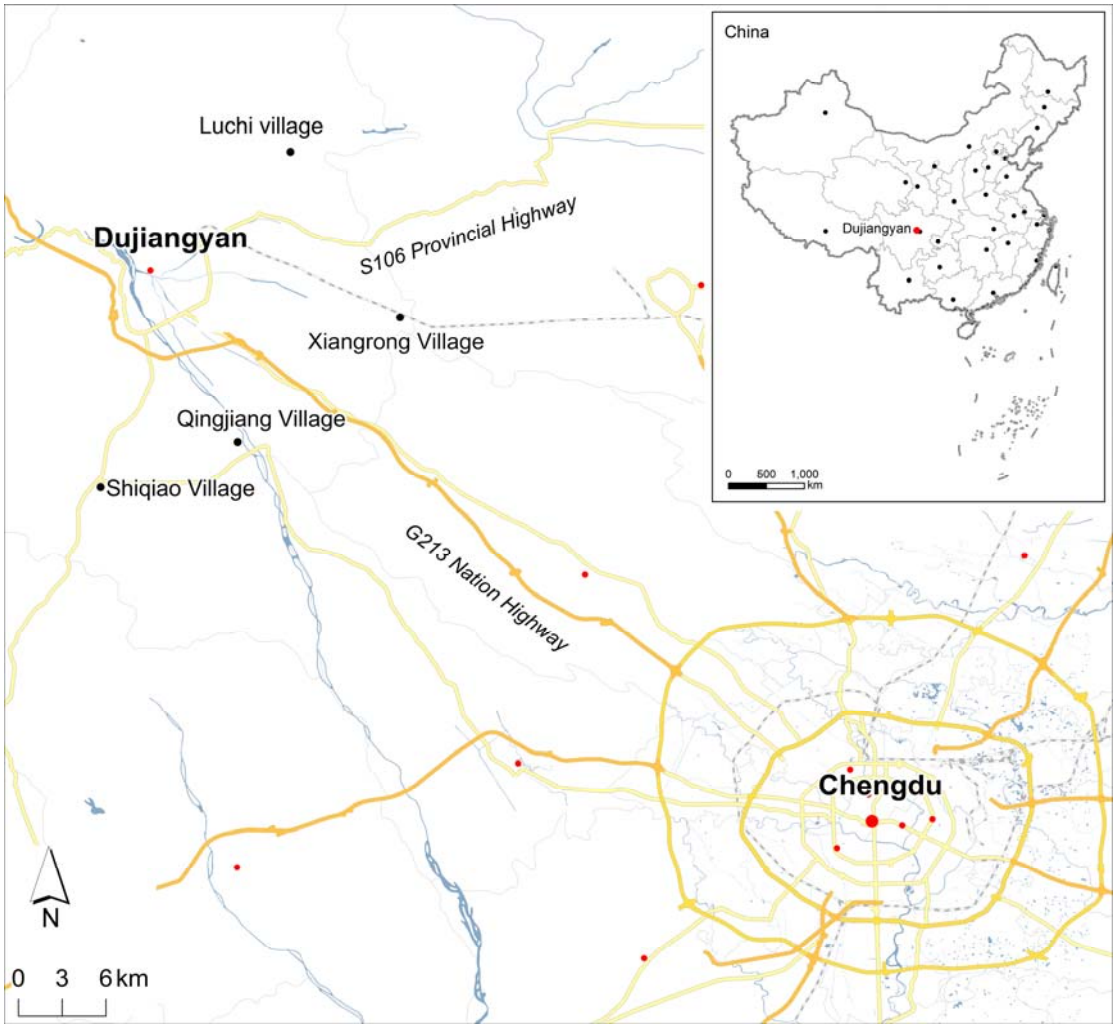


Figure 1 The location of the four case villages in Dujiangyan (Source: Elaborated by the authors)

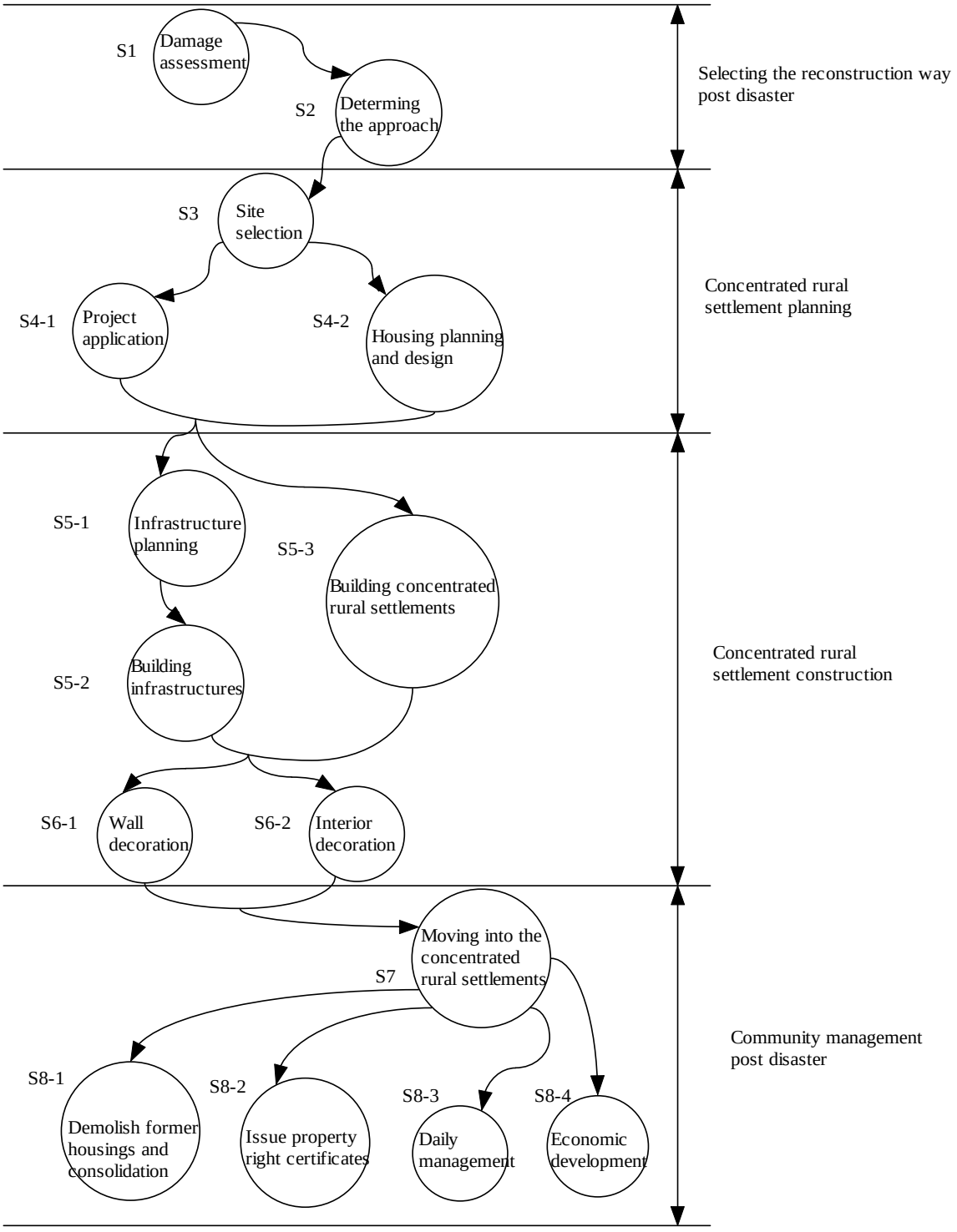


Figure 2 The implementation process of developing CRS in post-disaster reconstruction in Xiangrong Village/Qingjiang Village, Dujiangyan

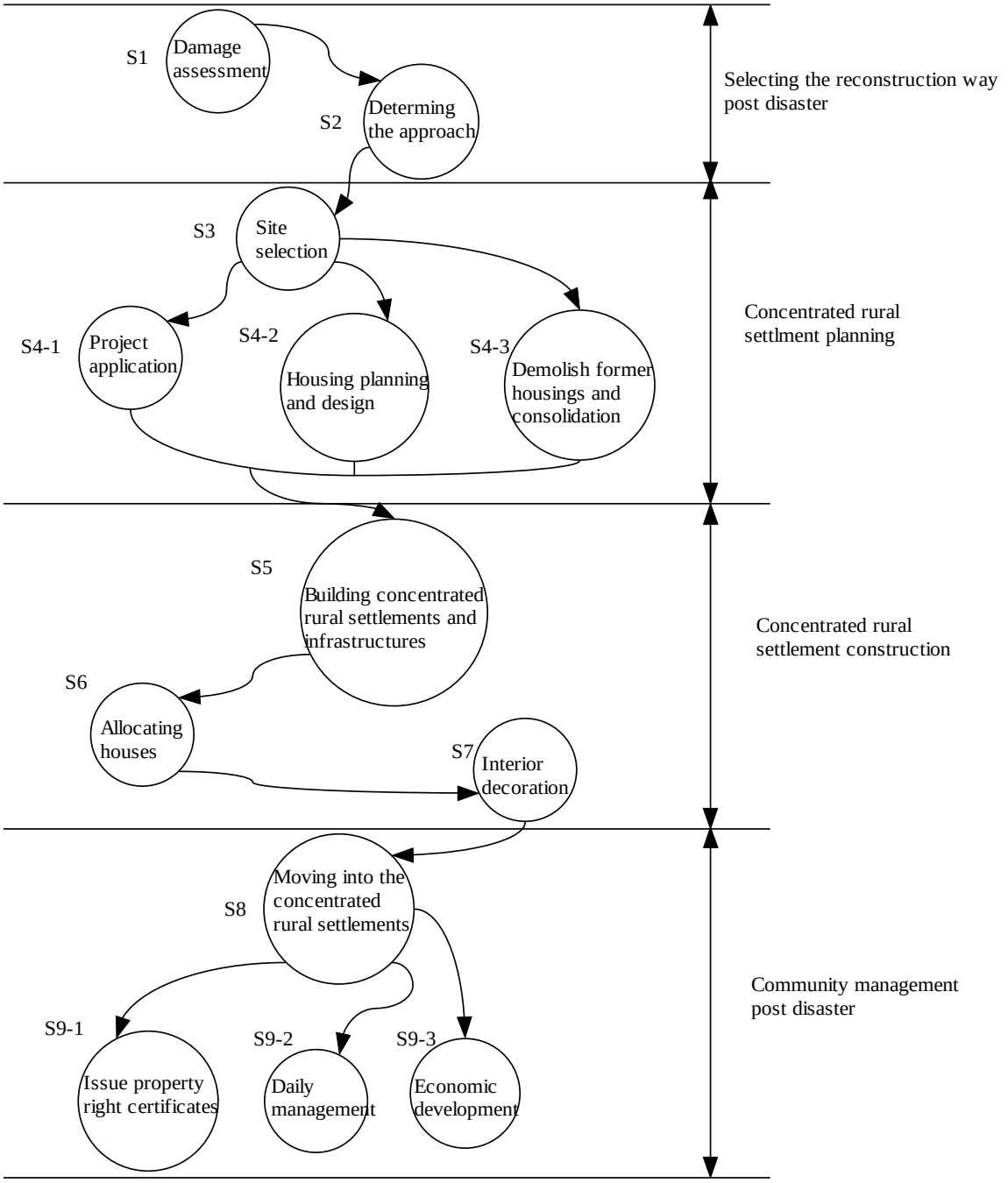


Figure 3 The implementation process of developing CRS in post-disaster reconstruction in Shiqiao Village/Luchi Village, Dujiangyan

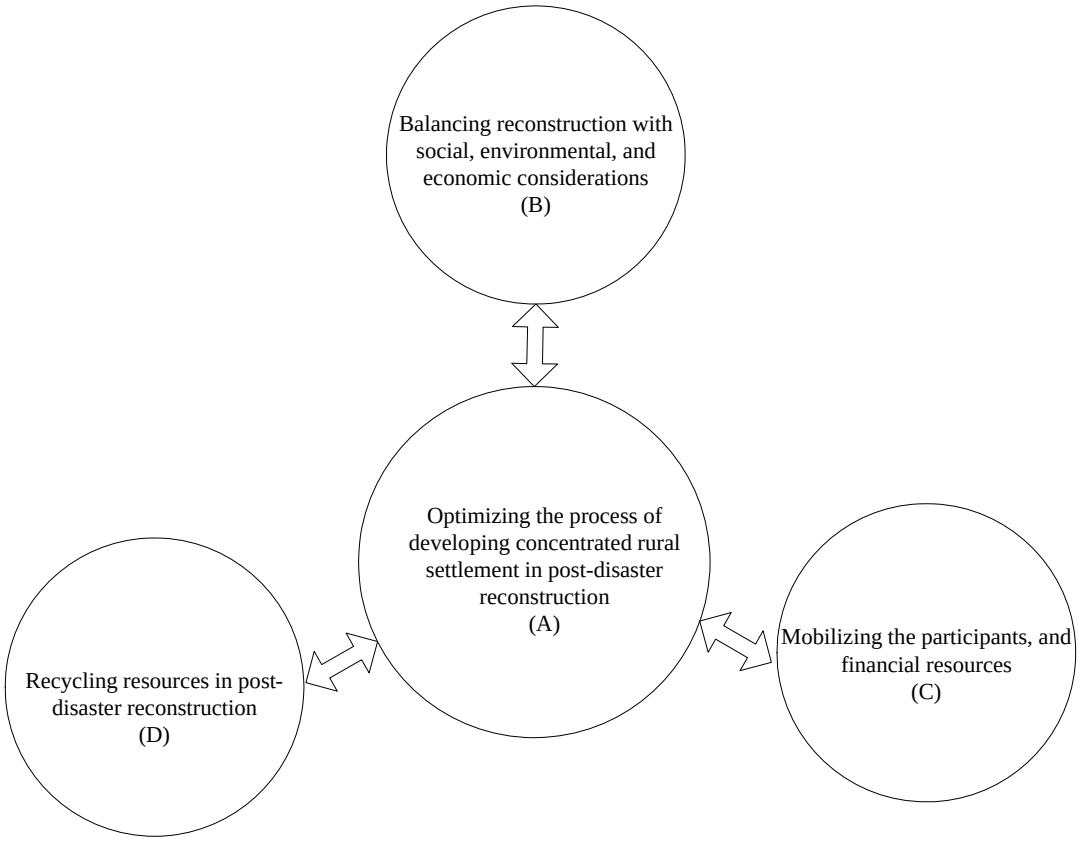


Figure 4 The decision framework of developing CRS in post-disaster reconstruction

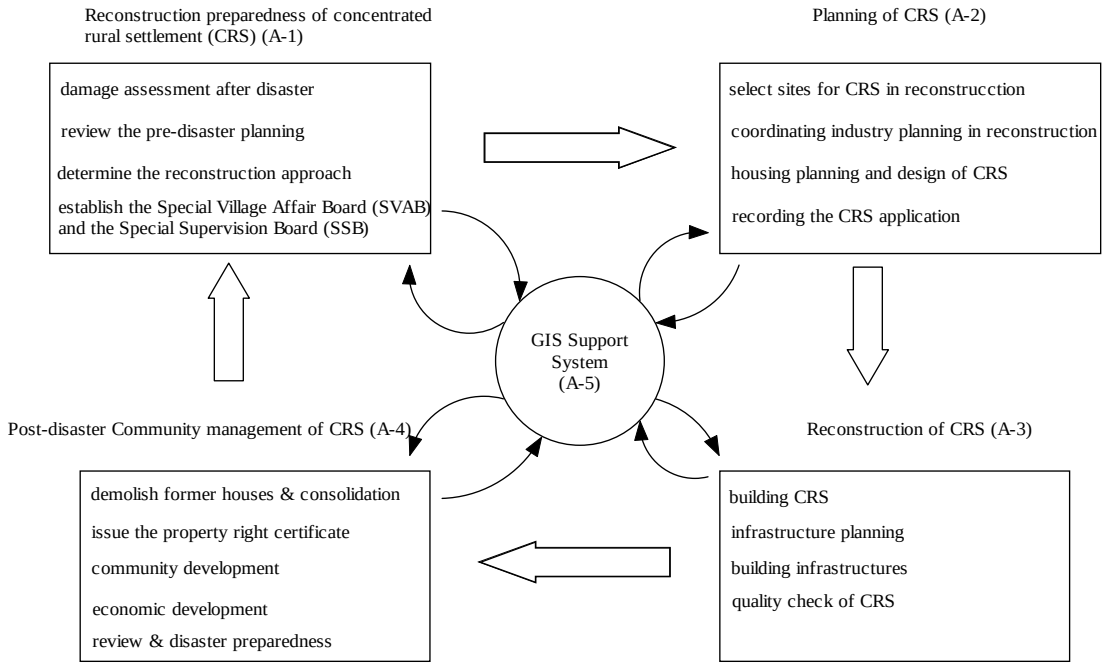


Figure 5 Sub-model of optimizing the process of developing concentrated rural settlement in post-disaster reconstruction (A)

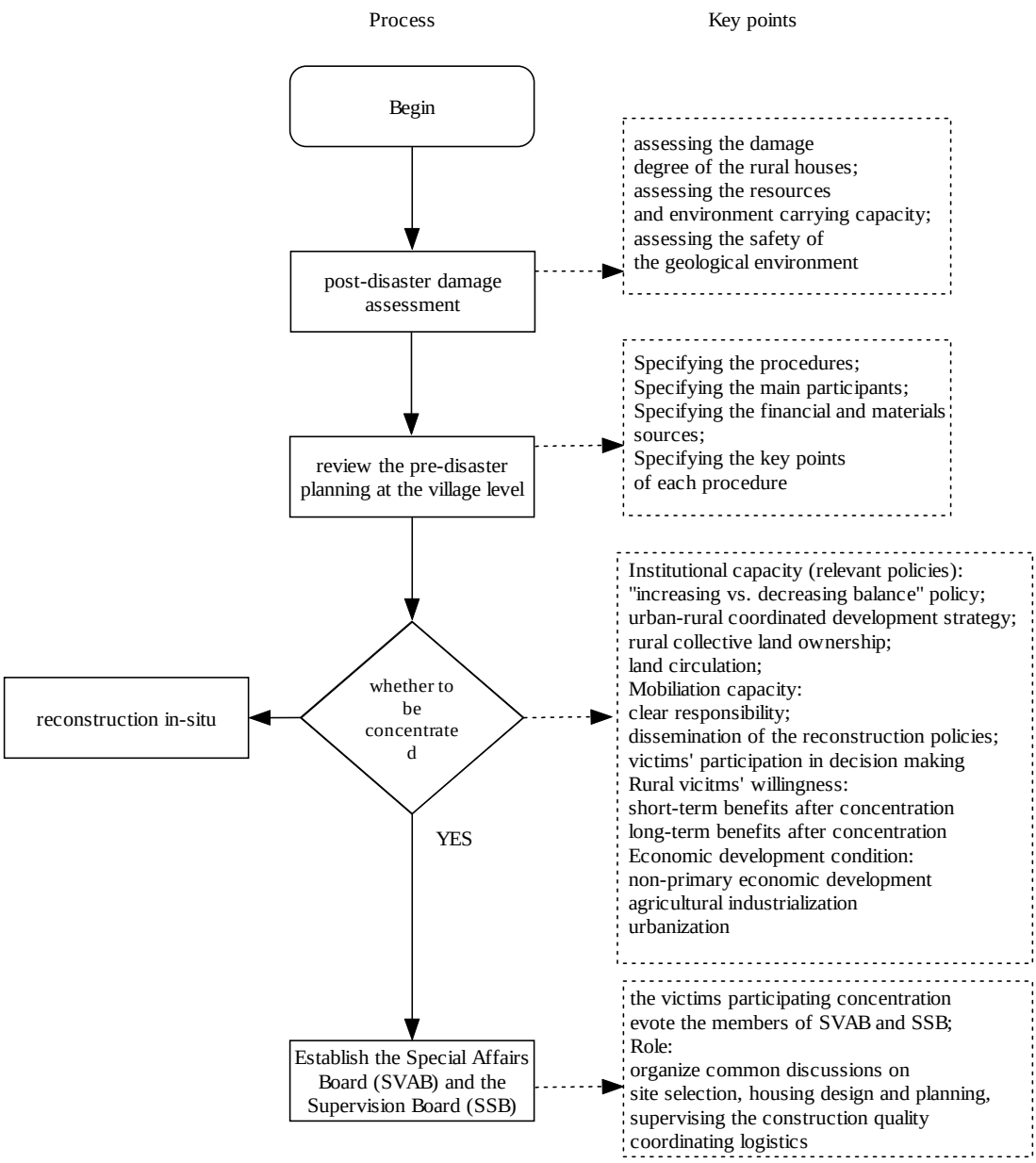


Figure 6-1 The preparedness of developing CRS in post-disaster reconstruction (A-1)

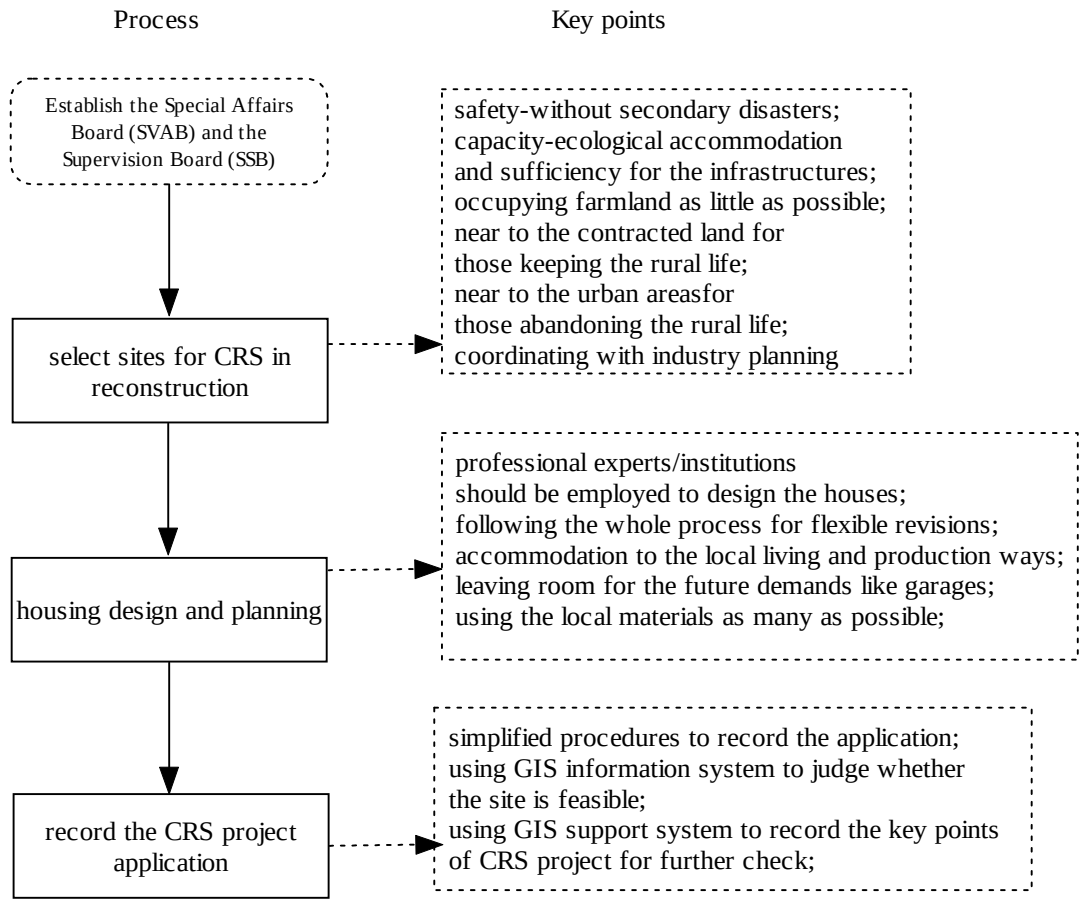


Figure 6-2 CRS planning (A-2)

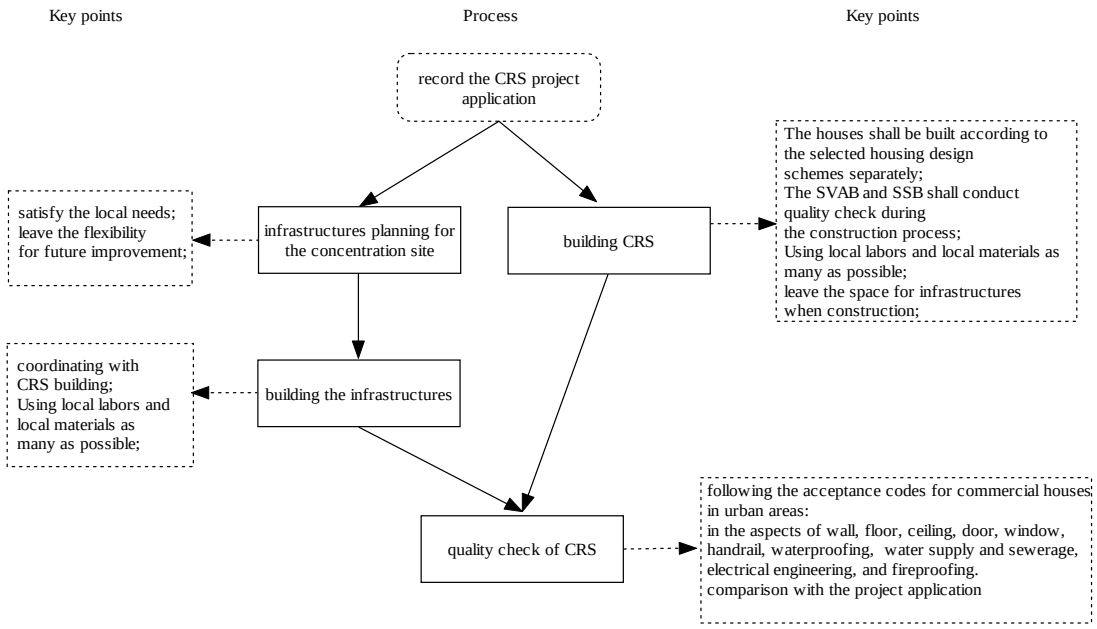


Figure 6-3 Building CRS (A-3)

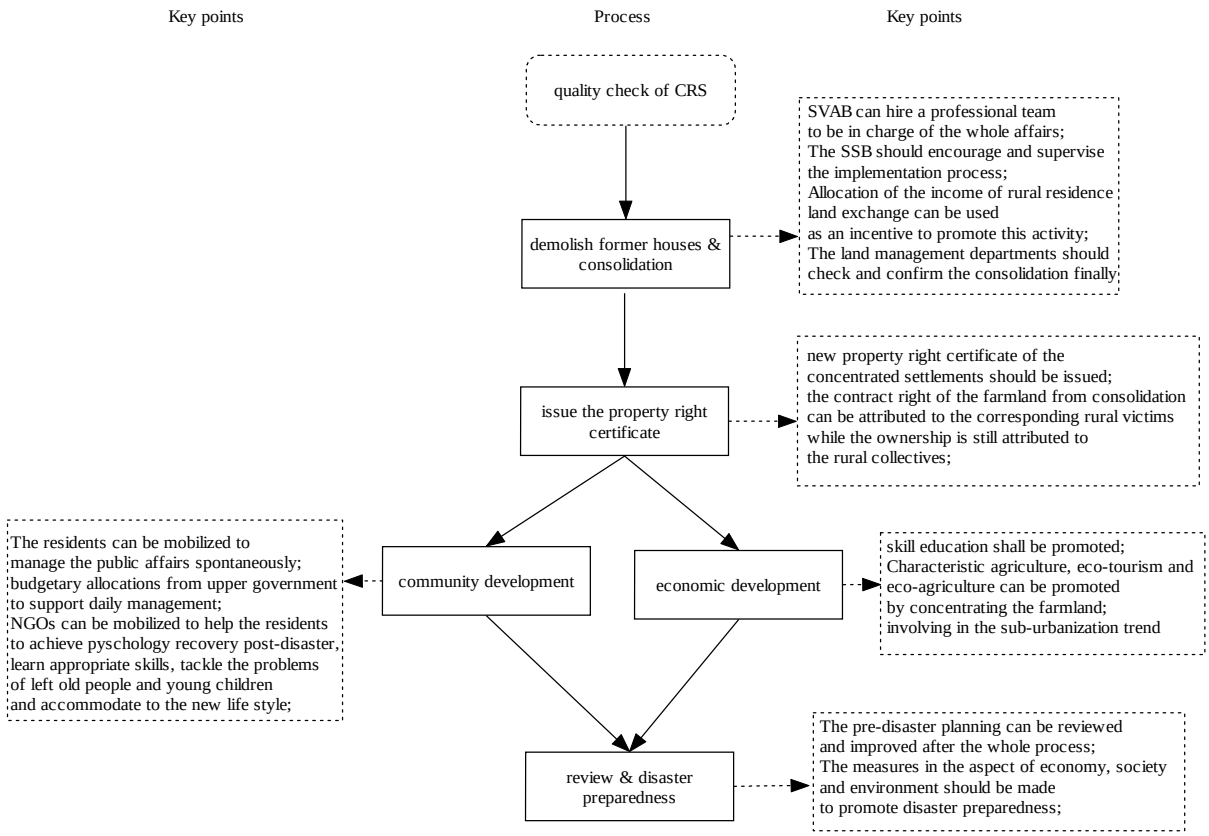


Figure 6-4 Post-disaster community management of CRS (A-4)

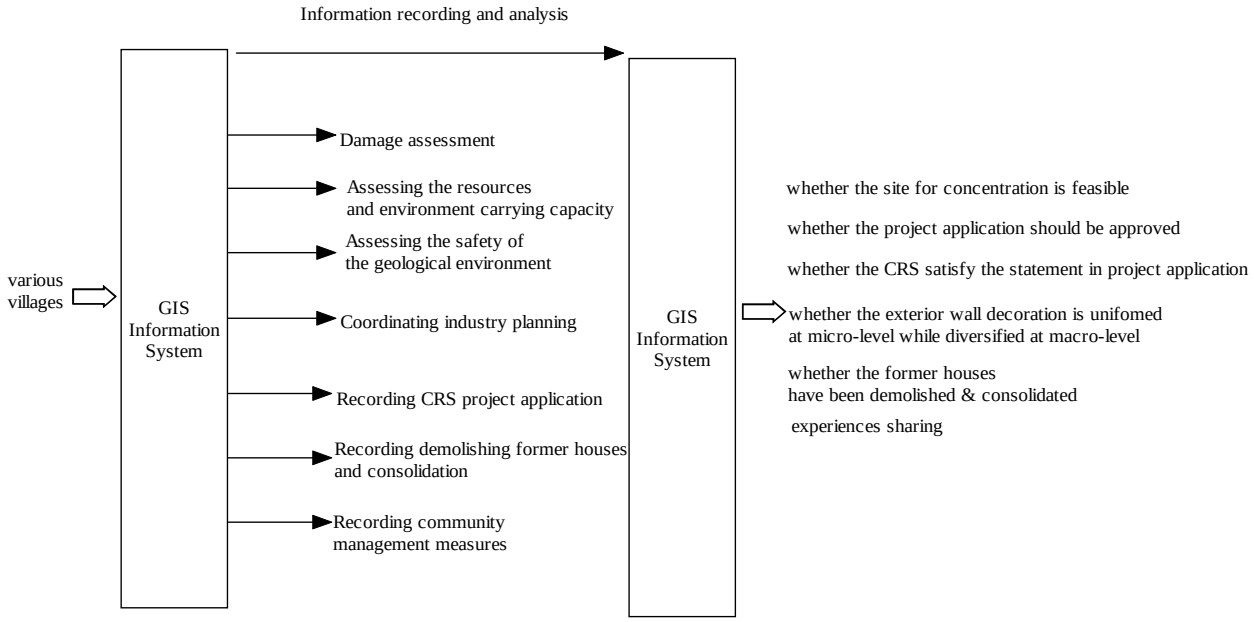


Figure 6-5 The GIS support system (A-5)

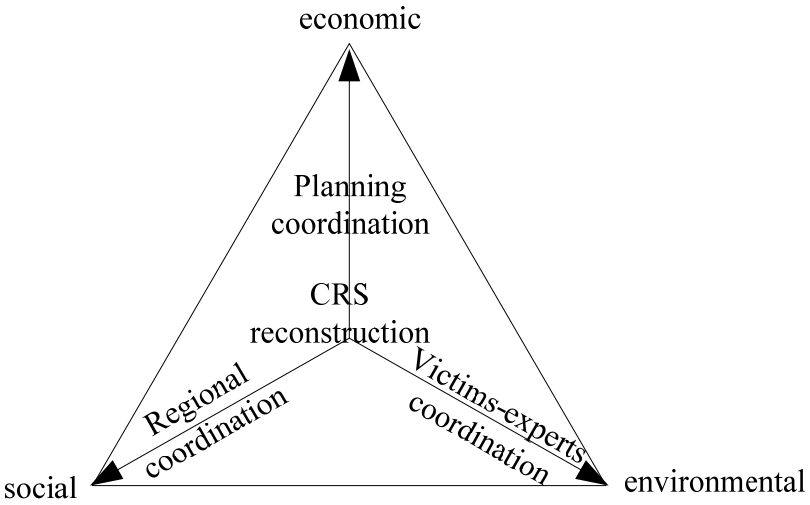
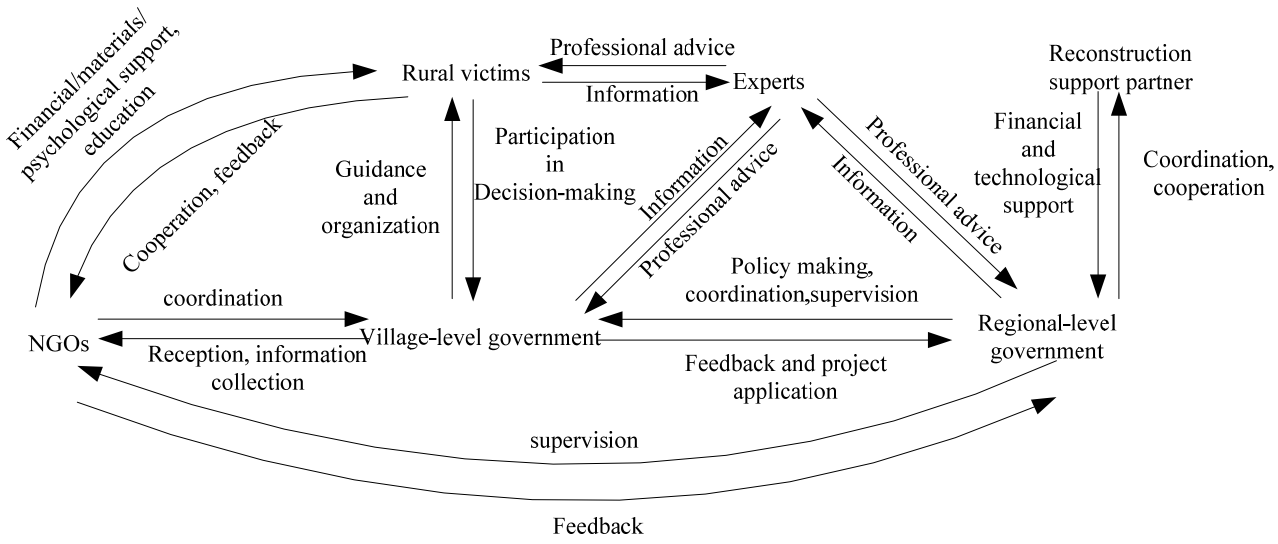
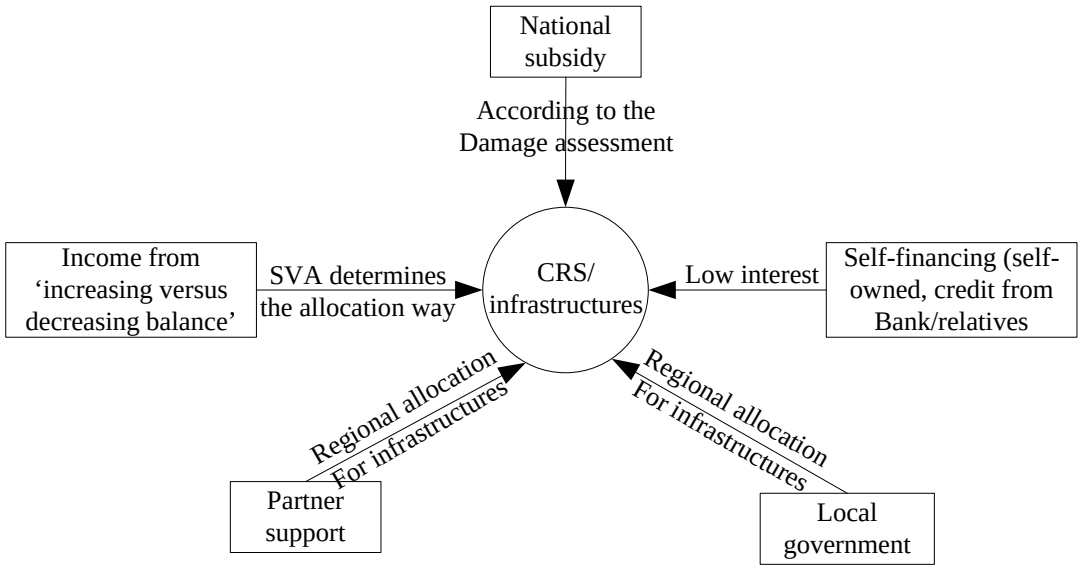


Figure 7 Sub-model of balancing reconstruction and social, economical and environmental considerations (B)



(a) The network of the mainly involved participants



(b) The financial resources

Figure 8 Sub-model of organizing participants and financial resources (C)

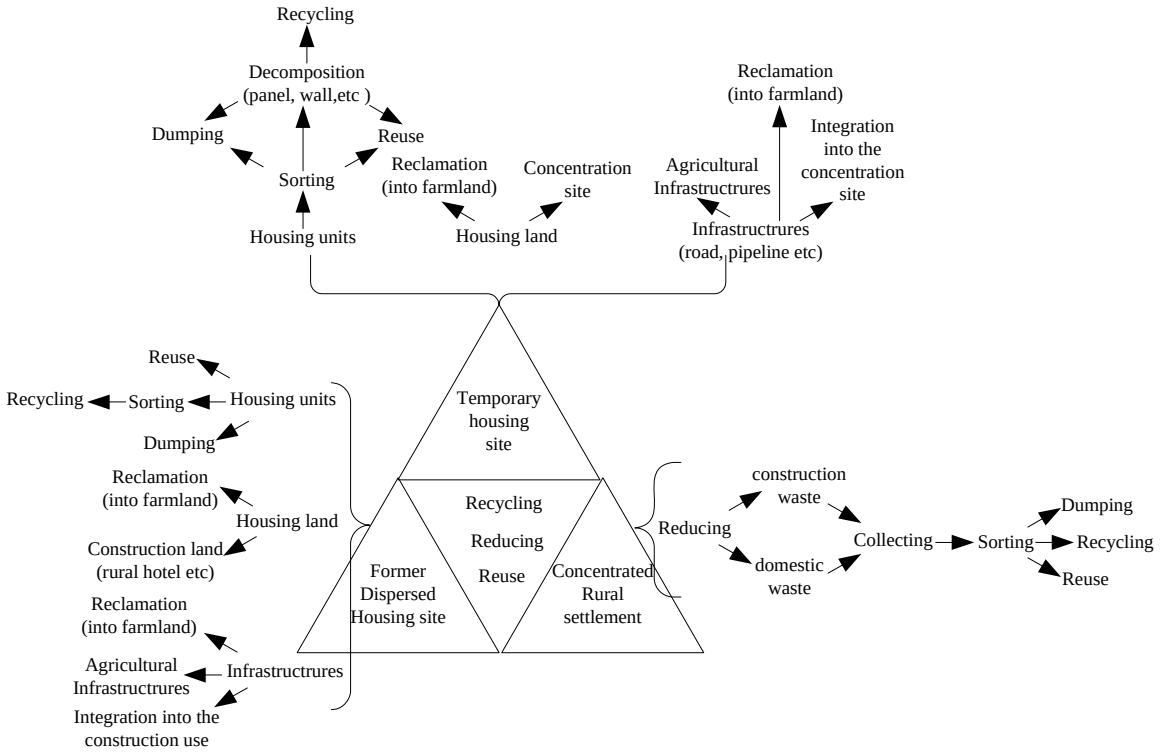


Figure 9 Sub-model of recycling resources in post-disaster reconstruction (D)