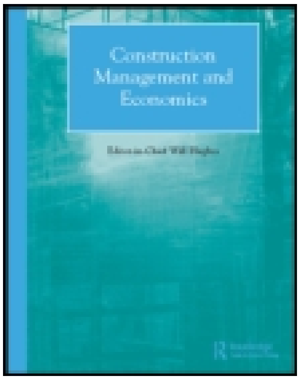

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Identifying factors affecting resource availability for post--disaster reconstruction: a case study in China

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Identifying factors affecting resource availability for post-disaster reconstruction: a case study in China

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The availability of resources allows for the rapid and cost-effective delivery of a construction project. For rebuilding programmes after a disaster, the need for better understanding of factors affecting resource availability and their potential impacts on resourcing outcomes can be of crucial importance to effective reconstruction performance. Drawing on an empirical survey in China following the 2008 Wenchuan earthquake, the critical factors affecting resource availability for post-quake reconstruction of housing are identified. Resource availability in a post-disaster situation is not only associated with (1) project-related factors such as quantity of resources required, project schedule, project resourcing plan, and resource procurement lead time; and (2) factors related to the reconstruction practitioners, including competency of resourcing manager and qualification of contractor; but is also related to (3) factors external to reconstruction projects including legislation and policy, general economic environment, and resource transportation cost and method. To address these factors, a multi-sector approach is needed for reconstruction decision makers and practitioners. A planned procurement strategy in the implementing contractors, a range of training initiatives for small and medium businesses, along with augmented regulatory, economic and transport infrastructure systems are likely to improve resource availability for post-disaster rebuilding projects.

Keywords: Disasters, post-disaster reconstruction, resource availability, construction projects, China.

Introduction

Resource management in construction projects has been subject to significant improvements in the last decade with various techniques, algorithms and models developed for various requirements of resource planning, resource procurement, resource scheduling, resource optimization and allocation. However, these outcomes which are mainly targeted for single and multi-projects in the normal construction environment seem to be unable to deal with the requirements of post-disaster rebuilding projects. In comparison with pre-event situations, post-disaster circumstances are more complex, volatile and dynamic (Alexander, 2004). Unlike pre-event construction projects, resources needed for a reconstruction project are no longer easy to secure.

Following a large-scale disaster, the majority of local production facilities and supply systems in manufacturing industries are likely to be damaged and the construction market tends to be in disorder, contested and highly adversarial (Nazara and Resosudarmo, 2007). This, if combined with disruption of transportation and energy supply (Cho *et al.*, 2001), and pre-existing historical problems of the local industry (Singh and Wilkinson, 2008), could significantly exacerbate the difficulty in procuring building expertise and materials (Jayasuriya and McCawley, 2008), leading to project failure and rework such as project suspension, quality defects, cost overruns and delivery delay (Boen, 2006; Steinberg, 2007). All these resourcing issues emerging in the wake of a disaster, however, can be anticipated. Reconstruction planners and building practitioners are thus needed to continuously adapt

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themselves to the evolving resource conditions after a disaster.

Despite the inherent links between resource availability and reconstruction performance, little research has examined resourcing issues after a disaster or suggested approaches to improved resource management for reconstruction projects. The need for an in-depth investigation on (1) factors affecting project resource availability in post-disaster rebuilding settings; and (2) adequate solutions to address resourcing difficulties faced by reconstruction stakeholders is imperative to achieve a better resourcing outcome during disaster recovery.

To fulfil this need, following the Wenchuan earthquake in 2008, an in-field survey was conducted in the earthquake affected areas in China between December 2008 and January 2009 to identify the determinants affecting resource availability for housing reconstruction. Although the study draws on the perceptions and perspectives in the wake of a disaster in China, the vulnerable areas identified can be demonstrably shown to apply to the international community.

Factors affecting resource availability for construction projects

Availability of resources has been recognized by a number of scholars as a driving force necessary for the successful performance of construction projects. For instance, Tukel and Rom (1998) identified availability of resources as being a main performance constraint in projects in diverse industries. Chua *et al.* (1999) further confirmed the importance of resource availability to the success of construction projects in spite of different project objectives. In measuring business performance in construction, Bassioni *et al.* (2005) underlined the role of resource availability in the overall business outcomes. In addition, lack of resources or non-availability of resources has also been identified by some researchers as a major deterrent to construction productivity in countries like Indonesia (Olomolaiye *et al.*, 1996), Thailand (Rojas and Aramvareekul, 2003) and the USA (Motwani *et al.*, 1995). Although the importance of resource availability to construction project performance has been recognized, the factors that affect it have been neglected in both discourse and practice of construction management. Only a limited number of tentative studies were carried out to with the aim of understanding this.

According to Morris and Hough (1987), achieving resource availability of construction projects requires top-level political involvement. Belassi and Tukel (1996) added that the economic and social stimulus external to a project is also important to generate innovative activities that can lead to the development of material alternatives. An essential step is the better knowledge of factors associated with a project itself (Eisner, 2008). Resource planning and scheduling (Tserng *et al.*, 2006), site inventory management (Liu and Wang, 2007) and the construction site location (El-Rayes and Khalafallah, 2005) bear on resource availability in terms of material transportation time and cost. Closer cooperation between procurement and other construction functions enables direct receipt of materials from suppliers to a construction site (Yeo and Ning, 2002). The design specifications (Tatum, 2005) and construction methods (El-Rayes and Kandil, 2005) determine how the project team is mobilized and resources are procured. Walker and Rowlinson (2008) suggested that procurement alternatives can have a profound impact on project delivery.

Pryke (2004) underlined the important role of the social network of project practitioners, especially large contractors in resource procurement. On account of their purchasing power, large contractors are able to deal directly with manufacturers and wholesalers, thus acquiring resources more easily than small and medium units (Agapiou *et al.*, 1998). The importance for contractors of handling issues such as organizational weaknesses, suppliers' defaults, and transportation delays in achieving a timely and cost-effective resource delivery is highlighted by Manavazhi and Adhikari (2002). Involving suppliers in the resource planning process to decrease deviation also helps to attain procurement improvement (Agapiou *et al.*, 1998).

Resourcing difficulties in post-disaster situations

In contrast with normal project construction, post-disaster reconstruction is likely to suffer project deficiencies in relation to the availability of resources. The post-disaster field observations by Russell (2005) and Zuo *et al.* (2008) provided examples in rework or disruption of reconstruction projects, as a result of failure to procure resources required for projects post-disaster. On the other hand, a range of role models demonstrated that post-disaster reconstruction practitioners benefited from proactive resourcing strategies and planning (Mitchell, 2004) and from good command of potential vulnerabilities and bottlenecks when sourcing resources (Singh and Wilkinson, 2008). As occurrence of disasters continues to rise throughout the world, the reconstruction task could only be achieved through ensured resource availability (Masurier *et al.*, 2008) and prudent allocation of limited resources (Freeman, 2004).

Moreover, problems such as 'Cost Surge' and 'Dutch Disease'[1] induced by resource shortages after a disaster were highlighted by Nazara and Resosudarmo (2007) and Rodriguez *et al.* (2007) as having a longer-term adverse impact on sustainability of local economy and market in the disaster affected areas. In response to market disorder caused by speculative behaviour, regulatory authorities normally turn to 'hard intervention' solutions by directly interfering in manufacturing and circulation (Hirshleifer, 1956). Herein lies another problem, that of generic restrictions posing a major disincentive to other suppliers from actively getting engaged in post-disaster reconstruction resourcing efforts (Oxfam Australia *et al.*, 2007). According to McGee (2008), price controls cause resources to be allocated inefficiently and could serve to delay disaster relief.

The pressure to acquire resources for post-disaster reconstruction is even higher for poorer countries as the local resources and capacities are inadequate and they have to rely on external assistance, such as NGOs, INGOs, World Bank, etc. (Jayasuriya and McCawley, 2008); or reallocate resources from existing projects to reconstruction to meet their recovery needs (Freeman, 2004). Consequently, dependence on external aid is likely to suppress the local self-production capacity and reduce the likelihood of the reconstruction programme succeeding (Cuny, 1983). These resource reallocation tactics disrupt markets and economic order (Makhanu, 2006), adversely affecting sustainable productivity layout and economic and social development goals in the long run (World Bank Operations Evaluation Department, 2005).

Singh (2007) concluded that five factors influence availability of resources for reconstruction, namely prioritization of works, ability to pool resources, lead time of procurement, existing contractual relationships and transportation into and around the disaster zone. According to Singh and Wilkinson (2008), availability of resources is also governed by the policies and strategies put in place by the authorities to deal with the reconstruction phase. Another major factor adding to the difficulty of post-disaster resourcing lies in the environmental impact. In examining the 2004 Indian Ocean tsunami impacts on the local natural environment, Shaw (2006) and Budidarsono *et al.* (2007) revealed the close interaction between the disaster and environment. Likewise, Olshansky (2006) pointed to the subsequent environmental-related disasters after the 2005 Hurricane Katrina. Specifically, Shaw (2006) concluded that two particular problems are becoming increasingly prominent environmentally after the tsunami. First, raw material exploitation for making building components and products poses a threat to the natural environment system. Secondly, inappropriate sourcing approaches are likely to induce secondary hazards; timber logging, for example, both legal and illegal, contributes to the incidence of flooding and landslides. As illustrated by Chang *et al.* (2010), the new timber administration rules issued by the Indonesian government on 1 January 2007 significantly reduced the possibility for donors to procure local timber for post-Indian Ocean tsunami reconstruction in Indonesia. A number of NGOs resorted to donor countries or other producing countries for timber resources. Additional pressures imposed on NGOs were environmental concerns over timber use, difficulties in purchasing suitable quality construction timber, and logistics for importing timber from overseas.

On 12 May 2008 the magnitude (M) 8.0[2] earthquake struck China's province of Sichuan and its neighbours. The Wenchuan earthquake, as it is commonly known, killed 69 266 people, injured 374 643 people and left 17 923 people missing.[3] The earthquake caused widespread destruction to buildings and infrastructure. More than 15 million housing units collapsed during the earthquake and resulted in direct losses to buildings and infrastructure of over US$150 billion (Paterson *et al.*, 2008). With the large-scale and intensive reconstruction unfolding in August 2008, China was not immune to the various resourcing problems discussed above. A lack of resources required for reconstruction combined with resourcing capacity bottlenecks limited the degree to which a successful recovery could occur. Through a field-based survey, this study aims to highlight the perceived causes and effects of resource availability in a post-disaster situation in China and to provide possible suggestions to deal with the resourcing constraints of the reconstruction projects. It is hoped that the information from the research will inform stakeholders in other countries on how to manage their resources for reconstruction projects after a large-scale disaster.

Research methods

This paper provides an investigation of reconstruction resourcing after the Wenchuan earthquake in China. Major disasters such as earthquakes and tsunamis are infrequent events, so it is impossible to fully plan or to be perfectly prepared in a disaster zone. The survey area and population were selected in terms of disaster impacts, roles of resourcing work and data accessibility. The field trip was conducted between December 2008 and January 2009 when the issue of resource availability intensified and became a significant impediment to the reconstruction process. A questionnaire was designed drawing on the factors derived from the literature. In order to supplement and enhance the questionnaire, a pilot study was conducted by consulting experts and practitioners involved in post-disaster housing reconstruction.[4] A total of 37 factors were extracted from both literature and the pilot study (see Table 1). According to the content and internal features of the identified variables in Table 1, the content analysis research tool, which contains a conceptual analysis and a relational analysis (Krippendorff, 1980), was applied to categorize these 37 potential variables into five groups with the following headings: market-related

Table 1 One sample t-test result

No.	Factors affecting project resource availability in post-disaster reconstruction	Mean	*t* -value	SD	Significance (2-tailed)
	(I) *Market-related factors*				
1.	Resource price fluctuation in market	3.97	6.009	0.865	0.000
2.	Local production capacity	4.24	9.040	0.739	0.000
3.	Competition for resources from other reconstruction projects	4.07	8.844	0.651	0.000
4.	Competition for resources from other existing construction projects	3.59	3.829	0.825	0.001
5.	Competition for resources from other industries	3.34	1.625	1.143	0.115
	(II) *Logistics-related factors*				
1.	Local transportation capacity	4.38	9.581	0.775	0.000
2.	Transportation method	4.48	12.602	0.634	0.000
3.	Transportation cost	4.55	12.183	0.686	0.000
4.	Resource procurement lead time	4.59	12.520	0.682	0.000
5.	Location of depot	4.10	7.697	0.772	0.000
	(III) *Project-related factors*				
1.	Project design drawings	4.21	8.401	0.774	0.000
2.	Quantity of resources required	4.59	13.607	0.628	0.000
3.	Project type	4.00	5.203	1.035	0.000
4.	Project schedule	4.66	18.427	0.484	0.000
5.	Project budget	3.90	5.617	0.860	0.000
6.	Type and method of construction	3.66	4.118	0.857	0.000
7.	Project procurement method	4.00	6.075	0.886	0.000
8.	Resource procurement contract type	3.52	3.057	0.911	0.005
9.	Project resourcing plan	4.59	9.034	0.946	0.000
10.	Location of construction site	4.38	11.945	0.622	0.000
	(IV) *Organization-related factors*				
1.	Qualification of contractor	4.59	10.360	0.825	0.000
2.	Selection of suppliers	3.41	2.268	0.983	0.031
3.	Partnership and supplier management	4.14	8.250	0.743	0.000
4.	Contractor resource database system	4.48	13.899	0.574	0.000
5.	Supplier inventory	3.97	7.112	0.731	0.000
6.	Contractor inventory	4.14	7.353	0.833	0.000
7.	Cooperation of parties in construction	3.86	5.073	0.915	0.000
8.	Coordination among parties in construction	3.69	4.170	0.891	0.000
9.	Communication with local authorities	4.34	6.717	1.078	0.000
10.	Contractor top management commitment	3.62	3.186	1.049	0.004
11.	Competency of resourcing manager	4.59	9.855	0.867	0.000
	(V) *Environment-related factors*				
1.	Legislation and policy	4.83	25.601	0.384	0.000
2.	General economic environment	4.55	13.229	0.632	0.000
3.	Local pre-event economic condition	4.10	7.697	0.772	0.000
4.	Physical impact of the disaster	4.14	8.250	0.743	0.000
5.	Social public attitude	3.21	1.099	1.013	0.281
6.	Community influence	2.62	-2.262	0.903	0.032

Note: Scale ranges from 1 = 'not important at all' to 5 = 'very important'. The null hypothesis is H_0: $\mu = \mu_0$ and the alternative hypothesis is H_1: $\mu > \mu_0$, where μ is the population mean, μ_0 is the critical rating at 3. The level of significance for the one-tailed test is 0.05.

factors, logistics-related factors, project-related factors, organization-related factors, and environment-related factors.

The questionnaires were sent by personal delivery during our field trip or by e-mail and post to 90 randomly selected building contractors involved in reconstruction work after the Wenchuan earthquake. The respondents were asked to rank the importance of each factor in achieving resourcing outcomes of post-disaster reconstruction projects on a five-point Likert scale from 1 to 5, where 1 symbolizes 'not important at all' and 5 represents 'very important'. The questionnaire also requested the informants to add any other potential factors and rate them accordingly. Statistical analysis determined the key factors affecting resource availability in post-disaster reconstruction situations. One sample t-test of the mean was conducted using SPSS, based on the sample's ratings, to check if the factors identified within the questionnaire were important in affecting project resource availability in post-disaster reconstruction situations. By using SPSS descriptive statistics, a ranking of the factors perceived by respondents was carried out to identify critical ones which significantly affected resource availability of reconstruction projects after the earthquake.

Research findings

The survey data are limited by the frequency of a disaster event and the accessibility of the data, and the focus on individual rather than community or institutional units of analysis. The survey was conducted in Mianzhu, one of the most severely affected regions during China's Wenchuan earthquake. The sampling frame contained 218 building professionals registered with Construction Bureau of People's Government of Mianzhu, Sichuan Province, PR China for post-earthquake reconstruction work in affected Mianzhu administrative region. The rationale behind this random sampling is that units are selected independently of each other to remove bias in the selection of the sample (Triola, 2008). Out of 90 questionnaires sent out, 29 responses were returned with response rate of 32% within three months. These participants comprised construction coordinators (21%), project managers (17%), and procurement managers (62%) responsible for material and equipment sourcing operations. The average working experience of the participants in the construction industry is 16 years. The maximum and minimum working experiences are 3 years and 36 years respectively. The profile of the participants is shown in Table 2.

T-test results in Table 1 show that only two factors, namely competition for resources from other industries (sig. 0.115) and social public attitude (sig. 0.281) have a greater significance level than 0.05. These factors are not statistically important with regard to resourcing while the other 35 factors indentified have an influence on project resource availability in post-disaster reconstruction.

The ranking hierarchy of the most significant factors affecting project resource availability in post-disaster reconstruction is tabulated in Table 3. The top 10 determinants were legislation and policy, project schedule, competency of resourcing manager, qualification of contractor, project resourcing plan, quantity of resources required, resource procurement lead time,

Table 2 Profile of the questionnaire respondents

Reconstruction project		Frequency	Percentage
Project type			
Residential		12	41%
Public facilities	School	4	14%
	Hospital	2	7%
Industrial		7	24%
Civil engineering		4	14%
Project duration			
Up to 12 months		21	73%
13–24 months		5	17%
>24 months		3	10%
Contractor size			
Large		12	41%
Medium		6	21%
Small		11	38%
Respondent experience			
Up to 5 years		6	21%
5–10 years		4	14%
>10 years		19	65%

Table 3 Ranking hierarchy of significant factors affecting project resource availability in post-disaster reconstruction

Rank	Factors affecting resource availability in post-disaster reconstruction	Mean
1	Legislation and policy	4.83
2	Project schedule	4.66
3	Competency of resourcing manager	4.59
4	Qualification of contractor	4.59
5	Project resourcing plan	4.59
6	Quantity of resources required	4.59
7	Resource procurement lead time	4.59
8	General economic environment	4.55
9	Transportation cost	4.55
10	Transportation method	4.48

Note: Sig. of these factors is 0.000, less than 0.05.

general economic environment, transportation cost and transportation method. The 10 factors identified as very important by the respondents with their mean more than 4.5 are discussed in this paper.

By using content analysis, the identified 10 key constraints can be classified into three categories: (1) project-related factors such as quantity of resources required, project schedule, project resourcing plan, and resource procurement lead time; (2) factors related to the reconstruction practitioners, including competency of resourcing manager and qualification of contractor; and (3) factors external to reconstruction projects including legislation and policy, general economic environment and resource transportation cost and method. In what follows, a discussion is presented on the three main categories, incorporating the past studies and observations made during the authors' two-month field trip in China.

Project-related factors

Project schedule

Project scheduling influences resource availability during post-earthquake reconstruction. This result agrees with Belassi and Tukel's study (1996) which showed that the urgency of a project, as one of project attributes, plays an important role in post-disaster reconstruction. Much of the urgency comes from livelihood recovery, notably residential reconstruction, often the top priority for disaster-affected communities. The role that reconstruction plays in long-term community redevelopment is often overlooked (Jha *et al.*, 2010). For instance, there was an imperative to complete rebuilding of permanent residences before winter for people affected by the 2005 great earthquake in North Pakistan (Mumtaz *et al.*, 2008) and people impacted by the Wenchuan earthquake in China.[5] Time needs to be allocated to reconstruction planning and scheduling (Schwab, 1998) and normal planning procedures and construction legislation cannot be bypassed (Silva, 2007). If this happens, the project is more likely to suffer resourcing bottlenecks (Resilient Organisations, 2006), exceed budgets (Davidson *et al.*, 2008) and overrun schedules (Steinberg, 2007). Given tight schedules in some of the reconstruction projects, fast-track (Rowland, 1995; Masurier *et al.*, 2008) was introduced to expedite recovery and reconstruction; yet conversely, it often resulted in poor decision making (Silva, 2007), poor reconstruction quality (Zuo *et al.*, 2006) and to a great extent intensified the shortage of resources and rate escalation of major building materials in the construction market (Jayasuriya and McCawley, 2008). In this respect, project scheduling can serve as an important element to be considered during post-disaster reconstruction planning.

Project resourcing plan

Apart from basic plans, project resourcing plans should involve proactive and preventive schemes to address potential bottlenecks. The significance of this variable suggests that a well-organized plan rooted in good factual detail can make the process manageable (Schwab *et al.*, 1998). In a disastrous situation, resourcing plans are essential and will be dependent on the knowledge of available resources for an initial response to the emergency and for the subsequent restoration phases (Alexander, 2002).

However, resourcing is always decided after a disaster which prevents the construction sector from being prepared for coping with disasters, and potential resources being used efficiently. Barenstein (2006) advocated that the affected community could contribute to improving the implementing agencies' planning efficiency by providing local resources and knowledge inputs into the resourcing plan. In addition, planning attention should be focused on critical resources with long lead times from overseas manufacturers (Zuo *et al.*, 2006). Detailed planning also needs to be decentralized to the level responsible for the execution of the works (Winch and Kelsey, 2005), because focusing on details of implementation is at the heart of preparing the elements of the plan for long-term post-disaster reconstruction (Schwab *et al.*, 1998).

Quantity of resources required

Hopkins (1995) pointed out that the total resources needed for full reinstatement is a starting point for assessing the implications for reconstruction timing, resource availability and supply/demand. As was observed by the researchers after the Wenchuan earthquake, reconstruction tasks were incommensurate in scale with the available resources and caused a number of problems undermining the construction market such as profiteering, inflation and precipitous wage increase of local labour.

As shown in Table 4, estimated supply shortfalls of main construction materials for the three-year reconstruction in China's Sichuan Province indicate the significance of resource availability in post-disaster rebuilding. The resource shortages were mostly induced by widespread and intensive rebuilding work. However, the quantity of resources depends on a number of variables such as physical impacts of the disaster, construction type and method, and requirements of building owners, etc., all of which deserve

Table 4 Supply shortfalls of cement, brick and steel in earthquake-stricken areas in Sichuan Province, China (adapted from http://www.sc.gov.cn)

Building material	2008–2009	2009–2010	2010–2011
Cement (million tons)	53	39	31
Brick (billion pieces)	35.5	17.8	3
Steel (million tons)	3–3.6	3–3.6	3–3.6

proper consideration for both project procurement managers and reconstruction planners.

Resource procurement lead time

One of the top 10 factors, resource procurement lead time, is concerned with the interval between the initiation of resource procurement and receipt of the resource into the project construction system. This result conforms with the findings of the study carried out by Singh (2007) who concluded that lead time associated with acquiring resources in post-disaster situations can be detrimental to the availability of these resources, especially in a construction industry which relies heavily on 'just-in-time' delivery. Furthermore, the fact that most reconstruction projects are likely to be fast tracked means that lead time and delays will be even more critical. Some reconstruction failure examples raised by the researchers like Steinberg (2007) and Kennedy *et al.* (2008) could be traced back to low resource coverage and long lead times in the resource procurement process leading to cost overrun and project delays. The relationship between resource procurement lead time and other factors which affect it, especially those causes of prolonged lead time, should be understood by resourcing managers.

Reconstruction practitioner-related factors

Competency of resourcing manager

Resourcing managers need to procure resources for project construction in a timely and economical way. Although much attention is given to the competency of project managers in construction projects (e.g. Edum-Fotwe and McCaffer, 2000; Pheng and Chuan, 2006), resourcing responsibility mainly falls to a functional manager in charge of resource procurement. Spekman (1985) highlighted the role of the procurement sector within a construction company in monitoring, gathering and dissemination of material-purchasing related information. Similarly, Singh and Wilkinson (2008) and Zuo *et al.* (2008) suggested resourcing managers should be more proactive in procurement/material management under post-disaster reconstruction circumstances. Resourcing managers need to show environmentally responsible behaviour (Chang *et al.*, 2006), and maintain the right relationships with stakeholders (Edum-Fotwe and McCaffer, 2000). To achieve this, capacity enhancing for those practitioners in post-disaster reconstruction is needed through the provision of training, expert advice, or funds (Kenny, 2005). Targeted education and technical assistance programmes should also be provided (Yoshida and Deyle, 2005).

Qualification of contractor

The qualification of contractor not only refers to the scale, financial and technical capability of a contractor, but also their industrial influence and social network. The contractor's capability was regarded as a key element to pool and source resources required during an emergency. Zuo *et al.* (2006) found that large-scale contractors are more likely to procure resources needed for disaster reconstruction. One of the reasons is that many large contractors maintain long-term relationships with their subcontractors and suppliers, and it is these relationships that determine the position of large contractors in post-disaster reconstruction (Masurier *et al.*, 2006b).

Another reason for superior resourcing ability of large contractors is that, in comparison with those of small or medium size, they are likely to have more competent professionals in resourcing. For instance, in the research survey, among 29 respondents, out of 19 with more than 10 years' working experience in procurement 12 were positioned in large construction companies. These professionals are likely to contribute to a better capability of an organization and enable the contractor to effectively handle the resourcing tasks confronting them in post-disaster situations.

Factors external to construction projects

Legislation and policy

Legislation and policy have been regarded by a number of researchers, such as Godschalk (1999), McEntire *et al.* (2002), Birkland (2006) and Masurier *et al.* (2008), as an overarching imperative to allow effective coordination and delivery of reconstruction work. This result is consistent with the findings of two studies (Lowndes and Skelcher, 1998; Considine and Lewis, 1999) that in the hierarchical governance model, 'legitimate' authority provides the means of integrating and regulating the relationships between actors into a functional system of operation. In Indonesia and Sri Lanka after the Indian Ocean tsunami (2004), and in New Orleans after Hurricane Katrina (2005) existing legislation and policy seemed to be unable to cope with post-disaster situations (Zuo *et al.*, 2008), especially after a large-scale disaster (Masurier *et al.*, 2006a); and inappropriate legislative and governmental systems could substantially limit the recovery progress (Burby, 2006) and hinder reconstruction resource procurement and utilization (Hanaoka and Qadir, 2005).

General economic environment

The overall economic environment, globally, nationally and locally, plays a prominent role in post-disaster reconstruction work which in turn provides a 'window of opportunity' to economically restructure. Jayasuriya and McCawley (2008) have shown the influence of the economic environment on resource availability in post-disaster reconstruction. They demonstrated that, unlike Indonesia, Thailand had not suffered from resourcing bottlenecks during the reconstruction after the 2004 Indian Ocean tsunami because of its particular economic circumstances. The higher demand in tsunami-impacted areas came in the context of a depressed construction sector which had not fully recovered from the 1997 economic crisis and so failed to cause price escalation post-tsunami.

Similarly in China, it was observed that the global economic crisis in 2008 had an impact on China's construction market, with a great impact on the steel industry. According to the China Iron and Steel Association (2009), in the second half of 2008, steel producers in China were cutting their production due to the reducing demand for steel nationwide. Nevertheless, these major steel makers were not willing to provide supplies needed for the earthquake-affected areas with a lower price. This profit-driven behaviour of Chinese steel makers made steel supply a problem in the disaster-affected areas.

Transportation cost and method

Transportation systems such as roads, airports and railways serve as lifeline access to available resources for a country's successful recovery. The significance of transportation has been confirmed in previous research. Some studies looking into post-disaster reconstruction logistics have manifested that high cost of resource transportation (Limoncu and Celebioglu, 2006), and lack of access alternatives (Singh, 2007) are a major concern for overall reconstruction. As was observed by the researchers in the field in China, the unavoidable costs related to logistics, such as costs incurred by lack of consistency in delivery and by volatile price fluctuations of fuel and physical distribution, accounted for a large fraction of resource sourcing costs.

The location of the construction site in association with distance, method and cost of resource delivery is also recognized by the respondents as a key factor affecting rebuilding project resource availability. According to the authors' observation in the earthquake-affected Mianzhu City in December 2008, all modes of transport including human and pack-animal carrying methods were applied for delivering building materials to construction sites in the remote mountainous affected areas where road access was disrupted.

Suggestions for improving reconstruction resourcing

Based on the survey results, resource availability for China's Wenchuan earthquake reconstruction is a function of the rebuilding project and internal capability of contractors, along with other issues in the external built environment such as legislation and policy, economy and transportation conditions. The factors identified in this research show what affects resource availability in post-disaster reconstruction. However, these factors were not fully recognized and addressed by Chinese reconstruction teams during their resourcing operations. In order to improve resourcing post-disaster, the following features should be addressed:

- The reconstruction planning by decision makers should be made through a proactive approach that is cognizant of the actual resource availability. Having a planned procurement strategy would effectively reduce the risks of long lead time and at the same time enhance procurement capability of the resourcing professionals. It is important for resourcing managers to incorporate as much resource-associated information into the plan as possible by building networks with stakeholders, material suppliers in particular.
- Large-scale construction companies, as the leading players in the construction industry, should provide procurement expertise to assist small and medium-size corporations with training in resourcing procedures, assessing quantities of resources required and procurement skills to reduce lead time and cost; local governmental agencies and construction associations play a coordination role in facilitating technical assistance by providing financial or in-kind support to launch a series of training initiatives. A range of 'fit-for-purpose' contractual relations and well-tailored resourcing strategies, when appropriate, could be linked with measures to foster resourcing capabilities of small or medium-size contractors.

- To be more certain of fulfilling resourcing needs of post-disaster reconstruction, a specific legislative and regulatory system is required. Legislation and policy need to be revamped prior to future disasters in order to facilitate effective resource acquisition and utilization for long-term sustainability in disaster prone areas. An effective enforceability of legislation and policy is essential to the formulation of an overall resourcing system and its outcomes after a disaster.
- The general economic environment is the most uncontrollable yet influential factor impinging on resource availability after a disaster. Its facilitation function for post-disaster reconstruction resourcing could only be realized by policy makers through a policy of robust and extensive programme of global economic integration and domestic deregulation, as well as sound macro-economic and local economic management.
- Given the importance of transportation in post-disaster resourcing, transport capacity extending strategies should be integrated into the pre-disaster mitigation programme and be targeted at transport alternatives to enhance the resilience of the overall transportation system. Planning for infrastructure reconstruction of transport should also be in line with industrialization and urbanization in disaster-impacted areas taking account of natural environmental conditions.

Post-disaster resource planning requires commitment from decision makers and practitioners in a multi-sector approach. Understanding and communication among stakeholders can make it possible to develop a collaborative reconstruction approach. To achieve this, systematic data collection, information systems and communication and coordination mechanisms are required. An enabling international environment is vital to develop the knowledge, capabilities and motivation needed to build disaster resilient nations and communities. Developing specific mechanisms to introduce human and material resources into China through both bilateral and multilateral channels for post-disaster reconstruction should also be considered.

Conclusions

Owing to the complex, dynamic and unpredictable environment in the aftermath of a disaster, the conventional procedures associated with project resource procurement are unlikely to be able to deal with the requirements of post-disaster reconstruction. By drawing on a field-based survey in post-earthquake China, three primary areas that confront post-Wenchuan earthquake reconstruction teams with respect to resource availability are identified: (1) project-related factors such as quantity of resources required, project schedule, project resourcing plan, and resource procurement lead time; (2) factors related to the reconstruction practitioners, including competency of resourcing manager and qualification of contractor; and (3) factors external to reconstruction projects including legislation and policy, general economic environment and resource transportation cost and method.

The resourcing in a disaster involves finding strategies to limit the cost of resource provision and increase accessibility to available resources to meet reconstruction needs. Suggestions are thus offered to reconstruction decision makers for legal and institutional changes in order to facilitate reconstruction work and reinforce capability.

This research supports findings from previous studies—highlighting the importance of legal framework, engagement of the construction practitioners, economic linkage, transportation network as well as environmental considerations. Many of these findings have been extended by the research in a way relevant to reconstruction planners and project managers operating in rebuilding the built environment after a disaster.

Clearly, the nature of resourcing practice during post-disaster reconstruction requires systematic thinking of how best to achieve resource availability. The research in this paper provides a means in which to understand and enhance this practice. Continuous improvement to remove bottlenecks or constraints during the resourcing process and to tap resourcing paths and alternatives are required. It is anticipated that the research constitutes an approach for understanding and adapting to resource uncertainties and sets up a baseline for a longitudinal cross-country, multi-disaster study.

Notes

1. Whenever a particular sector in a particular economy experiences a marked boom, the demand for inputs used in that sector tends to increase. This increased demand, in turn, tends to cause negative impacts for other industries that compete for the inputs used in the booming sector. The increased prices of inputs raise costs and reduce profitability in the competing (non-booming) industries. The resulting negative impact on the non-booming sectors is known as 'Dutch Disease', named after the experience in the Netherlands of de-industrialization in the wake of large inflows of export revenues from North Sea Oil in the late 1970s.
2. M 8.0 represents surface wave magnitude (Ms), the national standard used by the Chinese government for

earthquake magnitude. M7.9 for the Wenchuan earthquake from the United States Geological Survey (USGS) reports represents moment magnitude (Mw).
3. As of 11 September 2008, noon.
4. The people in the pilot study consist of three NGOs construction coordinators of post-tsunami housing reconstruction programme in Indonesia, two academic researchers in reconstruction procurement at Sichuan University, China and three project managers in charge of resource procurement in post-Wenchuan earthquake rebuilding projects.
5. Based on the authors' field observations after the Wenchuan earthquake in China.

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