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Optimal policy design for disaster-hit area of Japan: bottom-up systems analysis of special zone for reconstruction by the ISDM

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Abstract. *This paper proposes application of framework of system design of a special zone for reconstruction of Fukushima Prefecture which suffered serious damages from the Great East Japan Earthquake, tsunami and nuclear accident at the Fukushima Daiichi Nuclear Power Plant. The framework of system design used in this paper is called the Interactive Social Design Model (ISDM). The ISDM is useful for aggregating stakeholders' requirements and values through the process of the interactive and bottom-up communication with stakeholders, and derivation of the optimal policy in quantitative approach. In this paper, the optimal policy designed by the ISDM for the purpose of reconstruction of Fukushima is compared with the existing system of the special zones for reconstruction, in which local governments which suffered from the earthquake can choose support measures from the catalogue of policy measures designed by the central government of Japan.*

Keywords. *ISDM, the Vee model, special zone for reconstruction, the great eastern Japan earthquake*

1 Introduction

The Eastern Japan suffered a catastrophic loss of human lives, infrastructures for daily life and industries from the great earthquake and tsunami, especially in *Fukushima* Prefecture, a serious damage and harmful rumors of radioactive contamination are obstacles to rebuild regional social and economic systems. The accident in a nuclear power plant and that sustained effect causes severe situations that are unexpected before the earthquake. We need visualization of what are required for countermeasures against contamination and action plan for reconstruction.

The Government of Japan enacted the law for special zone for reconstruction at the end of 2011, which allows local governments of disaster areas to establish a special zone for reconstruction with approval of the central government. When local governments plan special zones, they can choose support measures from the support measures catalogue offered by the central government.

However, the policy measures in the catalogue are possibly not the requirements from the bottom of the community people's hearts that actually live in the disaster area, but the top-down policies that the central government believes them necessary for reconstruction.

2 The Interactive Social Design Model (ISDM)

This paper empirically validates the process of policy design for reconstruction of disaster-hit area of Japan by the Interactive Social Design Model (ISDM). The ISDM is the systems approach to design a solution to the social system by participatory and collaborative works by residents (Yasui *et al*., 2011). The ISDM is supposed to be effective in the case if a policy maker cannot know or predict the requirements and values of stakeholders with accuracy. By the IDSM, a policy maker has opportunities of sharing information of the requirements and values by the stakeholders' participation.

The ISDM inherits its methodological structure from the Vee model (Forsberg *et al*., 2005), which is a helpful tool of description of a lifecycle of system design and development (Ishii *et al*., 2009).

The ISDM consists of the following five phases;

1. Requirement Analysis
   Tools: Brain-Storming, KJ Method, VOC Analysis, Scenario Graph, Value Graph, Customer Value Chain Analysis (CVCA), Quality Function Deployment (QFD), Object Process Methodology (OPM)
2. Architecting & Design
   Tools: Morphological Design, Prototyping Rapidly, Pugh Concept Selection, Net Present Value Analysis (NPV), Cost-Benefit Analysis
3. Verification
   Tools: Experts Judgments, Local Opinion Poll, Analytic Hierarchy Process (AHP), Scenario Analysis
4. Implementation
   Tools: Policy Implementation
5. Validation
   Tools: Regression Analysis, Cognitive Chronological Ethnography, Causal Loop Modeling (CLM), Multi-Agent Simulation, Structural Equation Model

However, the actual policy implementation for the special zones is delayed due to political and administrative challenges. The special zones in *Fukushima* are not yet certified as of 27 February 2012. Therefore, it is impossible at this time to compare the outcome designed by the ISDM with the central government's actual proposal for the Fukushima special zones. This paper thus shows only the results of two phases (Requirement Analysis and Architecting and Design), and not the rest three phases (Verification, Implementation and Validation) among the above five phases.

3 Case Study

3.1 The Act of the Special Zone for Reconstruction

On 29 July 2011, the Government of Japan issued the "Basic Guidelines for Reconstruction in response to the Great Eastern Japan Earthquake", the policy guideline for post-disaster rehabilitation and reconstruction. Under this guideline, the Reconstruction Headquarters in response to the Great Eastern Japan Earthquake announced the government's policy in creating the "System of Special Zone for Reconstruction" as follows;

"To strongly assist the reconstruction efforts conducted by the communities subjected to the damage, a framework of Special Zone for Reconstruction is to be established. In the conduct of this scheme, proposals by affected communities are promptly put in practice in an integrated way by making use of tailor-made and innovative ideas, going beyond the conventional wisdoms and ideas. They include special measures for drastically reduced regulations and administrative procedures, as well as economic aid packages." (Reconstruction Headquarters in response to the Great Eastern Japan Earthquake, 2011)

On 7 December 2011, the Act of the Special Zone for Reconstruction came into effect. This act allows local governments located in "disaster afflicted zone" to formulate and submit a plan for a special zone for reconstruction which includes the incentives of special arrangements for deregulation, the special measures regarding land use restructuring, and the grants to local governments.

3.2 ISDM

In this paper, the policy support designed by the ISDM that is the bottom-up approach with stakeholders in *Fukushima* is compared with the existing scheme of special zone for reconstruction at the initiative of the central government mentioned in the previous subsection.

3.2.1 Requirement Analysis

On 11 December, 2011, a workshop was held in *Fukushima* under the aegis of "Link with Fukushima", a voluntary youth organization based in *Fukushima*, and SDM Institute of Keio University. In this workshop, seventeen participants including a local governmental official, students and staffs of the host organization discussed about the theme of reconstruction of *Fukushima* and policy making by bottom-up approach (Figure 1).

After the workshop, we sent questionnaires to staffs of the host organization and experts of special zone planning who were in charge of special zone policy of the Cabinet Secretariat, Government of Japan. Returned answers to questionnaires were used for requirement analysis in the ISDM.

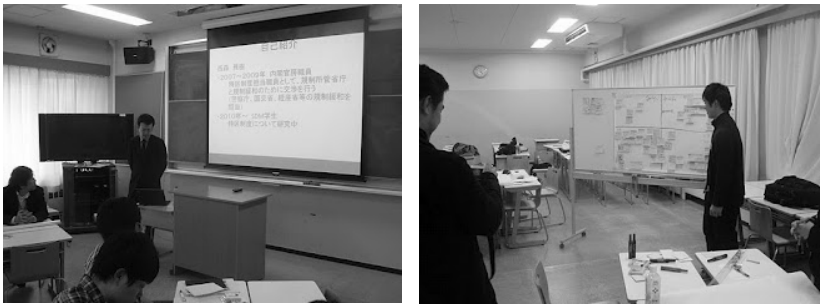

Fig.1. The Workshop for Fukushima Special Zone on 11 December, 2011 (adapted from (Link with Fukushima, 2011))

3.2.1.1 Brain Storming and KJ Method

Firstly in this workshop, Participants had brainstorming session and proposed almost 150 ideas for reconstruction of *Fukushima* in the session. These ideas were categorized by the KJ Method into nine groups of stakeholders' requirements and values; housing, radiation, medical care, agriculture, daily life, energy, regional economy, image-building, and future vision (Figure 2).

Fig.2. Brainstorming and the grouping session at the session on 11 December, 2011 (adapted from (Link with Fukushima, 2011))

3.2.1.2 Value Graph

The next process of the requirement analysis is to draw the value graph that can visualize relationship with the purpose of the policy designed by the ISDM, future goals, stakeholder's value and observable indices. The pivotal role of the value graph for this time is "reconstruction of *Fukushima*", that is the purpose of the policy. And the lower layers are extracted factors of "stakeholders' requirements and values" and "economic and social indices." The upper layer of the value graph shows the purpose and substantial goal of "reconstruction of *Fukushima*" (Figure 3).

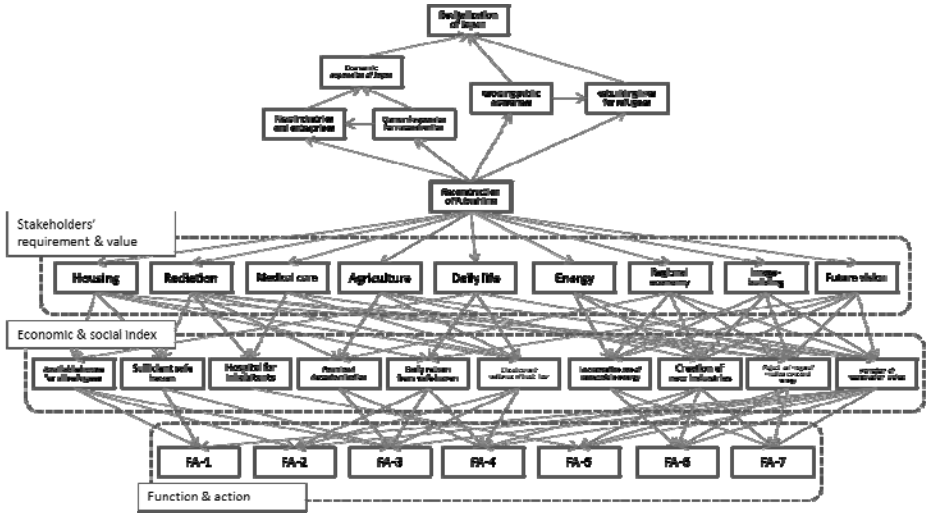

Fig.3. The Value Graph for the reconstruction of *Fukushima*

3.2.1.3 Weighted Poll

In order to weigh the importance of each factor of stakeholders' requirements and values, we conducted a survey in the form of a weighted questionnaire targeting the staffs of the workshop organizer and experts of special zones who have a career at the Cabinet Office of Japan. Twenty one respondents returned answers to the questionnaires. Table 1 shows the most important index of each factor in their answers.

Table 1. The most important index of each factor in the weighed poll

Housing	Radiation	Medical care	Agriculture	Daily life	Energy	Regional economy	Image-building	Future vision
Available house for all refugees	Sufficient safe haven	Hospital for inhabitants	Farmland decontamination	Early return from Safe haven / life at current residence without fear	Increase the use of renewable energy	Creation of new industries	Project an image of medical care and energy	Promotion of reconstruction project

3.2.1.4 Customer Value Chain Analysis

The Customer Value Chain Analysis (CVCA) is the method to describe the relationship with stakeholders; in the case of Fukushima, they are the central and local government, entities in *Fukushima* (enterprises and residents) and residents outside of *Fukushima*. The completed CVCA clearly shows some obstacles that have to be solved in order to make a progress for reconstruction of *Fukushima* (Figure 4).

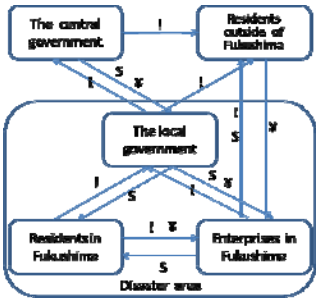

Fig. 4. The Customer Value Chain Analysis for reconstruction of *Fukushima*

The central government which plans the framework of special zone can have information of needs of disaster area only from each plan of special zone by local government, not directly from the local enterprises and residents in disaster area.

Information from the central and local government and local enterprises in *Fukushima* to Japanese nationals outside of *Fukushima* is not enough to understand about the current situation in *Fukushima*, especially related matters of nuclear accident and the safety of food made in *Fukushima*, then this shortage of information causes serious harmful rumors.

3.2.1.5 Quality Function Deployment (two steps)

3.2.1.5.1 QFD-1

Quality function deployment (QFD) can analyze the structure of value graph and the connection of each factor of that graph quantitatively. In this paper, the QFD applies to the estimation of each factor of "stakeholders' requirements and values", "economic and social indices" and "function and action." The QFD has two steps for analysis of these three layers.

The first QFD (QFD-1) is QFD that analyze "stakeholders' requirements and values" and "economic and social indices." The result of the QFD-1 implies that the importance of radioactive decontamination for revitalization of agricultural industry in *Fukushima*, which has the largest weight in the QFD-1 (Table 2).

Table 2. The first Quality Function Deployment (QFD-1) for "stakeholders' requirements and values" and "economic and social indices"

QFD-1		Economic & social indices										
		weight	Available house for all refugees	Sufficient safe haven	Hospital for inhabitants	Farmland decontamination	Early return from safe haven	Life at current residence without fear	Increase the use of renewable energy	Creation of new industries	Project an image of medical care and energy	Promotion of reconstruction project
Stakeholders' requirements & values	Housing	3	9	3			3	3				1
	Radiation	9		3	3	9		3			1	3

	Medical care	3			9			3			1	
	Agriculture	9				9		3		3		1
	Daily life	1	3				3	9				1
	Energy	1							9	3	3	
	Regional economy	1				3			3	9	3	1
	Image-building	1							3	3	9	1
	Future vision	9					1		3	3	3	9
	Score		30	36	54	165	21	81	42	69	54	123
	Composition ratio		4.4%	5.3%	8.0%	24.4%	3.1%	12.0%	6.2%	10.2%	8.0%	18.2%

3.2.1.5.2 QFD-2

Based on the information of weight of each factor of “economic and social indices” from the QFD-1, the second QFD (QFD-2) that analyzes “economic and social indices” and “function and action” can be deployed. The QFD-2 shows that radioactive decontamination in farmland, residential area and school is the most important factor in “function and action” (Table 3).

Table 3. The second Quality Function Deployment (QFD-2) for “economic and social indices” and “function and action”

QFD-2		Function & action							
		weight	Building temporary housing [FA-1]	Reconstruction of residential zone/support for rebuilding homes [FA-2]	Decontamination operation (farmland, residential area and school) [FA-3]	Radiation inspection of agricultural product [FA-4]	Attraction & foundation of Medical organization [FA-5]	Increase of the use of renewable energy[FA-6]	Fostering & promotion of new industries [FA-7]
Economic & social indices	Available house for all refugees	4.4%	9	3	1				
	Sufficient safe haven	5.3%	9		1				
	Hospital for inhabitants	8.0%					9		
	Farmland decontamination	24.4%			9	3			
	Early return from Safe haven	3.1%		3	3	1			
	Life at current residence without fear	12.0%		3	3	1			
	Increase the use of renewable energy	6.2%						9	3
	Creation of new industries	10.2%				3	1	3	9

	Project an image of medical care and energy	8.0%					9	9	3
	Promotion of reconstruction project	18.2%	1	3	9	9	3	3	3
	score		1.06	1.13	4.39	2.83	2.09	2.13	1.89
	Ranking		7th	6th	1st	2nd	4th	3rd	5th

3.2.2 Architecting & Design

3.2.2.1 Pugh Concept Selection

Policy alternatives of reconstruction supports that are based on the ideas discussed in the workshop are as follows;

・Solution 1 “Special housing zone”:

Improvement of residential zone (construction of temporary housing and support of rebuilding and relocation housing) and promotion of commerce and communication in residential zone

・Solution 2 “Special zone for radiation safety”:

Support of development and operation of decontamination in the private sector, radiation inspection of agricultural product, and promotion of public relations campaign for radiation safety

・Solution 3 “Special medical zone”:

Attraction of medical center and research of radiology based on the future vision of public medical care and welfare in *Fukushima*

・Solution 4 “Special zone for energy technology and industry”:

Attraction of research organization of renewable energy at the nuclear power plant site and fostering and promotion of new industries and venture companies in the related fields

Solution 3 is set as a benchmark for the Pugh Concept Selection. The Pugh Concept Selection implies that Solution 2 is the most effective policy in order to achieve the given stakeholders’ requirement and values (Table 4).

Table 4. The Pugh Concept Selection for alternative policies for reconstruction of Fukushima formulated by the ISDM

	Solution1 “Special housing zone”	Solution2 “Special zone for radiation safety”	Solution3 “Special medical zone”	Solution4 “Special zone for energy technology and industry”

		Improvement of residential zone (construction of temporary housing and support of rebuilding and relocation housing) and promotion of commerce and communication in residential zone	Support of development and operation of decontamination in the private sector, radiation inspection of agricultural product, and promotion of public relations campaign for radiation safety	Attraction of medical center and research of radiology based on the future vision of public medical care and welfare in Fukushima	Attraction of research organization of renewable energy at the nuclear power plant site and fostering and promotion of new industries and venture companies in the related fields
Stakeholders' requirements and needs	Housing	++	S	-	S
	Radiation	−	++	-	S
	Medical care	−	S	-	S
	Agriculture	S	++	-	S
	Daily life	+	++	-	+
	Energy	S	S	-	++
	Regional economy	S	+	-	+
	Image-building	−	+	-	+
	Future vision	−	+	-	++
	Score	3+ 3S 4−	9+ 3S	-	7+ 4S
	Ranking	4th	1st	3rd	2nd

3.2.2.2 Synthesis of Design

In order to get a desirable social design, the most valuable functions chosen by the two-fold QFD in the subsection 3.2.1.5 and the solution selected by the Pugh Concept Selection in 3.2.2.1 is better synthesized. By this synthesis, the solution which is evaluated the best by comparative design method can be equipped with the functions which are the most favored by the voice of stakeholders.

For the case of *Fukushima*, the special zone for radiation safety (Solution 2) is synthesized with the radioactive decontamination, which is the most favored by stakeholders in the weighted poll. This design implies that the supports for radio-active decontaminations are the most wanted special zone policy by the residents in *Fukushima*.

4 Discussion

In the ISDM, the brainstorming with stakeholders in *Fukushima* can visualize their requirements and values by bottom-up approach, and the weighted questionnaire to staffs of the host organization and experts of special zone planning and the quality function deployment can estimate the effects of potential policies for reconstruction quantitatively in two stages. That estimation allows the ISDM to suggest the optimal policy package for realization of the stakeholders' requirement and values.

This result makes clear the difference between the ISDM approach and the existing framework of special zone in which local governments in disaster area plan reconstruction strategy through the use of the central government's supportive measures as a precondition.

5 Conclusions

In this paper, the effectiveness of the ISDM is verified by the optimal policy design for the reconstruction of *Fukushima* Prefecture. Especially it becomes clear that the ISDM can design a right policy by the bottom-up approach in unprecedented situation such as the greatest earthquake and serious nuclear accident on record.

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