# Designing critical policy infrastructures by participatory systems analysis: the case of Fukushima's reconstruction

Toshiyuki Yasui*, Seiko Shirasaka and Takashi Maeno

Graduate School of System Design and Management,
Keio University, Collaboration Complex,
4-1-1 Hiyoshi Kohoku-ku,
Yokohama City, 223-8526, Japan
Email: t.yasui@z2.keio.jp
Email: shirasaka@sdm.keio.ac.jp
Email: maeno@sdm.keio.ac.jp
*Corresponding author

**Abstract:** Recent developments in service science and social design have resulted in new policy design methodologies. On the service science side, the concept of co-creation has appeared. On the social design side, methodologies of participatory systems analysis have emerged. Based on these developments, this paper proposes a participatory systems analysis model for public policy design (PSP), a new methodology that employs Bayesian network modelling. We select Fukushima, one of the northeastern areas of Japan most devastated by the Great East Japan Earthquake of 11th March 2011, to verify and validate the empirical efficacy of this methodology. The results show that it fosters both creativity and a sense of collaborative ownership of policy design, which are the core values for a better community.

**Keywords:** Bayesian belief network; causal relation diagram; co-creation; design perspective; earthquake; Fukushima; leverage point; participatory systems analysis; PSA; policy design; social system.

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**Biographical notes:** Toshiyuki Yasui earned his BA in International Relations from University of Tokyo in 1985, and immediately joined in the Ministry of Finance of Japan. During his distinguish services for the Japanese Government for more than 25 years, he experienced various key posts in the Ministry of Finance and the Financial Services Agency. In March 2011, he earned his PhD in Arts and Science from International Christian University, Tokyo. He teaches policy design and social system methodologies, and has lectures for Graduate School of System Design and Management at Keio University as Guest Professor and National Graduate Institute for Policy Studies as Visiting Professor. He was awarded twice (2010 and 2011) the Best Paper Award of the Year from the Japan Society of Competitive Intelligence.

Seiko Shirasaka is an Associate Professor of Graduate School of System Design and Management at Keio University. He received his MS degree in the field of astronautics from University of Tokyo in 1994 and immediately joined in Mitsubishi Electric Corporation. Since then, he had worked for several space system development projects as a systems engineer for 15 years. His research interests are on architecting methodology for technical systems and social systems, system assurance design and very small satellite design methodology. He earned his PhD in 2012 from Graduate School of System Design and Management, Keio University.

Takashi Maeno has been a Professor since 2008, and currently he is the Dean of Graduate School of System Design and Management, Keio University. He received his BS in 1984 and his MS in Mechanical Engineering in 1986 from the Tokyo Institute of Technology, Tokyo, Japan. From 1986 to 1995, he worked for Canon, Inc., in Tokyo, Japan. He received his PhD in Mechanical Engineering from the Tokyo Institute of Technology, Tokyo, Japan, in 1993. From 1995 to 2008, he was with the Department of Mechanical Engineering of the Faculty of Science and Technology at Keio University, Yokohama, Japan. He was a Visiting Industrial Fellow at the University of California, Berkeley, from 1990 to 1992 and a Visiting Professor at Harvard University in 2001.

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## 1 Introduction

Service science is heading for an era in which the value of co-creation is appreciated (Prahalad and Ramaswamy, 2000; Rawaswamy and Goulliart, 2010). Value co-creation theory drives the collaborative process in producing value long before a consumer purchases a service from a company (Xie et al., 2008). For a consumer, invisible and intangible service is very important (Vargo and Lusch, 2004). He or she seeks to be actively engaged in the creation of value in industry (Grönroos, 2006). Industry also pays keen attention to the value co-creation service model, since companies in manufacturing and services that adopt it are more competitive than those that do not (Ueda et al., 2008).

The discipline of social design reflects recent trends in service science. Participatory systems analysis (PSA), a new methodology for adaptive management, has been proposed as a solution to the problem of involving and accommodating (Checkland and Scholes, 1990) all stakeholders in a social system and in co-designing (Sanders and Stappers, 2008) solutions to problems. The term 'participatory' refers to stakeholder involvement in a bottom-up approach. The term 'systems analysis' denotes the identification of the root causes of a problem and a solution to it (Smith et al., 2007). Collective intelligence, which is significantly better than individual intelligence, emerges when human groups participate in cooperative tasks (Woolley et al., 2010).

By contrast, some market experts view public service as the most backward service in absorbing the two developments in service and social design mentioned above. Government service has been a synonym for ponderous, inflexible, and obsolete service for years in industrialised countries (Kamarck, 2007; Raadschelders et al., 2007). Among

such countries, Japan faces severe challenges. According to a recent Accenture survey (Kuroda, 2009), the Japanese, of the citizens of 21 countries, are the third least satisfied with the administrative services that they receive. They are particularly displeased with 'listening to and matching taxpayers-needs', 'public-private collaborations to meet needs', and 'accountability and trust'. To make matters worse, trust in public services in Japan has fallen significantly after the 3-11 Great East Japan Earthquake and the subsequent nuclear accident at the Fukushima Daiichi Nuclear Power Station (Nomura Research Institute, 2011).

Public service needs a new methodology – one with both participatory and collaborative system analyses – to enable stakeholders to design public policy. This methodology will recover the trust of taxpayers, since it satisfies their most esteemed values. It may be particularly effective in a country like Japan, where stakeholders thirst for co-creating experiences in the post-disaster reconstruction phase. Thus, this paper proposes the participatory systems design of policy [public policy design (PSP)] as an emergent systems approach to improve public service. The authors tested the proposed approach in the field of post-disaster Japan.

## 2 Conceptual background

The design of public policy is an inquiry into the achievement of practical and creative solutions to social problems (Simon, 1967). However, policymakers in modern society face dual challenges in arriving at policies: the accommodative and systemic identification of a problem and its systematic solution.

### *2.1 Identifying a problem in an accommodative and systemic manner*

Policy makers must first identify the social problem in need of solution (Walker, 2000). In pursing this objective, they often fail to arrive at a consensus among stakeholders, who cannot easily agree on a way to structure a problem. The differing mental models of stakeholders lead them to disagree on the causes of difficulties (Dunn, 2007). Thus, policymakers need to have knowledge commons to allow accommodation among shareholders (Checkland and Scholes, 1990), regardless of their mental models.

The commons theory is one of central approaches to ensure accommodation in designing public policy for a community. A community inherently holds power in common, that is, it undertakes collective action and management in governing itself. It possesses learning and organising capabilities that permit accommodation (Poteete et al., 2010).

The design methodology for accommodation requires a systemic mechanism to achieve accommodation. Such a mechanism must be human-centred, since it involves the inquiry into human interactions. Value co-creation, or goal sharing among stakeholders with differing mental models, is the most apparent form of accommodation in certain social systems.

### *2.2 Solving an identified problem in a systematic manner*

The second challenge that policymakers face is the systematic creation of public policy. A modern, risk-laden society (Beck, 2009) has many complex and multifaceted problems.

Each of these is so 'wicked' (Conklin, 2005) that an analytic and fragmented approach cannot achieve an optimal solution to it (Yasui, 2011). Government often proposes uncoordinated and inhumane policy responses (Bazerman and Watkins, 2004), as in the case of natural disasters (Lewis, 2008).

A systematic policy approach is the key to better public management in modern, risk-laden societies, since it influences the government to design comprehensive policies. Thus, the concept of a policy regime relates to 'system theory and related fields of organisational and regulatory analysis' (Hood et al., 2001). A complex, risk-fraught society needs a policy platform equipped with both systemic and systematic thinking. Policymakers cannot solve multifaceted problems without considering the interactions of their interconnected elements (Nadler and Chandon, 2004).

### *2.3 Participation matters*

A human-centred, systemic, and systematic architecture is indispensable to the design of public policies that accommodate all stakeholders concerned with the complex problems of a social system. It constitutes the critical infrastructure of a sustainable and resilient community. In the design perspective theory for public management of the 1980s and 1990s, researchers sought policy alternatives by combining policy goals and policy formulation and implementation mechanisms (Linder and Peters, 1984, 1987, 1991). This article attempts to expand design perspective theory by proposing a standard architecture that incorporates value co-creation theory and PSA. System engineering is the underlying discipline of this architecture (Yasui, 2011), which embodies systemic characteristics for self-learning and self-governance.

Ensuring a participatory process plays a significant role in the systemic and systematic design of public policy. It relies on an analysis of the context of a problem, the identification of the purposes of participation, and iterative design efforts (Bryson et al., 2013). A standard and pre-set architecture allows stakeholders to design policies iteratively without the collapse of accommodation. Therefore, the PSA is the foundational method for a PSP.

## 3 Methodology of the participatory systems-design of policy

The authors define PSP as a hybrid system-analysis that includes both theories of value co-creation and the PSA. They propose the PSP in order to overcome the low satisfaction of citizens with conventional public-service providers. The term 'participatory' of the PSP refers to stakeholder involvement in the identification of the root causes of social problems. The term 'systems design' refers to a systems engineering approach to design of innovative public policy in a failed social system. It also offers stakeholders a husbandry experience in their communities (Gratz, 1989). The PSP applies several holistic-thinking tools to a targeted problem: brainstorming and the KJ method (Project Management Institute, 2008), system dynamics and causal loop diagrams (Legasto et al., 1980), prototyping for empathy (Stanford University, 2012), and a Bayesian belief network (Ames and Neilson, 2001).

The previous studies of the PSA have mainly focused on conversational leadership (Brown and Isaacs, 2005), innovation as a catalyst (Dvir et al., 2006), and adaptive management in an organisation (Smith et al., 2007). Based on these studies, this paper

breaks new ground in applying the PSA to the process of policy creation. In addition, it also explores the PSA as a systems-engineering methodology for a socio-critical system (Yasui, 2011).

The PSP has five sequential steps by which stakeholders can create a public policy

a formulating a problem structure

b drawing a causal loop diagram

c deciding on systemic intervention points

d developing Bayesian network modelling

e deciding on the leverage point for policy intervention.

The PSP is a systemic and systematic architecture that radiates the converging policy ideas of participants who follow its five stages.

In the first step a, the PSA utilises the brainstorming method that permits participants to discuss freely problems; it then organises groups with the grouping method. Thus, participants collaboratively identify the components parts of problems, which they physically picture.

Second, in step b the causal loop diagram describes the relationships and interactions of the grouped and structured elements of step a. The PSP participants work together in drawing a causal loop diagram to identify the root causes of a problem.

In step c, participants specify possible intervention points in a problematic social system. Specifically, they carry out 'visual' scenario testing to observe the potential degree of change that particular elements will create in the system.

In step d, the causal loop diagram produced in step b and intervention points identified in step c structure Bayesian network modelling. The PSP participants populate the model, as they jointly decide on the subjective probabilities of parent nodes that will determine the probabilities of each child node. This human-centred, co-design process populates the Bayesian network. This process allows participants to share in the quantified outcomes of policy alternatives.

In step e, participants, through a sensitivity analysis of the structured Bayesian network modelling, recognise the leverage point(s) for policy interventions as the most sensitive node(s).

Table 1 summarises the five steps and the corresponding tools of each step of PSP.

**Table 1** The five steps of PSP and the corresponding tools of each step

| *Step #* | *Contents of step* | *Tools (examples)* |
|---|---|---|
| 1 | Formulating the problem structure | Brainstorming, KJ method |
| 2 | Drawing the causal loop diagram | System dynamics |
| 3 | Deciding on systemic interventions points | Systems dynamics, prototyping for empathy |
| 4 | Developing a Bayesian belief network | Bayesian belief network |
| 5 | Deciding the leverage point for policy intervention | Inductive sensitivity analysis |

## 4 Empirical validation of the PSP: the case of Fukushima

This section seeks to validate empirically the efficacy of PSA as a methodology by which stakeholders can create public policy.

As for a field for validation, the authors held a workshop at Fukushima University on 11 December 2011; 15 representatives of local communities and local governments attended it. Thus, the workshop had the characteristics of a consensus conference (Grundahl, 1995), since experts on public policy and ordinary citizens joined in one panel to search for better policy ideas. The workshop followed the five steps stipulated by the PSP. Participants sat at three tables, each with five persons. All three tables successfully proposed policy ideas for employment that included concrete narratives and images.

Fukushima is one of the areas most devastated the big earthquake, unprecedented tsunami, and nuclear accident of March 2011. This shattered area now faces the daunting challenge of reconstruction in the face of a loss of its industry and population because of radioactive fallout. This urgent concern made the workshop participants select 'Jobs in Fukushima' as a key issue.

### *4.1 Problem formulation*

Three tables implemented brainstorming sessions and raised more than 100 factors that may influence employment in Fukushima. The participants grouped these ideas in several policy agendas by participants, according to the KJ Method, a thinking method to unconsciously group ideas invented by Dr. Kawakita Jiro, a prominent anthropologist (Figure 1). It took 45 minutes in completing this step in that workshop.

**Figure 1** Brainstorming and the KJ method in the 'Jobs for Fukushima' workshop

Note: 11 December 2011 at Fukushima University.

*Source:* Photographs by T. Yasui

### *4.2 Causal loop diagram*

Three tables competed with each other in drawing the causal loop diagrams. This step allowed participants to visualise and share a holistic picture of a problem whose factors were confusedly connected and looped. Three tables identified six loops in total.

### *4.3 Systemic interventions points*

Based upon the causal loop diagrams drawn in the previous subsection, the participants identified systemic interventions points, which are equivalent to leverage points (Senge, 1990), in order to prevent loops from reinforcing adverse effects. Three tables decided on four systemic interventions points: keeping 3-11 memories alive, cleaning radioactive fallout from the soil of Fukushima, creating a learning tourism centre for energy policy, and uniting local residents more with the forests (Figure 2).

**Figure 2** Causal relation diagram and systemic intervention points identified of one table

Note: 11 December 2011 at Fukushima University.

*Source:* Photographs by T. Yasui

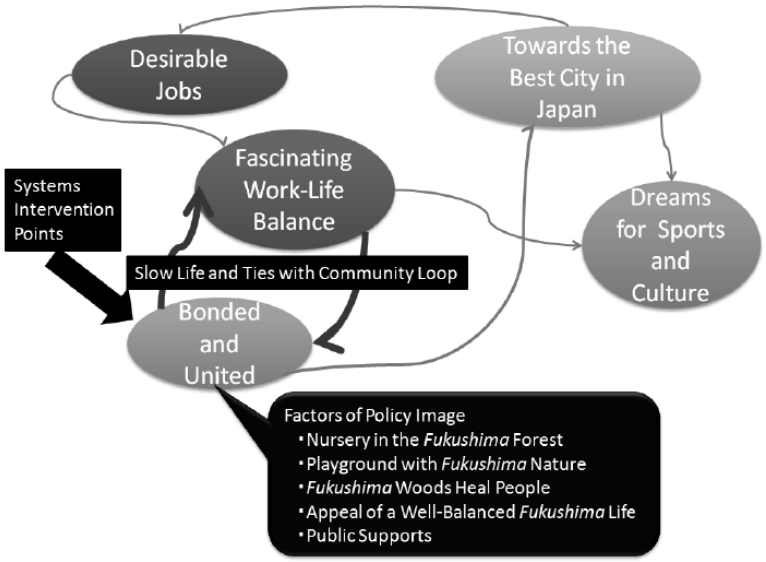
The participants then developed their policy outcome images on four identified interventions points, according to the method of prototyping for empathy (Figure 3). These prototypes visualised directions for the Japanese government to create employment in Fukushima:

a recovering employment in agriculture by adhering more strictly to standards on residual radioactivity in agricultural products shipped from it

b boosting employment in the tourism industry by launching an educational project about nuclear and renewable energy

c and attracting the educational industry and gathering the attention of families by enhancing the symbiosis of primary education with the forests (Figure 4).

**Figure 3** From causal relation diagram to policy factors




Note: 11 December 2011 at Fukushima University.

**Figure 4** Prototype for empathy made by one of three tables

Note: 11 December 2011 at Fukushima University.
*Source:* Photos by T. Yasui

### *4.4 Bayesian belief network*

The policy expert panel held on 27 February 2011 on the Keio University Hiyoshi campus developed the Bayesian belief network of policy outcomes proposed in the previous subsection. Three experts judged which policy alternatives correspond to policy outcomes. They identified eight policy alternatives and three intermediary parameters that led to the ultimate policy goal of fostering jobs in Fukushima.

**Figure 5** Structure of the Bayesian belief network 'Safeguarding jobs in Fukushima'

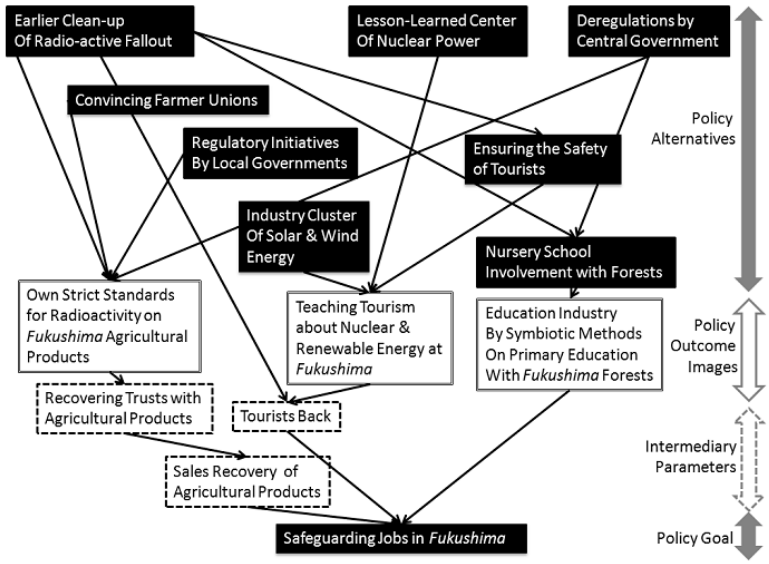
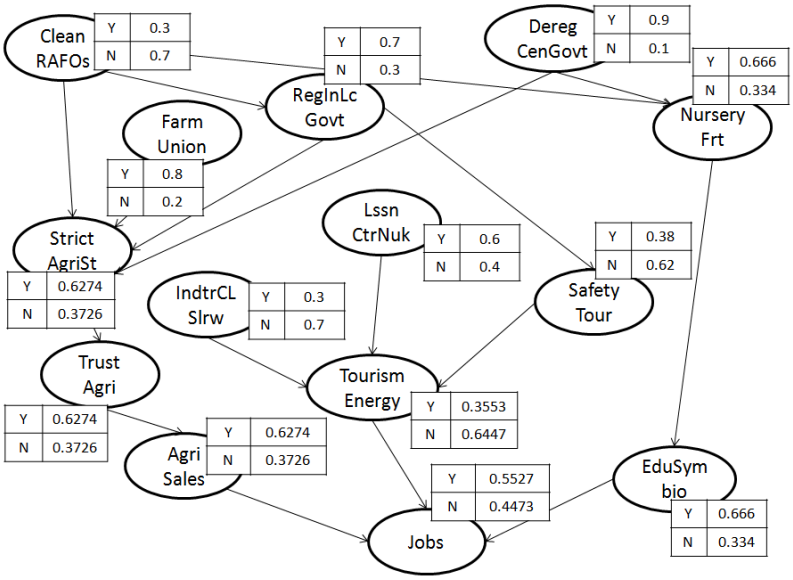



**Figure 6** Bayesian belief network of 'Fostering jobs in Fukushima: estimates in default



The policy experts also quantitatively determined the conditional probability of each alternative or outcome. Figure 5 is the Bayesian belief network structured by the panel. According to their modelling, the probability that Fukushima will be able to safeguard jobs, if the current probabilities of policy alternatives continue, is only 55% (Figure 6).

### *4.5 Leverage point for policy intervention*

The experts carried out a sensitivity analysis of policy alternatives for the developed Bayesian belief network of the previous subsection. They implemented the sensitivity analysis to evaluate the effect on the targeted policy goal of each alternative, if the latter achieved with 100% certainty (Table 2).

**Table 2** Sensitivity analysis of the policy alternatives in the Bayesian belief network of 'Jobs in Fukushima'

| *Policy alternatives* | *Probability of the goal in default (%) (a)* | *Probability of the goal if this alternative is done 100% (%) (b)* | *Sensitivity (% point) (c = b – a)* |
|---|---|---|---|
| Earlier clean-up of radio-active fallout | 55 | 81 | 26 |
| Ensuring the safety of potential tourists to Fukushima | 76 | 21 | |
| Starting nursery school involvement with the Fukushima forests | 71 | 16 | |
| Regulatory initiatives by local governments | 59 | 4 | |
| Constructing the lesson-learned centre on the nuclear accident | 59 | 4 | |
| Convincing farmer unions | 58 | 3 | |
| Establishing an industry cluster for solar and wind energy | 58 | 3 | |
| Deregulation by the central government | 58 | 3 | |

Table 2 shows two policy alternatives that were significantly effective in achieving the policy goal: earlier cleaning of radioactive fallout (26% point) and ensuring the safety of potential tourists to Fukushima (21% point). Therefore, they chose two policy alternatives as the leverage points for the policy goal of this case.

## 5 Discussion

One may argue that the empirical validation described in Section 4 does not ensure confidence in the PSP because it is based on only 15 stakeholders. Certainly, this empirical demonstration of its efficacy does not demonstrate the workability of the PSP for all types of stakeholders in a community. Nonetheless, it does support the viability of the PSP model for PSP in one community with highly complex social problems. It depends on the identification of various parameters at work within the community. In this sense, the number of stakeholders does not necessarily matter. Instead, the validation of the architecture of the PSP is more crucial.

Some may also have concerns about the probability estimates of the panel of experts who constructed the Bayesian network modelling in subsections 4.4 and 4.5. These three experts are all policy analysts who are well associated with earthquake reconstructions by the government of Fukushima. They implemented the modelling in a double-blinded process to ensure the impartiality and fairness of the model. Thus, the authors trust their ability to render an informed and unbiased verdict of the modelling. They translated the causal relation diagrams and systems intervention points to the Bayesian network model, in representing the stakeholders of Fukushima.

Finally, one may wonder why causal loop diagrams and Bayesian network modelling was not applied to the first step of a workshop instead of brainstorming. The methodology of PSP places the radiation phase, which provokes brainstorming, in the first phase. Causal loop diagrams and Bayesian network modelling bring together and make manifest the many elements that emerge in earlier steps; therefore, they are unfit for the proposal phase of the workshop.

## 6 Conclusions

The PSP, a proposed systems-approach for a social-design method, proved its efficacy as a bottom-up public policy with the stakeholders of the community. It successfully demonstrated a systemic and systematic way for the community to make policy without the artificial interventions of professional policymakers. The case of the Fukushima workshop proved that the PSP worked in achieving accommodation among participants and thus guiding them to co-create community employment policies.

## 7 Further research agenda

The authors recognised two further research agendas for the PSP. One is to extend its scope to sectors other than public services. Certainly, many service industries may benefit from the participatory and collaborative social-design methodology. Another is to identify thresholds that enable the emergent properties of the social system to appear with the catalysing effects of the PSP platform. The ‘Ba’ (Nonaka and Konno, 1998), the conceptual platform for collaborative design, may have a critical role to play in this process.

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