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Knowledge Transfer in Science-Policy Process

-Case Study on Remote Sensing Technology in Disaster Management-

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***Abstract*— Environmental policies often strongly depend on environmental monitoring data, yet these increasing datasets are not always used effectively in enacting and implementing public policy. Because two different types of actors which are scientists and policy makers involved, we assumed that the knowledge transferring is one of the obstacles to make the science-policy process effectively. In the view of this, this paper addresses to clarify what are the obstacles to make the process difficult and factors to make it smooth. We discussed the roles of scientific information in terms of scientists' seeds and policy makers' needs. We used the process of applying Advanced Land Observing Satellite (ALOS) to disaster management in Japan as a successful case study on bringing the new scientific technology into damage control policy. As a result, it reveals that the scientific information gives big efforts not only to implement the policy but also to make policies. However, whether the information would transform into policy relevant knowledge or not depends on how policy makers perceive it. This transformation process can be expressed by a two-by-two matrix to show the relation between scientists' seed and policy makers' need. If policy makers think the information provided by scientists is useful, the information successfully transferred into policy-relevant scientific knowledge. If it is not, it causes the gaps: distance or direction.**

***Keywords*—knowledge transfer, science-policy process, remote sensing technology, disaster management**

I. INTRODUCTION

As policy quandaries, environmental problems are complex and difficult to deal with. They are complex because their casual chain has complicated interactions between biological, physical and social systems. They are difficult to deal with because their solution depends on the collaboration between scientists and policy makers. Implementing effective environmental policy requires not only the combined efforts of many disciplines to understand environmental problems, but also active interactions with stakeholders. To assist in this effort, interactive models of research are increasingly being adopted to understand complex environmental issues, their impact on human and natural systems, and the opportunities and constraints for policy making directed towards adaptation and mitigation [1]. Despite efforts to describe and characterize interactive research by many researchers, the existing literatures have to make more explicit, theoretically informed generalizations about the conditions under which interaction achieves greater or less success.

From agenda setting to implementation, environmental policies in areas as diverse as air quality, climate change, water quality and land use; all depend on environmental monitoring and research to set emission limits, establish safe levels of exposure, evaluate the fate of pollutants in the ecosystem, and many other decisions at the local, national and international level [2]. The data that support this process are often complex, ambiguous, dispersed across multiple monitoring networks maintained by different organizations, provided one by one in many narrow technical papers, developed with competing theories, and presented with jargon that is not clearly understood by policy makers. The culture of science that generates and analyzes the data is very different from the culture of politics that uses the resulting knowledge for decision making. Environmental problems like climate change or water quality are not scientific problems or political problems alone, but interdisciplinary problems that require a unified science-policy solution. This requires collaboration between scientists and policy makers working together by creating environmental knowledge that is useful for policies.

Figure 1 shows the science-policy process which defines the conditions that facilitate the use of scientific data for policy [3]. It begins with converting raw data from monitoring networks into information by scientists. They also interpret this information into scientific knowledge. Then, scientific knowledge is transformed (or translated) into policy-relevant scientific knowledge by the collaborative works with scientists and policy makers. As the knowledge is provided to policy makers, they use it as one factor among many others in their decision making. It is important to note that scientific data is only one source of information that is a strong science-based component. This science-policy process represents a path from scientific data to the policy knowledge in a form that increases the likelihood that it will be used appropriately.

In the view of knowledge transferring, this paper will focus on the step of the collaborative works which involved two different types of actors: scientists and policy makers. We address to find the factors to make the process difficult and smooth respectively.

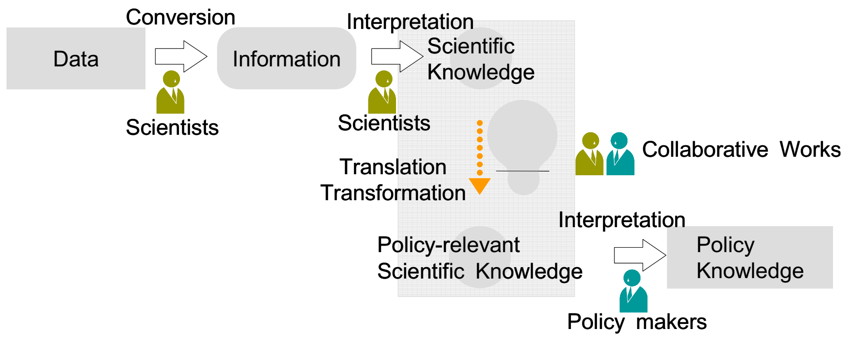

Figure 1. Process from data to policy makers' knowledge [3].

II. CASE STUSY: REMOTE SENSING TECHNOLOGY IN DISASTER MANAGEMENT

The Advanced Land Observing Satellite (ALOS) has been developed to contribute to the fields of mapping, precise regional land coverage observation, disaster monitoring, and resource surveying. It was launched in January 24, 2006 by Japan Aerospace Exploration Agency (JAXA). ALOS has three sensors: the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), which is comprised of three sets of optical systems to measure precise land elevation; the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), which observes what covers land surfaces; and the Phased Array type L-band Synthetic Aperture Radar (PALSAR), which enables day-and-night and all-weather land observation. ALOS's remote-sensing equipment enables precise land coverage observation and can collect enough data by itself for mapping on a scale of 25,000 to 1 without relying on points of reference on the ground. It is expected to play an important role in cartography by providing maps of Japan and other countries, including those in the Asia-Pacific region, which is one of ALOS's main objectives. Other objectives include regional observation for harmonization between the environment and development on Earth, domestic and overseas disaster monitoring and resource surveys. Its contributions to the mitigation of environmental destruction and natural disasters will make it an essential satellite for our future.

The main objective of ALOS was mapping, and these maps are useful in disaster management. Space programs have been drastically shifting recently from pure research and development to the real utilization of space. However JAXA is a space agency for R&D, which means that they are not experts in disaster management. So the Cabinet Office of the Government of Japan, and the Ministry of Education, Culture, Sports, Science and Technology established a committee to look at the potential of using satellites in disaster management. The committee brought together governmental bodies, institutions and experts to exchange opinions and explain their needs. It was discussed how to present satellite images in a way that would facilitate their work. It was the first challenge for JAXA to hear directly from specialists in this field. There were six meetings in total, from February to August 2006 [4]. And now, JAXA has working groups with members from the related ministries and institutions conducting demonstration tests in the different areas that were suggested in the committee. The first challenging area is the production of topographic satellite maps, and their implementation in disaster management. For example, JAXA are trying to use ALOS's images to create hazard maps, which illustrate the risks of damage from hypothetical disasters. By monitoring danger zones in advance, the government hope to be able to predict the best escape routes when a natural disaster strikes. Also, it's possible to make topographic satellite maps combining ALOS's images with digital maps published by the Geographical Survey Institute. To promote the use of these maps in early-response activities such as rescue crew dispatch just after disaster hits, JAXA asked the National Police Agency, the Fire and Disaster Management Agency, and the Ministry of Defense about their needs. In response, JAXA has made a 1/25,000-scale sample of a topographic satellite map of southern Tokyo. The map indicates emergency transportation routes in different colors, and notes key landmarks such as the locations of heliports. In addition, comparing pre- and post-disaster satellite images can help to find out such things as collapsed buildings or fires, and to assess damage much more easily. The sensor on ALOS is capable of 3D imaging. JAXA generate 3D images of the entire nation, which would be available to all ministries working on disaster management. JAXA are also conducting demonstration tests to detect such natural phenomena as volcanic eruptions, movements of the Earth's crust, maritime and coastal disasters, landslides, and floods, and to assess the damage they cause. It is also carried out joint demonstration to predict volcanic eruptions with many research institutions, including the Japan Meteorological Agency, the Geographical Survey Institute, and the National Research Institute for Earth Science and Disaster Prevention - all members of the Committee for the Prediction of Volcanic Eruptions.

In Japan, ALOS observed the area affected by the Noto Peninsula earthquake in March 2007, and confirmed upheaval in the region. ALOS is also providing the Japan Coast Guard with information about sea ice movement, and contributing to analysis of diastrophism in the vicinity of the island of Iwo Jima, which relates to the prediction of volcanic activity. Internationally, ALOS has conducted emergency observations for large-scale disasters, especially in Asia. These have included the landslide in Leyte, Philippines, in February 2006; the eruption of Mount Merapi in Java, Indonesia; an oil spill in the east of the Indian Ocean; flooding in Jakarta, Indonesia; an earthquake in the Solomon Islands; and sea ice in the northwest of Canada [5].

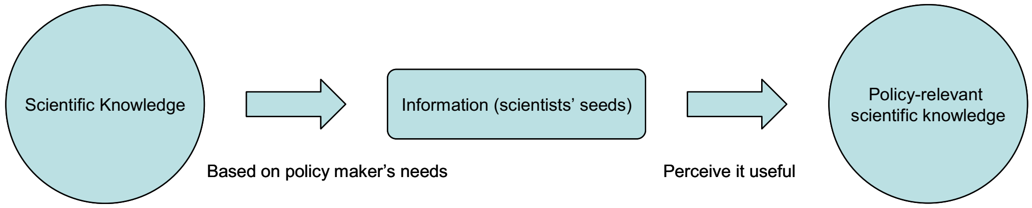

Figure 2. Basic concept model of knowledge transferring

ALOS's images also contribute to international cooperation in disaster management through its memberships in the International Charter "Space and Major Disasters" and the Sentinel Asia [6]. The International Charter primarily consists of space agencies around the world, with the aim of providing Earth observation satellite data when large-scale disasters strike. Sentinel Asia aims to share information on the Internet for disaster management in the Asia-Pacific region. Forest fires and floods are serious problems in Asian countries.

III. Mechanism of Knowledge Transferring

Based on the case study, it is necessary to have collaboration with end users and exchange ideas with them as to the best satellite applications to meet their needs. Figure 2 shows the basic concept model of knowledge transferring from scientific knowledge to policy-relevant scientific knowledge. Scientific knowledge changes the form to information based on policy makers' needs. This seeded information is transformed into policy-relevant scientific knowledge when policy makers perceive it useful. We use the terms "seed" and "need" to discuss the relationship between scientific results as scientific knowledge and their use as policy-relevant scientific knowledge for several reasons. First, the analogy is simple. Decisions about science (i.e., science policy decisions) determine the composition and size of research portfolios that "seed" scientific results. People in various institutional and social settings who look to scientific information as an input to their decisions constitute a "need" function for scientific results. Of course, the need function can be complicated by many factors, e.g., sometimes a policy maker may not be aware of the existence of useful information or may misuse, or be prevented from using, potentially useful information. Our key point is that there is reasonable conceptual clarity in distinguishing between processes concerned with the seeds of science, and those concerned with its use. In a second reason for characterizing scientific knowledge in terms of seeds and needs, science seeds and needs are closely interrelated. Science policy decisions are made with some consideration or promise of societal requests and priorities [7]. Thus there is a feedback between the needs of science and the characteristics of seeds.

IV. Relations between Seeds and Needs

We believe that policy makers can make decisions with better outcomes if they understand how seeded information relates to their needs. So we propose the matrix to show the relations between science seeds and policy makers' needs (see Fig.3). The matrix consists of a two-by-two grid, with one axis representing science seeds and the other representing policy makers' needs. The horizontal-axis of the grid, or the needs side, poses the question, "Are policy makers satisfied with information?" The vertical-axis asks, "Does the information match with the policy makers' needs?"

The matrix's top-left quadrant represent the case in which the science seeds match with policy makers' needs, that is, policy makers have access to the information they need from the science side. In this case, the information is successfully transformed to policy-relevant scientific knowledge which can be used for making decisions. On the bottom-left, despite the case in which information does not match with policy makers' need, the information is transformed to knowledge. The information is not directly related to policy makers' need however it helps policy makers to understand scientists' perspectives and their information. Therefore, the information can be used to support policy making as policy makers' knowledge. In those two left-sided cases, the information changes the form to policy makers' knowledge. On the other hand, the right-sided cases emerge the gap between scientists and policy makers. The top-right case indicates that policy makers are not satisfied with the information, even as it matches with policy makers' needs. It means that the information is not enough to make policy makers understood. This situation is called "distance-gap" explained in [3]. It is emerged when there is an inability of some policy makers to make use of highly technical advice, lack of public confidence in scientific information, the difficulty of obtaining high-quality science at short notice and a lack of universal support for scientific input into policy making due to both contradictory science and a lack of certainty surrounding the available results. The bottom-right case, which scientists' seeds do not match with policy makers' needs, emerges the "direction-gap" also defined in [3].

As a concrete example, we adapted the case of applying remote sensing technology in disaster management into a two-by-two matrix (see Fig.4).

For damage detection and disaster real-time monitoring, a very important aspect of remote sensing is the production of data so that operations people can quickly and directly use it. An operational space-borne system for risk assessment, should guarantee the following aspects [8]: (1) the re-visit-time (the maximum period between two consecutive acquisitions on a given site) should be compatible with the delay allowed for product generation in the case of an emergency, (2) the resolution and the coverage of images should be appropriate for the required application.

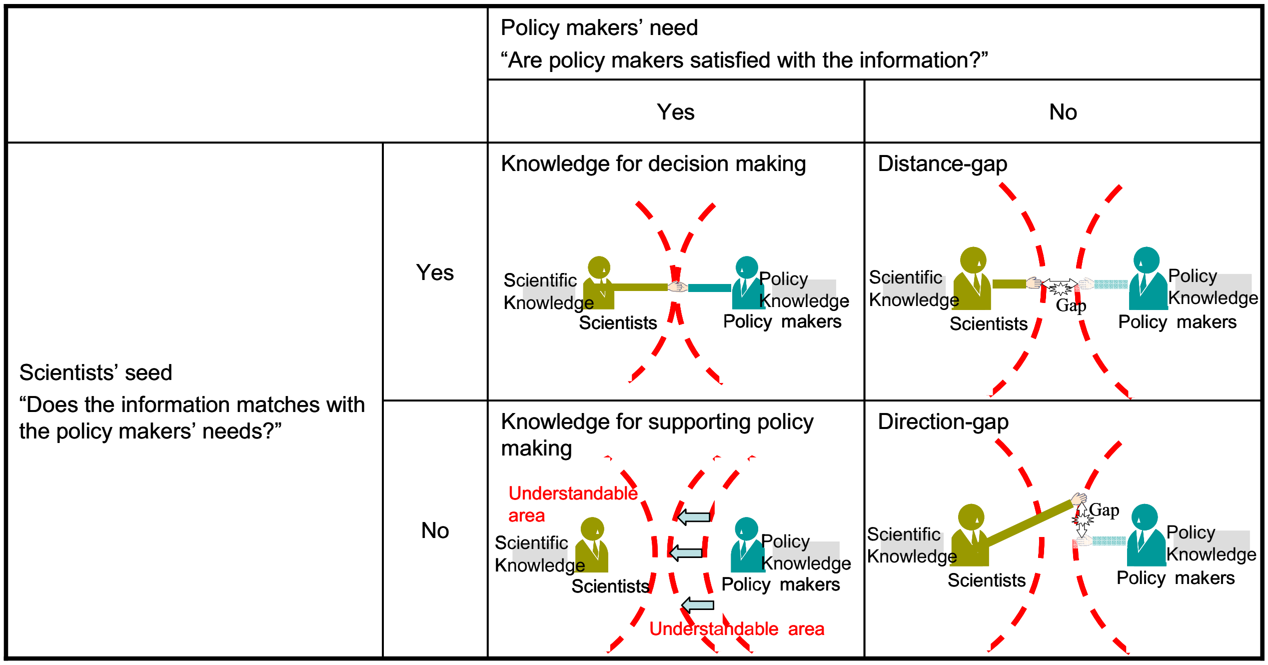

Figure 3. Two-two matrix showing the relation between scientists' seeds and policy makers' needs

		Policy makers' need "Are policy makers satisfied with the information?"	
		Yes	No
Scientists' seed "Does the information matches with the policy makers' needs?"	Yes	**Information to bridging the direction-gap** •Relative advantage: remote sensing can monitor a wide area at once and acquire up-to-date information •Compatibility: fits easily into existing practice •Complexity: some aspects of remote sensing are technologically difficult •Trialability: there are some projects already started, and the demonstration tests are conducted •Observability: easy to see	**Factors in distance-gap** •Presenting with jargon •Different behavior and attributes between scientists and policy makers •Different appreciation of scientific uncertainty
	No	**Information to bridge the distance-gap** •Possible resolution and re-visit time by sensor types	**Factors in direction-gap** •Unclear request from policy makers •Unfocused scientific information

Figure 4. Effective information for knowledge transferring and factors in gaps in the case of applying remote sensing techology into disaster management

V. INFORMATION TO BRIDGE THE DISTANCE-GAP

One of the biggest aspects to make a gap is scientific uncertainty. As the uncertain information varies by users, the responsibility to provide this information also lies on different actors. The concept of uncertainty in providing information on environmental issues is closely linked to the concept of data and model quality. The appreciation of data quality on its turn is dependent on the final application and use of the data. The independent use is relevant for any analysis of this concept with respect to environmental data and models.

Common grounds of data between scientists and policy makers provide a structure to request and receive relevant, timely data from a trusted source. It provides the policy maker sufficient information to make comparisons and small changes, using the scientists as a means to process large amounts of data. The common grounds of data improve the scientific capability to study the environment and human impact.

Figure 5 shows the "distance-gap" as the difference in levels of confidence for a given scientific finding expressed by the scientists and policy makers. This relationship is portrayed as linear for the scientific community where the confidence level tracks the rate of confirmation. In contrast, the degree and rate at which social confidence and consensus develops for a given scientific finding may lag behind that of the scientists due to a complex of social factors. In reality, the shape of this function will vary with individual scientific findings. The level of confidence by the scientists increases with the level of scientific confirmation. As evidence accumulates to support the underlying hypotheses, confidence in its representations increases. In time, a model achieves greater standing as inferences concerning its representations are disseminated and de-bated in scientific literature and other forums. At some threshold of accord with the scientists, consensus emerges. However, the emergence of the so-called scientific consensus does not necessarily guarantee the level of certainty demanded by most policy makers [9]. In the case of large-scale simulation models, constants and parameters contain assumptions and uncertainties that propagate in uncertain ways to produce un-certain output. Such uncertainty is usual for scientists, but it may not for policy makers.

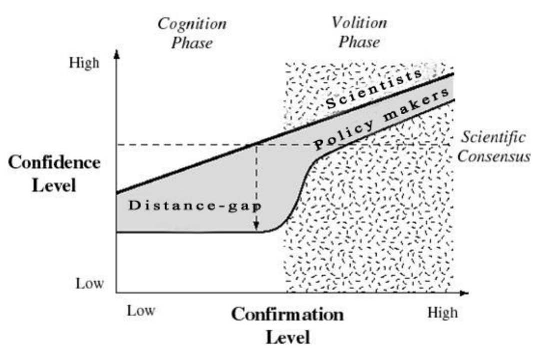

Figure 5. Example of Distance- gap defined as the difference in levels of confidence for a given scientific finding expressed by the scientists and policy makers (adapted from [7]).

Although scientists are familiar with uncertainty and complexity, policy makers often seek certainty and deterministic results. There are two general approaches for bridging this distance-gap. These are: (1) increasing the rate of scientific confirmation; (2) providing information to help policy makers understand risk and uncertainty as scientists do. The information in the second approach will be categorized in bottom-left case shown in Fig.3.

In the case shown in Fig. 5, the information to bridge the gap is possible resolution and re-visit-time by sensor types.

VI. INFORMATION TO BRIDGE THE DIRECTION-GAP

To bridge direction-gap, we clarify what policy makers need from scientists. We consider the case to transfer new technology in the policy.

The scientific and social issues represent a set of conflicting risks and uncertainties that have not been addressed by conventional analytical approaches. Managers involved in these issues require new approaches that can integrate existing models of planning, analysis, decision making. This need arises at a time when there is a growth of new technologies to support the practices of risk management, risk assessment, and decision analysis. Yet given the availability and appropriateness of these technologies, there are many barriers to their adoption within risk management organizations. Decisions about adopting unfamiliar technologies are themselves complex risk management decisions that warrant a high level of procedural rationality, particularly in designing and evaluating trial applications. Successful applications are developed through a process of technology and knowledge transfer. Successful technology transfer often requires two complementary actions [10]: (1) the introduction of a new technology can be defined, and (2) the transfer of understanding or knowledge about the technology and its application. Both aspects of technology transfer are necessary.

Rogers [11] described fundamental barriers to the "diffusion of innovations" across a diverse set of governments, societies, and organizations. He listed five perceived attributes of innovations that dictate how they are received:

- Relative advantage: How much better is the innovation than that which it supersedes?
- Compatibility: How consistent is the innovation with the existing values, past experiences, and needs of potential adopters?
- Complexity: How difficult is the innovation to understand and use?
- Trialability: How easily can the innovation be experimented with on a limited basis?
- Observability: How visible are the advantage of the innovation to potential users elsewhere in the organization?

We believe that these attributes can be the formats to cover policy makers' needs, and the information is categorized in the top-left case shown in Fig. 3.

As a concrete example, we simply answer the above five attributes in the field of remote sensing technology based on [3] (see Fig.5).

Relative advantage is the extent to which the innovation is perceived to be better than the current practice. The perceived positives must outweigh the negatives. Policy makers must be convinced that remote sensing can monitor a wide area at once and acquire up-to-date information, and these in turn can lead to better, more informed decision making. These put the responsibility on developing remote sensing applications to educate policy makers about what remote sensing has to offer so that they will consider its application as an additional source of information to meet existing requirements. Remote sensing should be viewed as a supplement to or enhancement of existing information, not as a replacement. Even without improvements in decision making, remote sensing may be a more cost effective approach to assessment in some instances. For small-scale projects, remote sensing may be too costly at this time, but for large-scale projects, remote sensing techniques can offer significant cost savings compared to conventional on-site measurements.

Compatibility is the degree to which the innovation is perceived to be consistent with current values, past experiences, and priority of needs. Remote sensing should be perceived as very compatible with existing practices. Remote sensing is just another source of geospatial information used for environmental assessment upon which informed decisions are made.

Complexity is the degree to which the innovation is perceived to be difficult to understand or use. As is the case with any technical disciplines, there are associated vocabularies that are unfamiliar to the policy makers. Those in the remote sensing field need to be conscientious about using terminology that is unfamiliar to policy makers from other backgrounds so as not to give the false impression that remote sensing has difficulties for technical challenge. It should be agreed that some aspects of remote sensing are technologically difficult; a distinction should be made between the development of remote sensing application products and the interpretation of these products for policy purposes. Developing extraction techniques and application products is technologically demanding requiring a trained image analyst, but less skill and training are required to interpret these products in the context of policy.

Trialability is the extent to which an organization can try out one idea on a limited basis with the option of returning to previous practices. Because remote sensing requires a certain level of expertise and specialized computer software, trialability has been started in some organizations [8]. In this case study, the teams consist of scientists and policy makers to conduct demonstration projects, and it allows teams an opportunity to learn more about remote sensing and gain greater familiarity with how it may impact traditional workflows.

Observability is the extent to which the results of an innovation are visible to others. An innovation with highly visible, beneficial results is more rapidly diffused. There are many web sites to distribute information and educational materials and communicate results of various projects (ex. [13]). Some organizations are also involved in communicating organizational activities at professional workshops and conferences and some of this information is presented in professional journals.

VII. Conclusion

The scientific information gives big efforts to the process of policy making. However, it is not smooth to implement the scientific knowledge into policy. In this paper, we focused on clarifying the factors to make the knowledge transfer difficult and smooth between scientists and policy makers in the science-policy process. We discussed the roles of scientific information in terms of scientists' seeds and policy makers' needs based on the process of applying ALOS to disaster management. When scientists change the form of scientific knowledge to information, this information will be the "seed" and should be made useful for policy makers. However, whether the information would transform into policy relevant knowledge or not depends on how policy makers perceive it. This transformation process can be expressed by a two-by-two matrix to show the relation between scientists' seed and policy makers' need. If policy makers think the information provided by scientists is useful (have benefit), the information successfully transferred into policy relevant scientific knowledge. If it is not, it reveals the gap with causes: distance or direction.

References

[1] M. C. Lemos, B. J. Morehouse, “The co-production of science and policy in integrated climate assessments,” Global Environmental Change, vol. 15, pp.57-68, 2005.

[2] J. A. Engel-Cox, R. M. Hoff, “Science-policy data compact: use of environmental monitoring data for air quality policy,” Environmental Science & Policy, vol. 8 (2), pp. 115-131, 2005.

[3] M. Miyashita, Y. Nakamori, “Knowledge Management in Science-Policy Process,” Proc. of the 7th International Symposium on Knowledge and Systems Sciences, pp. 265-270, 2006.

[4] MEXT, “Meeting Report of Satelite Utilization for Disaster Management,” unpublished.

[5] JAXA, “Report of ALOS Achievement,” unpublished

[6] http://dmss.tksc.jaxa.jp/sentinel/

[7] D. Dalrymple, “Setting the agenda for science and technology in the public sector: the case of international agricultural research,” Sci. Public Policy, vol. 33 (4), pp. 277–290, 2006.

[8] F. Sarti, J. Inglada, R. Landry and T. Pultz, ”Risk management using Remote Sensing data: moving from scientific to operational applications,” The tenth of Brazilian Simposium of Remote Sensing, 2001.

[9] M. Pulles and D. Heslinga, “On the variability of Air Pollutant Emissions from Gas Fired Industrial Combustion Plants”, TNO/MEP, Netherlands, 2003.

[10] M. Miyashita, M. Makowski, and Y. Nakamori, “Applicability of Satellite-Derived Data to Oil Spill Assessment”. The 5th International Symposium on Knowledge and Systems Sciences, (KSS2004), pp. 258-262, 2004.

[11] E. Rogers, Diffusion of Innovations Free Press, New York, 2003.

[12] R. Perry, S. Britsch and J. Zainal, Development Plan Marine & Coastal Environmental Database for Bahrain, Environmental Research and Wildlife Development Agency, 2001

[13] http://oceancolor.gsfc.nasa.gov/SeaWiFS/