Invited paper

THE IMPROVEMENTS NEEDED FOR ENVIRONMENTAL INFORMATION IN JAPAN

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Received Date: March 23, 2011

Abstract

Environmental information is vital for effective and sound decision-making process. However the collection of environmental information and its conversion into a usable form is not free of charge and often requires some time to become available, since various types of information need to be integrated due to the fundamental interdisciplinary nature of the environment and our society. Ultimately, environmental information is meaningless if it is not used; the collection and generation of environmental information should not be merely a goal; rather, it is the means for better decision-making. Japan has developed and advanced an environmental information system and has probably entered into the next stage where we need to re-align and re-design the manner of collecting, managing, and using the information under various constraints (especially financial constraints).

Keywords: Environmental information, Financial pressure, Multidisciplinarity, Outsource, Reliability

Introduction

Hamanaka (1986) argued that environmental administration should be based on scientific information. The Asian Development Bank (1999) has also pointed out that “authentic statistical data relating to existing environmental conditions are vital in making appropriate decisions on environmental planning and management.” As these arguments indicate, environmental information is of central importance for many governments and international organizations needing to tackle various complicated environmental issues in a reasonably sound and accountable manner.

In contrast to the clear importance of environmental information, how environmental information should be collected, managed, and used is not so clear. This challenge is further complicated by the multidisciplinary nature of environmental information, which necessarily covers a wide range of fields dealing with environmental issues, such as rapid urbanization due to migration from rural areas to urban areas, air pollution because of traffic jams, water quality degradation because of unregulated industrial discharge, the rapidly increasing generation of municipal solid waste and its management, and climate change due to the massive increase of green-house gas emissions (i.e. unsustainable production and consumption).

While the challenge can be understood as being reasonably managed in developed countries, such as Japan, it is not well known how environmental information is actually maintained and used. In particular, an interesting research question is whether the currently provided environmental information is consistent with the actual needs of the users of the information.

The objectives of this article are threefold. First, we would like to show the results of a survey on how environmental information users actually perceive the information in terms of both importance and priority. Second, we present the results of a survey on the current state of the Japanese continuous air quality monitoring system as an example of an environmental information system. Third, we present the output of another survey about the state of the monitoring system for hazardous air pollutant substances to provide a supplemental understanding of the properties of the air quality monitoring system. The organization of this article is consistent with these stated objectives and is completed with an overall conclusion, as well as some recommendations to the governments of developing countries for the improved collection and management of environmental information.

Importance and Priorities of Environmental Information for Users

Environmental Information Strategy

In March 2009, the Ministry of the Environment, Japan, announced a brief policy document titled “Environmental Information Strategy" (hereinafter referred to as the EI-Strategy) with the aim of realizing an environmental administration based on environmental information and of providing information in response to the needs of users, as well as promoting the implementation of measures.

The EI-strategy has identified several issues that should be improved to realize a sustainable society that shares and uses environmental information properly. Those issues include (1) fragmented information and data collection systems in various organizations, such as the central government and local municipalities; (2) an inadequate amount of environmental information that explains the relationship between the environment and socio-economic activities; (3) an inadequate accumulation and maintenance of time-series data describing changes in the state of the environment, (4) limited use of information and communication technologies, and (5) lack of reliability in environmental information.

In Japan, a number of environmental information sources are present, such as “Environmental Statistics,” which is published by the Ministry of the Environment. However, as the EI-strategy pointed out, the conventional methods for collecting, utilizing, and disclosing environmental information do not necessarily consider the needs of users, and the current EI may not be responding well to user needs, so that the value of EI cannot be fully realized. In general, information is meaningless if it is not used.

Therefore, the purpose of this section of the article is to clarify the priorities or “needs” of the users of environmental information and to identify how priorities differ depending on the attributes of the users. To this end, a questionnaire survey was conducted. The summary of the survey is described in Table 1.

To analyze the collected data from the survey, we adopted the Analytic Hierarchy Process (AHP). AHP was developed by Thomas Saaty in the 1970s and is often applied to gain insights into issues in which the decision-making process involves multiple selections (alternatives) and judgment criteria. In the AHP framework, those issues with a complex decision-making process are considered to have a hierarchical structure, comprising purpose, evaluation criteria, an alternatives, in order to conduct a comparative assessment of alternatives through a paired comparison of evaluation criteria.

Table 1. Summary of the Questionnaire Survey

Survey Period, Method, and Subjects	➢ July 13 to August 15, 2009 ➢ Web survey conducted on the internet ➢ An electronic message was sent to the potential respondents ➢ Those who were assumed to use environmental information often were identified and were found to comprise municipal government staff at environmental divisions, researchers working on the environment, and consultants working on environment issues
Number of Respondents	80 individuals (number of effective respondents: 78) ➢ Municipal government personnel (mainly 41 "core"cities): 34 people (14 individuals, 41%)* ➢ Research institute personnel: 28 individuals (13, 46%)* ➢ Environmental consultants: 13 individuals (9, 69%)* ➢ Others: 3 individuals (1, 33%)*

(* Number of respondents and the percentage of respondents among the total number of people with the same attributes. The percentage is termed the consistency index (C.I.))

The questionnaire survey requested the respondents to select two out of the seven requirements that could be important as attributes of environmental information. Based on an extensive review and the EI-strategy, we prepared the following seven requirements that environmental information should embody: (1) convenience, (2) reliability, (3) comparability, (4) immediacy of reporting, (5) comprehensiveness, (6) ease of processing, and (7) provision of information in English. Based on the selection of two requirements, 21 combinations were possible for the paired comparisons. A set of questions regarding organizational affiliations, gender, age, fields of interest, and aspects of the information was also established in order to analyze the evaluation trends of the respondents with varying attributes. Although numerous fields were included in the environmental information, this study focused on three fields: material recycling (waste-material related), global warming, and policy-related fields.

As in a typical AHP procedure, paired comparison tables were created based on the results obtained from the questionnaire survey, and the eigen value method was adopted for setting the weight (priorities) and calculating the evaluation values. The consistency index (C.I.) is a measure of consistency for the multiple paired comparisons provided by the respondents, with the C.I. value decreasing as the paired comparison table becomes more consistent. A value of 0.1 to 0.2 or lower is generally considered to be consistent (Mori and Matsui, 2004).

Analysis Results

The analysis of the survey revealed that "reliability" was weighted with the highest values, irrespective of the respondents' affiliation and was the most emphasized among the seven requirements (Table 2). This result is consistent with the findings of the Asian Development Bank (2002). In terms of the weight for the "immediacy of reporting," differences were observed among the three groups of respondents' representing different affiliations. The respondents belonging to administrative organizations valued this component the most among the three groups, revealing that this group is in need of the latest information. Respondents from the research and educational institutions, however, did not emphasize "immediacy of reporting" (rated least of the seven requirements). Instead, this group emphasized "comprehensiveness" after "reliability," which potentially revealed the characteristics of researchers and educators, who are attempting to capture the subject matter in an objective manner. “Convenience” and “ease of processing” were weighed relatively higher with environmental consultants. This preference may reflect their position of performing business tasks that entail the relatively frequent use and processing of environmental information.

Next, the focus was placed on the three above-mentioned environmental fields (i.e., material recycling and waste materials, global warming, and policies). The results confirmed that “reliability” was the most emphasized among the requirements and that its ranking as the highest priority was shared in common by the respondents of the respective fields (Table 3.) The weights of “convenience” and the “immediacy of reporting” were more important for respondents in material recycling than those in the policy fields, whereas “comprehensiveness” was considered to have less weight for respondents of the policy fields. The background to this preference is that an abundant amount of information is already present in the material recycling (waste materials) and global warming fields, so that the need to make this information easier to use and more quickly updated has a higher priority. On the other hand, in the policy fields, the policies are formulated with a consideration for the information obtained from other fields; thus, information with a broader scope is considered necessary.

Furthermore, respondents who declared that they are affiliated with the global warming field evaluated “comparability” as the second most important of the seven requirements. This ranking is believed to be a result of the need for both international and regional comparisons, which are essential when dealing with global warming issues. The “provision of information in English” was given the least amount of weight among the seven factors for those affiliated with this field.

Table 2. Evaluation of Weights for the Different Affiliated Organizations of the Respondents

	Administrative Organizations (sampling count: 34)		**Research and Educational Institutions (sampling count: 28)**		**Environmental Consultants (sampling count: 13)**	
Requirement	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
Convenience	0.094	0.071	0.097	0.077	②0.171	0.095
Reliability	①0.398	0.114	①0.364	0.138	①0.333	0.130
Comparability	③0.119	0.063	③0.114	0.063	0.130	0.055
Immediacy of reporting	②0.164	0.071	0.098	0.063	③0.132	0.071
Provision of information in English	0.044	0.032	0.087	0.071	0.034	0.000
C.I.	0.252	0.126	0.246	0.148	0.210	0.155

(Note: ①, ②, and ③ represent the ranking order of weights in the vertically segmented groups in both Tables 2 and 3. The standard deviation is abbreviated as “s.d.” in both Tables 2 and 3.)

Table 3: Evaluation of Weights for the Different Environmental Fields of the Respondents

	Material Recycling (sampling count: 21)		Global Warming (sampling count: 18)		Policies (sampling count: 8)	
Requirement	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
Convenience	③0.124					
Reliability	①0.370	0.126	①0.378	0.130	①0.370	0.110
Comparability	0.104	0.045	②0.122	0.071	③0.149	0.110
Immediacy of reporting	②0.156	0.084	③0.121	0.055	0.116	0.071
Comprehensiveness	0.105	0.071	0.107	0.045	②0.163	0.095
Ease of processing	0.086	0.063	0.099	0.105	0.065	0.032
Provision of information in English	0.056	0.055	0.057	0.063	0.069	0.071
C.I.	0.268	0.155	0.23	0.118	0.266	0.134

Conclusion of the Section

Irrespective of the respondant attributes, the importance of "reliability" was found to be the highest among the seven requirements. Furthermore, even though "immediacy of reporting" was rated the third highest by the administration-related personnel, the research and education personnel placed the least emphasis on this requirement. In terms of the overall trend in the responses, no clear similarity was observed in the response patterns based on the affiliated organizations of the respondents. However, the response patterns based on related environmental fields revealed that the patterns for weighting were similar between the respondents related to the material recycling field and the global warming fields. In contrast, no clear similarity was evident between the pattern of these two groups and that of the respondents related to the administrative field, with the exception of "reliability."

Finally, the limitations of the analysis in this section need to be mentioned. The questionnaire survey was conducted on a website, and the respondents did not necessarily represent an adequate sample of the population. The authors attempted to investigate the initial baseline data for this section of the article by asking prominent respondents in each field. Hence, some caution should be applied in the interpretation of the results of this analysis.

The Actual Conditions of the Operation of the Continuous Atmospheric Observation System by Local Governments in Japan

The Continuous Atmospheric Observation System Is One of the Most Rapid Systems in Japan Providing Environmental Information

In this section, we focus on the Japaneses continuous atmospheric observation system. Because of its development and growth, the air quality monitoring system is likely one of the most well-organized environmental information systems in Japan. In particular, we would like to focus on the actual immediacy of the reporting of the atmospheric observation data; within an hour, the system allows one to check the preliminary data on a website. This property is one of the most crucial characteristics for better and effective environmental administration; any delay in the identification of serious health issues caused by particular chemicals are one such example.

In the past, the emphasis on information obtained through continuous atmospheric observation was based on its importance in determining the advisability of emergency strategies or environmental standards; however, a number of substances (e.g., pollutants) are satisfying environmental standards at the present time (Table 4). Therefore, the emphasis is shifting to the evaluation of environmental effects, as well as the preparation of basic data for the formulation of environmental plans. However, it remains unclear how the local government personnel, who are in charge of observing and monitoring the data-usage conditions, view the problems in the current data-acquisition framework for the continuous atmospheric observation system or the issues surrounding it. In particular, to what extent is the immediacy of reporting, which can be one of the most significant benefits of continuous monitoring, considered important by local government personnel? Furthermore, the relocation of atmospheric pollutants from the Chinese continent is also becoming a topic of interest, with the needs for constant atmospheric monitoring changing in recent years.

The purpose of this section is to clarify the actual conditions and issues relating to the collection of data from continuous atmospheric observation by local governments. For this reason, a survey was conducted with local government personnel. Afterwards, a regression analysis was conducted based on survey findings, as well an as investigation into the number of stations not achieving an effective measuring time.

Table 4: Compliance Status for the Tokyo Metropolis Environmental Standard for FY2007 (Short-term Evaluation)

Item	Type of station	SPM	Ox	SO_2	CO
# of compliant stations /# of effective stations (compliance rate (%))	General	35/46 (75)	0/40 (0)	20/20 (100)	11/11 (100)
	Motor vehicle exhaust monitoring stations	10/34 (29)	0/0 (-)	5/5 (100)	17/17 (100)

Note: SPM: suspended particulate matter, Ox: photochemical oxidant, SO_2: sulfur dioxide, CO: carbon monoxide

Questionnaire Survey

We conducted a questionnaire survey intended for a total of 132 local governments and central government agencies in Japan performing monitoring work in order to gain an understanding of the current status of continuous atmospheric observations by local governments. The collection rate of the questionnaire was 106/132 (80.3%).

A five-level evaluation, from the perspective of the data provider, was requested on the relative importance of preliminary values and the screened (final) values (Figure 1), as well as the current status on the use of the data with regards to the respective measured items (Figure 2). The degree of importance for rapidly available values was particularly high for photochemical oxidant (O_x), which was likely due to the health hazard it represents.

The proportion of local government personnel who felt that continuously measured data were “being used” (considered to be the sum of the ratios for selections 4 and 5) appeared to show a significant difference in the distribution between the measured items. O_x and suspended particulate matter (SPM) are characteristic items, and the above-mentioned proportions represented more than 50% of the total response, so that these two items were relatively high in comparison with the other items. The use of O_x levels in the judgment criteria for issuing a photochemical smog alarm likely explains the high level of awareness on the O_x data. In terms of carbon monoxide (CO), the proportion of respondents who were “using” the data was about 10%, which was extremely low in comparison with other items.

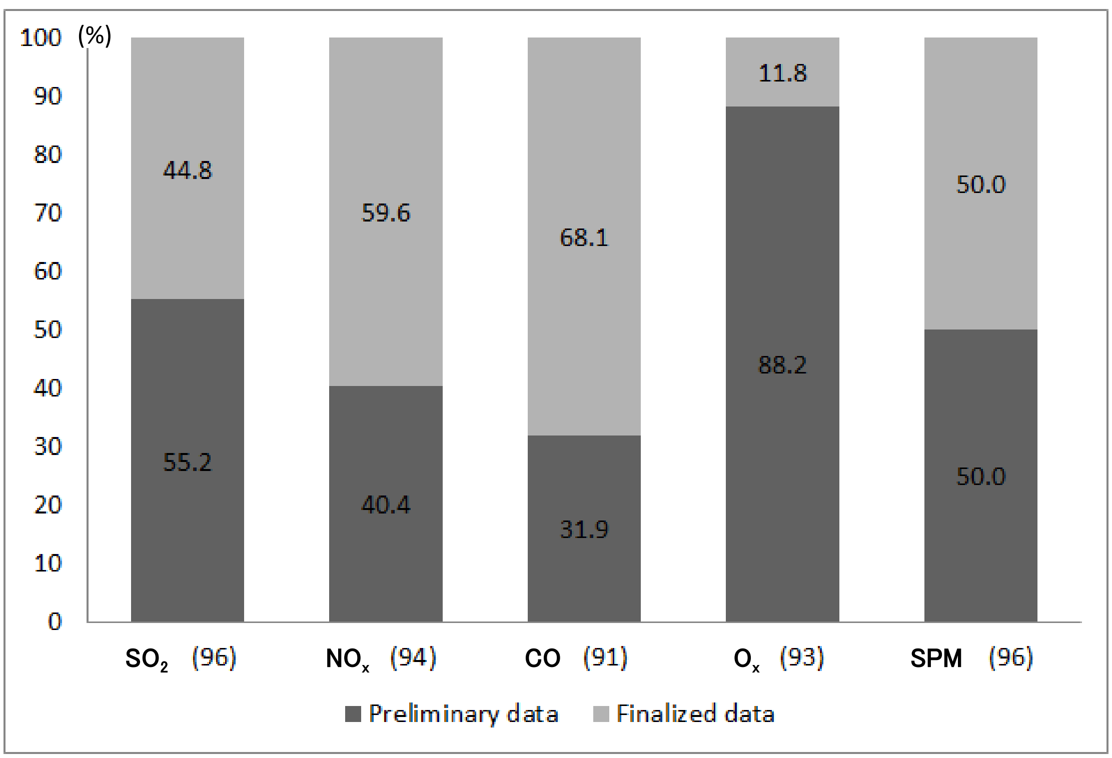

Figure 1. Relative importance of the preliminary and finalized values (%)

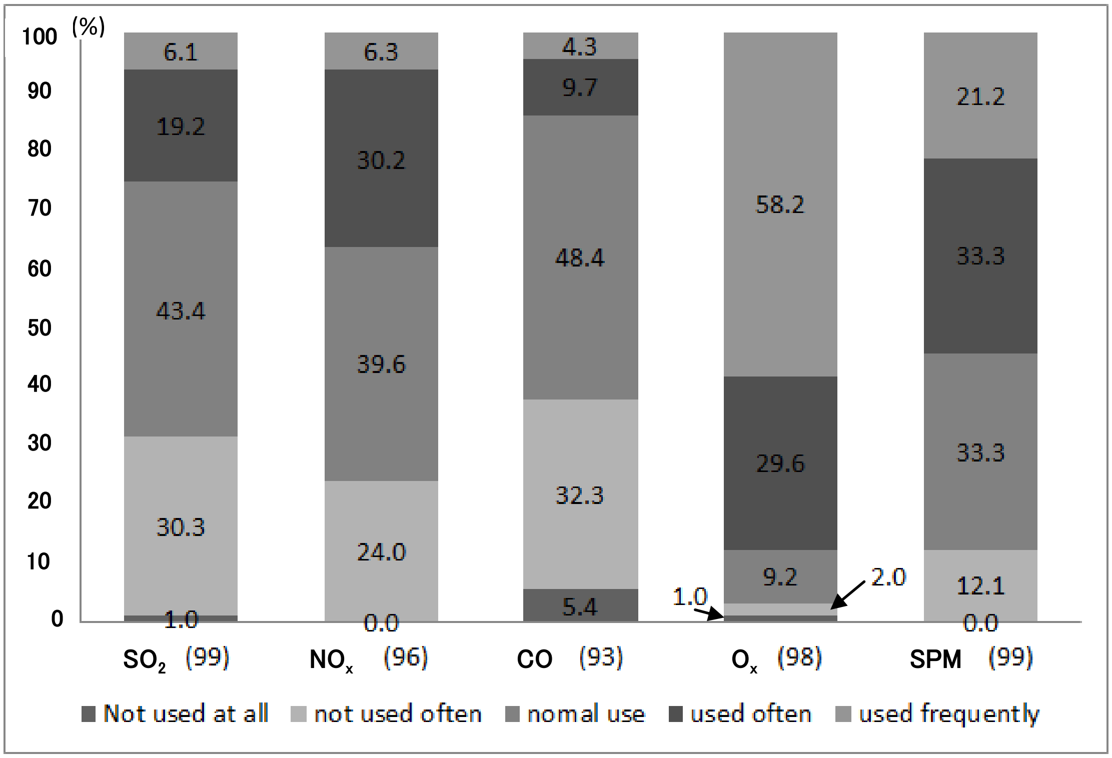

Figure 2. Status evaluation of data usage (%)

Number of Measuring Stations and Total Expenditure

Two simple regression analyses were conducted based on the findings of the questionnaire survey. Since high correlations were observed between the respective descriptive variables and the measurement issues[1], a simple regression analysis was conducted with the aim of gaining baseline information, with the total administrative cost related to the continuous atmospheric observations (JPY) used as the dependent variable and the total number of measuring stations (stations) or measurement apparatuses (units) used as the explanatory variables. Typical conditions were assumed for the error terms.

The results of the regression analysis are shown in Table 5. With regard to the coefficient value for ① in Table 5, the total administrative expense could increase by 3.03 million yen per year with each addition of a monitoring station. Another regression analysis implies that the total administrative expense could increase by 434,000 yen per year for each measuring apparatus in ② of Table 5.

[1] Although conducting a more detailed analysis (for example, the combination of a principal component analysis and a regression analysis to tackle multicollinearity) is desirable, obtaining "actual" financial and assigned personnel information in terms of measurements is difficult. For instance, a single municipal officer seldom performs a single duty; rather he/she often performs various duties, implying that counting the assigned staff number for air quality monitoring is quite challenging. Measurement of the institutional arrangement in the environmental information system remains an important research topic.

Table 5: Regression Analysis Results

	①Number of Monitoring Stations	②Total Number of Measuring Apparatuses
Coefficent (JPY/station or unit)	3.03×10^{6}	4.34×10^{5}
P-value	7.41×10^{-20}	4.48×10^{-25}
Adjusted R^2	6.09×10^{-1}	7.02×10^{-1}

Effective Measuring Time

Value data for continuous atmospheric observations are sometimes missing because of an abnormal peaking triggered by unexpected causes (example: road construction work) or periodic maintenance work on the measuring station, etc. An effective measurement time of 6,000–8,760 hours per year has been stipulated. If the values supplied from the measuring stations have not achieved those number of hours, the values are considered invalid. The number of measuring stations that did not reach the effective measuring time was analyzed based on the measurement data for 15 measurement items (a total of 308,790,000 hours) for FY2003 to FY2007. The measurement data were taken from 470 measuring stations in seven prefectures and 19 cities (a total of 26 municipalities) conducting continuous atmospheric observations and were based on raw data (in text format) supplied to us from these individual local governments via the National Institute for Environmental Studies (NIES), Japan.

Some variance occurred from year to year; however, the overall number of measuring stations that failed to reach an effective measuring time was quite small (see Table 6). On the other hand, there was a tendency for other measurement items, such as sulfur oxides, nitrogen oxides, hydrocarbons, SPM, wind force, wind speed, and other similar items not described in Table 6 to be simultaneously unattained. Furthermore, localized characteristics were observed, including a number of stations at a particular municipality not achieving the required time with regard to hydrocarbons. Such localized characteristics will require more detailed investigations in the future.

Table 6: Number of Measuring Stations that Did Not Reach the Effective Measuring Time

Items	No. of Stations	Fiscal Year				
		2003	2004	2005	2006	2007
SO_2	272	0	0	6	0	0
NO_x	419	1	0	2	1	0
CO	117	1	1	2	0	0
O_x	295	0	0	0	0	1
CH_4	178	3	2	4	3	1
SPM	455	1	0	2	0	1

Conclusion of the Section

The results of the second questionnaire survey conducted with local government personnel confirmed that the reporting of O_x was a high priority and that the immediacy of reporting for O_x served a number of uses (see Figure 1), which is a benefit of continuous measurements. The need for the immediacy of reporting the observation data on other substances, however, is somewhat limited, presumably due to the fact that the concentrations of those substances are already below the environmental standards. The observation data for these "good" substances are actually not well used, as shown in Figure 2. The authors are concerned that the collection of the observation data for those "good" substances may have fallen into simple routine work, without a consideration of how the data should be used for better decision-making in environmental administration while the accumulation of the monitoring data of these good substances is quite crucial and meaningful for various scientific researches.

Analysis of the Current Situation for the Monitoring of Hazardous Air Pollutants by Local Governments in Japan

Hazardous Air Pollutants as Emerging Concerns

Since the 1960s, the air quality monitoring in Japan has targeted air pollutants such as NO_x, SO_x, CO, O_x, and SPM. In the last 15 years, however, the importance of monitoring hazardous air pollutants (collectively called HAPs in this article), such as tetrachloroethylene and benzene, are becoming increasingly significant, partly because more knowledge is being acquired about the health risks associated with these HAPs.

Although HAPs monitoring is conducted in a manner in which 24-hour data can be obtained more than once per month, the amount of data on HAPs is far less than that of the first group of pollutants, implying the existence of uncertainty on HAPs monitoring data (Kawasaki-city, 2009.) Of note, many local governments, including operators of HAPs monitoring, are also now facing serious financial pressure (Yoshinari, 2008).

An objective of this section is to analyze the current situation for HAPs monitoring by local governments. In particular, this section focuses on the current situation of operating systems that are primarily managed by in-house staff and contract provider (i.e., outsource) and analyzes their characteristics based on local characteristics and HAPs monitoring costs.

Data and Analysis

For analyzing the current situation for HAPs monitoring by local governments, the necessary data were collected, as shown in Table 7.

Table 7. Data Sources for the Data Analysis

Category	Details and Sources
General information on HAPs monitoring	Interview survey of experts in the field of air quality monitoring
Current operational practices and issues	Questionnaire survey of local governments performing HAPs monitoring (127 questionnaires were sent and 103 were collected.)
Statistical data on the scale of HAPs monitoring	HAPs monitoring data (April 2008~March 2009) obtained from NIES (National Institute for Environmental Studies, Japan)
Statistical data on the characteristic of local governments	Fiscal conditions, population, personnel salaries

First, the local governments were classified into groups based on the monitoring practices. To this end, correspondence analysis and cluster analysis were adopted and then the characteristics of HAPs monitoring were examined by logit model based on the results of the classification. A multiple regression analysis was then conducted to estimate the total costs of HAPs monitoring.

Results

Based on the information obtained from the survey, the local governments in charge of HAPs monitoring can be qualitatively categorized into four groups: (i) the In-House group, (ii) the Outsource group, (iii) the Process-Demarcation group, and (iv) the Combination group. Each box in Figure 3 refers to processes in HAPs monitoring.

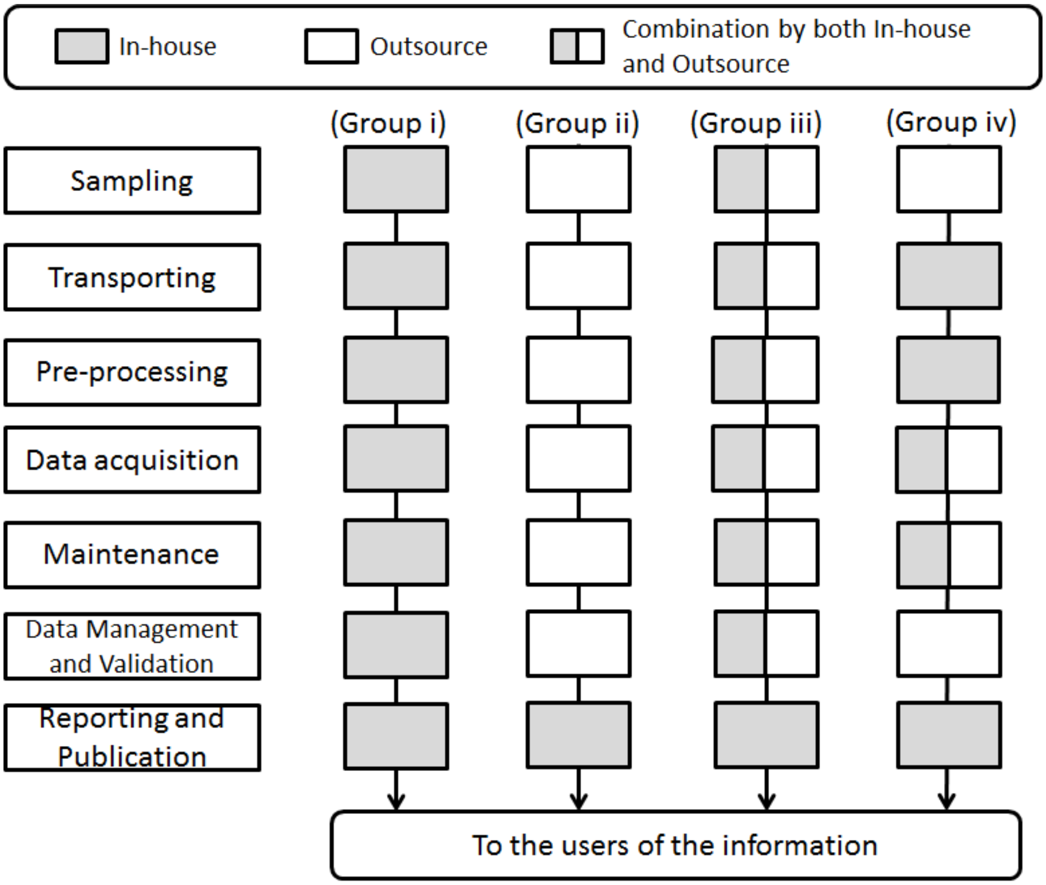

Figure 3. Definitions of the classified groups

For confirming the appropriateness of the scheme in Figure 3, both correspondence analysis and cluster analysis were adopted based on the HAPs monitoring practices by local governments. As shown in Figure 4, the results showed that the four groups were relatively distinct from each other.

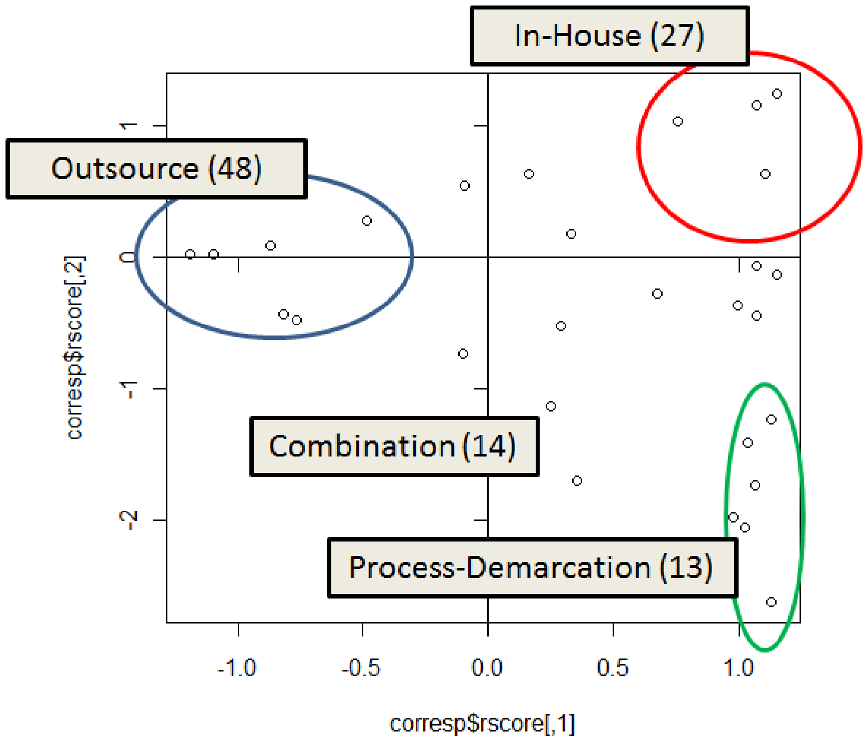

Figure 4. Results of the correspondence and cluster analyses

To investigate the relationship between the categorization above and the characteristics of the members of each group, a multinomial logit model was applied for the local characteristics of the local governments. In the multinomial logit model, the probability, Y_i, that a local government (i) chooses a group (j) is defined as follows.

$$P(Y_i = j) = \frac{\exp(\beta_j' \mathbf{x}_i)}{1 + \sum_{k=0}^{3} \exp(\beta_k' \mathbf{x}_i)}, j=0,1,2,3 \qquad \text{Equation 1.}$$

where the column vector $\mathbf{x}_i$ (i = {1,2, …, n}, where n is the number of the local governments) contains attributes of local governments and β' is the corresponding unknown regression coefficient to be estimated. Table 8 shows the descriptive statistics of $\mathbf{x}_i$. These factors are predicted to influence the frequency of HAPs monitoring.

Table 8. Descriptive Statistics

Local Characteristics	Description	Mean	Deviation
Scale dummy [-]	= 1: prefecture government	0.369	0.232
Population [million people]	Number of citizens in the area	1.06	1.87×10^6
Square area [thousand km^2]	Size of the area	3.31	6.20×10^4
Population density [thousand people/km^2]	Population density in the area	2.01	7.02×10^3
Subsidy dummy [-]	= 1: Subsidy received from central government = 0: otherwise	0.204	0.162
Road density [km/km^2]	Length of the road per 1km^2	8.33	90.1
Proportion of second industries (i.e., manufacturing) [%]	Rate of second industry's offices in all industries	18.2	0.239
Industry delivery amount [million Yen]	Industry delivery amount in the area	2.66×10^6	1.33×10^{13}

Table 9 shows the results of the multivariate logit model and lists only local characteristics that were statistically significant. In this analysis, the "outsource group," which had the largest numbers of samples, is regarded as the standard group. This result shows that local governments that have a smaller scale population tend to belong to the outsource group. A trend in which local governments with a high amount of industry delivery chose the outsource group rather than the In-House group and the Process-Demarcation group was also observed. Moreover, whether or not a local government was a prefecture government was a statistically significant factor in choosing the In-House or the Outsource group.

Table 9. Results of the multivariate logit model

Group	Coefficients	Marginal effects
In-House		
Scale dummy [-]	2.47**	0.352
Population [people]	2.37×10^{-6}***	3.06×10^{-7}
Industry delivery amount [million yen]	-3.92×10^{-7}***	-5.51×10^{-8}
Process-Demarcation		
Population [people]	1.83×10^{-6}**	8.62×10^{-7}
Proportion of second industry [%]	14.2*	1.36
Industry delivery amount [million yen]	-3.19×10^{-7}*	-1.90×10^{-8}
Combination		
Population [people]	2.43×10^{-6}***	1.64×10^{-7}
Subsidy dummy [-]	-2.58*	1.58

*Significant at the 10% level, **significant at the 5% level, ***significant at the 1% level.
Note: Standard group is Outsource group.

Next, for investigating the cost structure of HAPs monitoring, an equation for multiple regression analysis was defined as follows.

$$C = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon \qquad \text{Equation 2.}$$

- Where C: $total\ costs\ for\ HAP\ monitoring$ [10^4 $Yen/year$]
- x_1: $scale\ (total\ frequency)\ of\ monitoring$ [$scale/year$]
- x_2: $number\ of\ objects\ of\ HAPs$[$class/\ year$]
- x_3: $number\ of\ staffs\ on\ monitoring$[$person/year$]
- ε: $error\ term$

The constant term β_0 shows the fixed cost of monitoring (e.g., data management etc). β_1, β_2 and β_3 are the coefficients of the explanatory variables and show the annual monitoring cost, which is defined as the cost per 1 time point, 1 monitoring point, and 1 substance; the maintenance cost; and the labor cost per capita, respectively. Because of limitations in the data regarding costs and the number of government officers in charge of HAPs monitoring, some assumptions in terms of the effective number of officers (ENO) in charge of HAPs monitoring were examined to calculate the labor cost. Tables 10 and 11 show the result of this analysis for the two assumptions, which were no restriction on ENO (no adjustment) and the strongest restrictions on ENO (ENO = 2) respectively.

In Table 10, for example, the monitoring cost per scale for the Outsource group was 7.55 thousand yen, and the estimated labor cost per capita was 0.522 million yen. For the In-House group, the monitoring cost per scale was statistically insignificant, while the estimated labor cost was 2.1 million yen. In comparison with the estimated labor cost for all local governments, the estimated labor costs for the two groups above reflect their distinct differences. Both Tables 10 and 11 show that the monitoring costs per scale for all groups were not strongly influenced by the ENO assumption.

Table 10. Results of the Regression Analysis for Total Costs (No adjustment) [10^4 yen/year]

		β_0	β_1	β_2	β_3	Adj R^2 (F-Value)
All Local Governments (n = 97)		22.0	0.825***	4.84	160***	0.716 (81.8***)
	In-House (n = 24)	-107	0.233	32.4	210***	0.635 (14.4***)
	Outsource (n = 46)	208	0.755**	3.38	52.2**	0.301 (7.45***)
	Process-Demarcation (n = 13)	-89.8	0.209	26.0	164**	0.489 (4.82**)
	Combination (n = 14)	2028	1.07***	-136	251***	0.855 (26.6***)

Table 11. Results of the Regression Analysis for Total Costs (ENO = 2) [10^4 yen/year]

	β_0	β_1	β_2	β_3	Adj R^2 (F value)
All Local Governments (n = 97)	267	0.776***	7.97	-8.86	0.445 (26.7***)
In-House (n = 24)	67.8	0.253	45.5	-25.7	0.024 (1.19)
Outsource (n = 46)	324	0.711**	3.34	-14.5	0.132 (3.29**)
Process-Demarcation (n = 13)	164	0.347	19.6	32.7	-0.061 (0.77)
Combination (n = 14)	1843	1.02***	-93.7	27.0	0.706 (11.4***)

*Significant at the 10% level, **significant at the 5% level, ***significant at the 1% level.

Conclusion of the Section

This study confirmed that those local governments conducting HAPs monitoring can be classified into four groups, assuming that each local government is trying to adjust its monitoring operations under various constraints. The cost structure of HAPs monitoring is also different among the four groups. As a further study, the examination of HAPs monitoring by the In-House group, which faces the worst financial condition among the four groups, should be conducted not only financially but also for the positive aspects of their current operations, including the tradition of "know-how" within local minicipalities.

Overall Conclusions

Environmental information is vital for any government to realize an environmentally sustainable society. However, as this article partially indicates, the collection of environmental information and its conversion into a usable form is not free of charge and often requires some time to become available, since various types of information need to be integrated. This necessity of this integration reflects the fundamental interdisciplinary nature of the environment and our society. Ultimately, environmental information is meaningless if it is not used; the collection and generation of environmental information should not be merely a goal; rather, it is the means for better decision-making. Japan has developed and advanced an environmental information system and has probably entered into the next stage where we need to re-align and re-design the manner of collecting, managing, and using the information under various constraints (especially financial constraints). In addition to Japan, a number of other developed countries now need to tackle these new, quite complicated, and often cross-boundary environmental issues, for which a single environmental information source from a single state is not adequate.

One of the most difficult points is to fully understand the benefit of environmental information because of its invisibility and accumulative effects. Indeed, if environmental information would have mitigated or avoided some potentially serious environmental and/or health issues, then those issues would not be able to be recognized simply because they had been avoided, so that the value of environmental information would still be difficult to understood. Therefore the existence value of any kinds of environmental information should not be underestimated regardless of the frequency of their usages.

More attention and investment should be placed on the augmentation of environmental information systems in developing countries, not only for physical equipment but also for human resources (especially the technical staff of local governments). Institutional arrangements to maintain an environmental information system is likewise vital, especially for quality assurance and the quality control of the information. As the result of this article implies, the reliability of environmental information is crucial. The needs of environmental information evolves over time as environmental conditions change in Japan, where, as an example, the focus of air quality monitoring has been shifting from typical air pollutants to hazardous substances.

Acknowledgment

This work was supported by KAKENHI (Grant-in-Aid for Scientific Research (C)), Reference #: 20510032. The authors also would like to express sincere appreciation to those who kindly responded to our surveys. The contribution to this article by Ms. Guanyi Deng is also acknowledged greatly.

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