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Perceptions on Transboundary Air Pollution among Scientists and Policymakers

- Results from Interview Surveys in Japan -

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Abstract

The problem of transboundary air pollution has become increasingly evident in East Asia in recent years and there is a pressing need to build an effective framework for international cooperation on the atmospheric environment. However, there are gaps among countries with regard to their views on transboundary air pollution and their stances on international cooperation. This study, focusing on the perceptions of Japanese stakeholders, identifies the commonalities and differences in the perceptions of respondents and related stakeholders by conducting interviews with selected scientists and policymakers in Japan, examines the desirable components of an international framework for atmospheric management in the East Asian Region, and discusses the barriers and challenges pertaining to the creation of such a framework.

From the interviews, it was found that most respondents perceived photochemical oxidants and particulate matter originating in the Asian continent as problems. When asked about the perceptions of other domestic stakeholders, respondents shared common opinions with regard to the commonality among scientists' perceptions, the sensational coverage by the media and the high interest held by industry. However, opinions were split on matters such as the interest and understanding of the media, views of the problem held by different industries, and the degree of recognition among the general public. Responses revealed that, even though government officials of China and Korea should have information on scientific findings related to transboundary air pollution as those findings have been shared at international discussions, Japanese respondents felt that China was comparatively passive in recognising the issue, and that Korea and Japan differed on the pollutants of primary concern and their attitudes toward what is an appropriate framework for international cooperation. Factors identified as barriers for international cooperation include environmental management capacities of the East Asian countries, recognition related to the ownership of existing frameworks of international cooperation, and the political and economic factors specific to Asia.

Based on the research results, policy challenges related to developing the framework for effective international cooperation are identified. They include, but are not limited to, improving scientific knowledge pertaining to transboundary air pollution while forming an epistemic community, adopting methods that take into account the political and economic background in Asia while considering each member nation's awareness of ownership in designing a framework for international cooperation.

Since this study is based on data from a limited number of survey respondents, the results should not be treated as a comprehensive and quantitative assessment of the perceptions of Japan's scientists and policymakers. Therefore, based on the findings of this study, further research should be carried out with a larger sample of respondents encompassing a wider scope of stakeholders.

Keywords: transboundary air pollution, atmospheric environmental policy, international cooperation

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Abbreviations and Acronyms

EANET	Acid Deposition Monitoring Network in East Asia
GHGs	greenhouse gases
LRTAP	Convention on Long-range Trans-boundary Air Pollution
LTP	Long-Range Transboundary Air Pollutants in Northeast Asia
NMHC	non-methane hydrocarbons
NO_X	nitrogen oxides
$PM_{2.5}$	fine particulate matter
SLCF	short-lived climate forcer
TEMM	Tripartite Environment Ministers Meeting among Japan, China and Korea
VOC	volatile organic compounds

1. Introduction

In Asia, emissions of air pollutants, such as nitrogen oxides (NO_X) and volatile organic compounds (VOC), have increased rapidly since the late 1980s in step with the region's remarkable economic growth (Ohara 2011). Upon entering the 21st century, the amount of air pollutants emitted from Asia surpassed that of North America and Europe (Akimoto 2006). Concurrent with this rapid increase in emissions, problems such as the transboundary transport of ozone and aerosols and the increase in background concentrations of ozone on a hemisphere-wide scale have come to the fore. In addition, the amount of greenhouse gases (GHGs) emitted from the combustion of fossil fuels and their concentrations within the atmosphere are worsening on a global scale.

In recent years, the issue of transboundary air pollution has drawn attention in Japan due to the very low attainment rate of the environmental standard for photochemical oxidants and the observation of highly concentrated ozone in its remote islands.[1] The attainment rate of the standard for photochemical oxidants in 2009 was only 0.1% of Japan's ambient air pollution monitoring stations (one station out of 1,152) and 0% of its roadside air pollution monitoring stations (one station out of 31), continuing the trend of extremely low achievement rates. The annual average daily maximum of one-hour concentrations has also risen steadily over the past years (Ministry of the Environment 2011).[2]

In addition, the number of areas subject to photochemical oxidant warnings is increasing, and in recent years, warnings are issued even for regions outside of major cities. The first-ever photochemical oxidant warnings were issued in Nagasaki and Kumamoto prefectures in 2006, in Niigata and Oita prefectures in 2007, in Nagano and Saga prefectures in 2008, and Yamagata and Kagoshima prefectures in 2009 (Yoshikawa *et al.* 2011). One instance that gained public attention was the issuance of photochemical oxidant warnings across a wide area including Kyushu and western part of Japan on May 8th and 9th, 2007, coinciding with high concentrations of photochemical oxidants in the remote islands of northern Kyushu, where there are no large sources of the pollutant (Ohara 2011).

While the concentration of photochemical oxidants has increased and the area subject to warnings has expanded, the concentrations of NO_X and non-methane hydrocarbons (NMHC), the precursors to photochemical oxidants, are both on the decline. In fact, NO_X levels have been falling since the fiscal year 1996, while NMHC levels have declined, more or less, since 1985.

[1] In Japan, photochemical oxidants are listed among the pollutants for which the environmental standards for air quality are set. The notification for the environmental standards defines photochemical oxidants as "oxidising substances such as ozone and peroxiacetyl nitrate produced by photochemical reactions (only those capable of isolating iodine from neutral potassium iodide, excluding nitrogen dioxide)." The most prevalent photochemical oxidant is ozone (O_3) (Committee on Photochemical Oxidants and Tropospheric Ozone, 2007).

[2] The environmental standards are formulated in accordance with the Basic Environment Act as levels which are desirable for the "protection of human health and the conservation of the living environment". The standards for photochemical oxidants stipulate that "hourly values shall not exceed 0.06 ppm" to prevent adverse health effects from short term exposure. If all of the hourly values at a given monitoring station do not exceed 0.06 ppm, then that station is assessed as having attained the environmental standards. When a one-hour value of the concentration of photochemical oxidants is more than 0.12 ppm and the status is considered to continue due to weather condition, warning are issued to prevent damages to human health.

The Committee on Photochemical Oxidants and Tropospheric Ozone (2007) believes that one reason that the concentration of photochemical oxidants has increased over the long term, despite the decline of the precursors, was the growing effect of the transboundary transport of pollutants in the Asian region coinciding with the recent rise in background concentrations of ozone in the northern hemisphere and drastic increase in emissions of NO_X and other substances in Asia.[3]

The hemisphere-wide concentrations of background ozone are expected to increase regional pollution and, furthermore, to affect Japan's attainment of the environmental standard for photochemical oxidants due to their transboundary transport from Asia to Japan (Akimoto 2006). According to a report issued by the Task Force on Hemispheric Transport of Air Pollution (TF-HTAP) in 2010, several studies have been published on the increased concentrations of background ozone at the middle latitudes of the northern hemisphere, and while uncertainty remains regarding the degree of increase and actual causes, the increase in the latter half of the 20th century has been remarkable, and the outcomes of these studies agree with the wealth of research findings on the increase in anthropogenic emissions of ozone precursors (UNECE 2010).

A comprehensive review of the existing research on the impact of the transboundary transport of pollutants from Asia can be found in the mid-term report of the Committee on Photochemical Oxidants and Tropospheric Ozone. Other studies also have been conducted and published in this field. For example, Ohara *et al.* (2008) analysed the features and causes of the episode of high concentrations of photochemical oxidants in May 2007, while Nagashima *et al.* (2010) estimated the source-receptor relationship for surface ozone in East Asia during the early 2000s.

Therefore, it is essential to minimise the increase in the hemispheric background concentrations of ozone and the impact of transboundary transport in order to reduce concentrations of photochemical oxidants in Japan. Since Japan also contributes to background concentrations of ozone, it goes without saying that it must continue strengthening measures to reduce domestic emissions. Meanwhile, it is desirable that all countries build a framework for international cooperation on reducing precursor substances (Akimoto 2006).

Given the accumulation of scientific knowledge gleaned from studies of transboundary pollution, it is highly likely that similar measures for particulate matter will need to be considered in an effort to achieve the environmental standards set for fine particulate matter ($PM_{2.5}$) in 2009.[4] In fact, the Central Environment Council's report entitled "On the Establishment of Environmental Standards for Fine Particulate Matter" (3 September 2009) indicates the possibility of transboundary pollution and the need for international cooperation,

[3] Other potential causes include impacts on photochemical oxidant concentrations due to increased amount of ultraviolet light and intrusion of stratospheric ozone into the troposphere. However, the former has not been proven through quantitative assessments and the latter has not shown any impacts on the increase in the annual average concentrations of tropospheric ozone.

[4] Fine particulate matter is defined as airborne particles that pass through a size-selective inlet with a 50 % efficiency cut-off at an aerodynamic diameter of 2.5 μm. The annual standard for $PM_{2.5}$ is less than or equal to 15 $\mu g/m^3$ and the 24 hour standard is less than or equal to 35$\mu g/m^3$ (Notification No. 33, September 9th, 2009).

by mentioning that "it can be inferred that there are some impacts of cross-boundary advection" and "in addition to domestic measures, there is a need to promote technical cooperation in reducing pollutants while forming of a common understanding of air pollution mechanisms with neighbouring countries" in sections to discuss challenges related to setting the standards. More recent scientific studies on the transboundary transport of particulate matter include Kanaya *et al.* (2010) and Kaneyasu *et al.* (2011). The former used monitored data of $PM_{2.5}$ concentrations in Fukue Island, Nagasaki prefecture to suggest that the influence from the Asian continent was strong for the high $PM_{2.5}$ days. The latter compared measurements on Fukue Island and in the cities of Fukuoka and Nagasaki and the results suggested that $PM_{2.5}$ concentrations in Northern Kyushu and their changes over time were virtually dominated by the long-range transport of air pollution from the Asian continent rather than domestic urban air pollution throughout the year.

The process of building an international framework that includes both developed and developing countries and building a consensus within the framework is expected to be fraught with difficulties, as the case of international negotiations on climate change shows. Regarding the issue of transboundary ozone, an agreement on cooperation in the area of scientific research was reached at the 9th Tripartite Environment Ministers Meeting among Korea, China, and Japan in December 2007, but discrepancies remain among each country's official views. In order to reduce air pollutants in the East Asian region, it is necessary for the various parties overcome their differences in perception and build an effective framework for international cooperation on the region's atmospheric environment. Existing literature related to international cooperation in Asia on environmental issues includes Takahashi (2002), Kim (2007), Matsuoka (2011) and others. Those works primarily focus on the acid rain problem, and little research can be found related to transboundary air pollution concerning ozone and particulate matter or the perceptions of stakeholders on these issues.

With the purpose of addressing this issue, the Institute for Global Environmental Strategies (IGES), in cooperation with researchers in various countries, conducted a survey in fiscal year 2010 on the perceptions among scientists and policymakers in Japan, China, Korea and Thailand on transboundary air pollution. This paper aims to analyse the results of the survey conducted in Japan to identify the commonalities and differences in the perceptions of respondents and related stakeholders in Japan, and also to elucidate policy implications by discussing various modalities for strengthening the international cooperation framework regarding atmospheric management in East Asia and identifying related barriers and challenges.

2. Methodology

In order to survey the perceptions on the issue of transboundary air pollution, semi-structured interviews were conducted with scientists and policymakers working in fields related to transboundary air pollution. Semi-structured interviews proceed based on a list of questions but allow the interviewer to modify the wordings of the questions, their order, and content, when he or she feels appropriate (Cohen and Crabtree 2006).

For this survey, a common list of questions was sent to the interviewees in advance. The list included questions regarding their perceptions and the perceptions of others on transboundary air pollution and the barriers and challenges pertaining to related domestic policies and international cooperation. Based on the list, opinions were elicited during the face-to-face interviews, which were conducted between December 2010 and February 2011.

Interviewees

Interviewees were selected from academic experts and policymakers engaged in duties in the field of air pollution. This interview technique is classified as elite interviewing and, although it uses a smaller sample than standardised interviewing, it may "help the investigator to acquire a better picture of the norms, attitudes, expectations, and evaluations of a particular group than he could obtain *solely* from less intensive observations or through conducting a greater number of less intensive interviews (Dexter 2006) ".

The primary reason scientists and policymakers were selected as the "elites" in this survey is because both play important roles in the development of a framework for international cooperation on transboundary air pollution. One of the preconditions for the development of a framework for international cooperation is a shared recognition of transboundary air pollution among scientists. Such recognition, then, must be understood by policymakers and judged that the political priority of the issue is high enough to place it on the agenda for inter-governmental negotiation. Another reason for the selection is the significance of both parties' roles in deciding the detailed rules under frameworks of international cooperation. The effective interaction between scientists and policymakers is believed to be one of the factors facilitating the success of the Convention on Long-range Trans-boundary Air Pollution (LRTAP), which played a critical role in Europe's transboundary air pollution policy (Kelly *et al.* 2010).

The interviewees who cooperated with this survey represent a total of seven groups (or categories), including the research fields of atmospheric chemistry, climatology/meteorology,

environmental cooperation in Asia, and environmental economics as well as government officials from national, prefectural and local levels.[5]

Survey questions

The survey form is comprised of three main groups of questions. The first group of questions deals with the respondents' own perceptions on the following:

a. Scientific certainty of the transboundary air pollution from the Asian continent, severity of the problem, and perception of air pollutants thought to constitute a transboundary issue.

b. Perceptions on the source regions and the receptor regions of the air pollutants mentioned in response to the previous questions.

c. Perceptions on the impacts caused by transboundary air pollution in Japan.

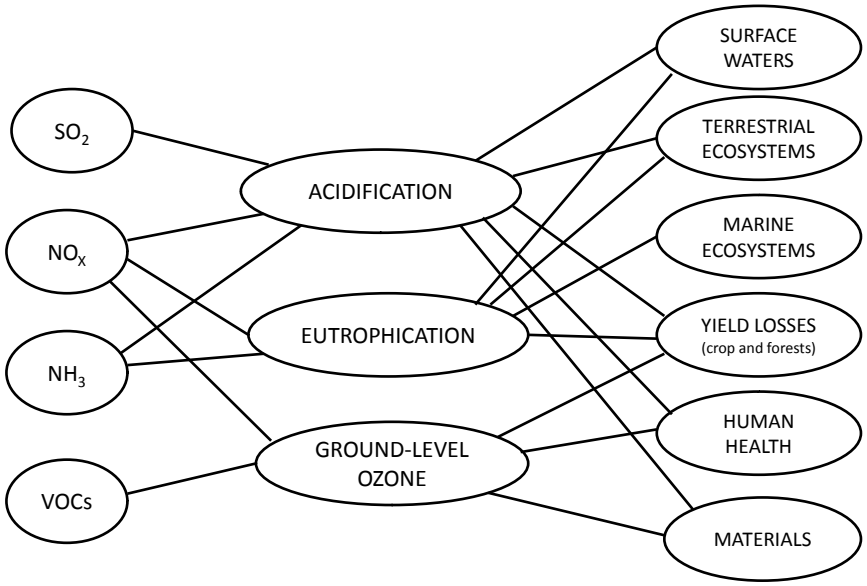
The second group of questions deals with other stakeholders' perceptions of transboundary air pollution. Interviewees were asked to provide their opinions on the perceptions of scientists, the media, industry, the general public, and other countries (namely, China and Korea), on the items in the first group of questions. This set of questions attempts to obtain inputs for identifying gaps in perception among stakeholders after being compared to survey results from other countries and the results from future surveys conducted with other stakeholders. As such, the aim of these questions is not to accurately capture the other stakeholders' own perceptions, but to grasp views of Japan's scientists and policymakers on the other stakeholders' perceptions.

The third group of questions focuses on domestic policies concerning transboundary air pollution and the barriers and challenges pertaining to international cooperation. Regarding domestic policy, two types of transboundary air pollution policies were specifically selected as foci, and respondents were asked if they thought these could be feasibly implemented and what the barriers and challenges might be. The first type of the domestic policies was the multi-effect, multi-pollutant approach. Since the atmosphere contains a mixture of many substances that react with each other and transform into other substances, an accurate assessment of the interactions among multiple substances is important to control air pollution (Ohara 2011). However, Japan's air pollution measures have primarily relied on "single-pollutant approach" – with major policies focusing on setting air quality standards and emission regulations for individual pollutants.

In comparison, LRTAP employs the multi-effect, multi-pollutant approach in the Gothenburg Protocol adopted in 1999. More specifically, the Protocol, aiming to abate acidification, eutrophication and ground-level ozone, sets emission ceilings to be met by the year 2010 for four pollutants, namely, sulphur dioxide, NOx, ammonia and VOC (Figure 1). Those ceilings are mandatory and differ from country to country. The commitment of each country was

[5] In the case of one organisation, two people participated in the interview, while only one respondent participated from other organisation. Therefore, this paper uses the word 'group' as the unit used for counting the number of respondents.

decided through negotiation strongly guided by the results of an integrated assessment model, which estimated the emission reductions required of each country based on information regarding impacts on ecosystems, deposition patterns, and abatement costs (Secretariat for the Convention on Long-range Transboundary Air Pollution 1999, revised 2002).



（Source: Secretariat for the Convention on Long-range Transboundary Air Pollution 1999, revised 2002）

Figure 1 Concept map of the multi-effect and multi-pollutant approach in the LRTAP

The second approach is to promote air quality policy in tandem with climate change mitigation policy, in other words, to promote a policy of co-benefit and co-control which is drawing attention in the context of climate change measures. Climate change mitigation measures to reduce emissions of greenhouse gases (long-lived substances) include measures that are also effective in reducing air pollutants (short-lived substances). In addition, since ozone and black carbon in fine particulate matter are short-lived climate forcers (SLCF), reduction of those substances are recently drawing worldwide attention as effective not only for reducing air pollution but also for climate change (UNEP 2011).

Finally, to identify the barriers and challenges pertaining to international cooperation in the area of transboundary air pollution, respondents were asked to provide their views on what kinds of international cooperation framework would be desirable in the near future and what would be the barriers and challenges regarding the creation of such a framework.

The list of questions which was sent to the interviewees is attached as an appendix at the end of this paper.

Methodological limitation

As mentioned above, the methodology adopted by this study is elite interviewing. While it is effective in obtaining the opinions of a specific group of experts, one limitation is that it is often based on a very small sample size. This study is also subject to this limitation, as the analyses are based on the responses of seven people. Therefore, representativeness of this study is very limited, not only in terms of the range of types of stakeholders is also limited (focusing only on scientists and government officials) but the study is also not based on a representative sample within each group. Given this, care must be taken in handling the results: they are not intended to reflect the comprehensive and quantitative perceptions of Japan's scientists and policymakers; rather, they are a qualitative indicator of selected stakeholder perceptions and future policy issues.

3. Results

An overview of the responses to the first group of questions about respondents' own perceptions can be found in Table 1. Due to the small sample used for this survey, the answers of respondents were shown with codes (A through G), which is assigned to each respondent in order to avoid the risk of revealing their identities by indicating any attributes. The letters in parentheses after each response in the tables refer to these codes.

All of the respondents, when asked about their perceptions of transboundary air pollution, indicated that the phenomenon is occurring. The expressions used ranged from "without a doubt" to "it appears to be occurring", but five of the seven groups replied with relatively high certainty. Meanwhile, one respondent said there was uncertainty about the quantitative levels of emissions and advections. As for the severity of the issue, some respondents felt the current damage was temporary or not yet at a serious level, while others expressed concerns about severe damage that might occur in the future due to increased emissions or altered climactic conditions. Some respondents indicated that there was not enough data to determine the severity of the problem.

Over half of the respondents indicated that photochemical oxidants[6] and particulate matter[7] were air pollutants thought to constitute a transboundary issue. On the other hand, some respondents replied that the focus should not be on individual substances, but on their significance within a multi-component system, and another touched on the issue of acid rain.

As for the origin of photochemical oxidants, one group suggested mainland Asia and another group suggested that the problem should be approached on the hemispheric scale. Three groups of respondents mentioned areas affected by pollution, and in each case they indicated either southwestern Japan or the Kyushu region. One group indicated that impacts might be nationwide. As for specific impacts, several groups mentioned increased ozone concentrations and exceedances of the environmental standard, and one group discussed the possibility of impacts on rice growth and long-term aggravation of adverse effects.

Two groups pointed out that Outer Mongolia and China were the sources of particulate matter. As opposed to responses on ozone, no one mentioned a hemisphere-level approach to the issue. None of the respondents indicated precise regions within Japan that are affected by particulate matter. Respondents indicated increased concentrations of suspended particulate matter and possibly exceeding $PM_{2.5}$ standards in the future as impacts.

[6] Three of these groups referred the term 'photochemical oxidant', and two used the word 'ozone'. Since ozone is the most prevalent photochemical oxidant, this paper uses 'photochemical oxidant' to represent both terms.

[7] The terms mentioned in the actual responses were '$PM_{2.5}$' (2 groups), 'yellow sand' (3 groups), and 'aerosols' (1 group). While aerosols are often used almost interchangeably with particulate matter, $PM_{2.5}$ and yellow sand are technically not the same as they are only a part of particulate matter. However, this paper employs the term 'particulate matter' to cover those different terms since the concepts have some overlaps.

Table 1 Responses on own perceptions of transboundary air pollution

Questions	Overview of Responses	
Scientific Certainty	*Qualitative certainty* "It appears to be occurring (A)", "(Qualitatively-speaking) without a doubt (B, D)", "I see it as highly certain (C)", "It is quite clear (E) ", "It seems certain (F)", "Transboundary [pollution] has been an issue since the 80s (G)" *Quantitative uncertainty* "Emissions, advection (A, B, D)"	
Severity of the Problem	*Current status* "The issuance of four warnings per year is not severe (B)", "At present, reports of damage due to photochemical oxidant include eye irritations (B, C)", "Temporary (C)", "There is not much data on damage caused by ozone and particulate matter in Japan (D, F)", "Severity differs depending on the substance (F)" *Future* "Concern over future increases in line with economic growth in East Asia (A)", " There is a possibility that a severe situation might occur depending on climactic conditions (C)"	
Major Pollutants / Origins, Affected Regions, Impacts	Pollutants	Origins / Affected Regions / Impacts
	Photochemical oxidants (A, B, C, D, F)	*Origins* "Contribution from the Asian continent on Japan's windward side seems to be significant (A)", "Advection from the continent (China) is suspected, originating in coastal China (B)", "Advection must be considered on a hemispheric scale (D, F)", "To a greater or lesser extent, everyone is a source and everyone is a receptor (F)" *Affected regions* "Western Kyushu (B)", " Kyushu region" (C), "Southwestern Japan" (D), "The impact may be nationwide (C)" *Impacts* "Increase in ground-level ozone concentration (A, C)" "Exceedances of the environmental standard in the western Kyushu region are visible impacts (B)" "As for the effect on vegetation, it might have an effect on rice growth. Over the long term, adverse effects on health might become more serious (B)"
	Particulate matter (A, B, C, D, F, G)	*Origins* "Outer Mongolia (B)", "Regions such as China are the probably big sources. There are also issues of transport of pollutants within China (G)" *Affected regions* "Nationwide (B)" *Impacts* "Increased concentrations of suspended particulate matter due to yellow sand (A)" "Future concern is exceedance of $PM_{2.5}$ standards in the long run (B)"
	Causative agents of acid rain (A, G)	"It is possible that acid deposition may increase in the future (A)" "There is no proven impact in Japan (F)"
	Multi-component system (E,G)	"Impacts will be wide-ranging, such as acid rain in rainy regions and health effects in other regions (E)" "While damage will differ from region to region, impacts might be observed not only in air but water, forests and soil. Regions with high precipitation will be affected most (G)"

Note: The letters in parentheses refer to respondent codes.

Table 2 provides an overview of the responses to the questions on other stakeholders' perceptions (second group of questions). Almost all of the respondents agreed that scientists have a more-or-less shared recognition. However, one group opined that the perceptions between atmospheric chemists and meteorological physicists differ. Replies about the media were varied, with some respondents saying the media was aware of the issue of transboundary pollution and found it serious, while others claimed they showed no interest in the issue. In particular, many respondents criticised the media's portrayal of the issue, calling it "sensationalist" or claiming that "the media likes controversy". Almost none of the respondents said that industry was not interested in the issue, but they expect a range of sector-specific responses. For example, some said that the agriculture, forestry and airline industries saw

transboundary air pollution in terms of its burden on their activities, while the countermeasure technology, preventative sanitation (masks etc.) and measurement instruments industries viewed the issue in terms of business opportunities. As for attitudes about regulation, two groups replied that Japanese industry is seriously responding to requests to reduce pollution issued by local governments when pollution warnings are issued. Others remarked that industry justifies demands for the relaxation of regulations due to the existence of transboundary air pollution and makes the excuse that the issue is not their responsibility. Meanwhile, one respondent commented that, in the metropolitan Tokyo area, none of the companies are asking to relax regulations. Opinions regarding the perceptions of the general public seemed to differ depending on where the respondents lived and environmental awareness of general public. However, only one group saw little difference among the perceptions of the media, industry and the general public, and believed that awareness of all three was overall insufficient.

Table 2 Responses on other stakeholders' perceptions of transboundary air pollution

Questions	Overview of Responses		
Scientists	*Commonalities* "Scientists commonly recognise transboundary advection as a problem (A)", "They have a relatively shared recognition of the issue (E)", "There is considerable recognition of the fact that yellow sand contains various hazardous substances (G)", "Scientists' perceptions are the same as my own (C, D)" *Differences* "Opinions between atmospheric chemists and meteorological physicists differ (F)"		
Media	*Recognition of the transboundary air pollution issue* "Media recognise the issue of transboundary air pollution and think it is serious (A)", "Of late, they show little interest or see it as passé (F)", "They are more interested in international frameworks on climate change (G)" *Coverage* "Coverage is sensationalist or swayed by the political climate (B)", "They want to make a show of the issue of transboundary pollution (D)", "They want to write that Japan is suffering from damage (F)", "It seems as if they want to cause a ruckus (E)", "The media likes controversy (F)", "Coverage is sporadic (C)" *Underlying science* "Each reporter's understanding of the science is different (E)", "The coverage lacks a scientific approach (F)"		
Industry	*Concern over negative impacts* "The agriculture, forestry and airline industries might be concerned about how the issue will impact them (A)" *Business opportunities* "There are also business opportunities, so those in sectors related to countermeasure technology are probably very aware of the issue (C)", "It is a business opportunity for mask manufacturers and the measurement instruments industry (E)", "It might be a business opportunity for electric vehicle manufacturers (D)" *Attitudes on regulation* "Industry responds seriously to the government's calls for reductions (B, C)", "Some companies ask for laxer regulations because transboundary air pollution exists (B)", "Some companies use transboundary air pollution as an excuse to say that air pollution is outside of their responsibility (D)", "There are no companies that request to relax regulations because of transboundary air pollution (C)"		
General Public	*Regional/individual differences* "Residents of Kyushu are concerned (B)", "People who are environmentally conscious are probably aware of the issue (A, C, E)", "People don't know because they have no information or they have forgotten (F)", "People are probably affected by the media's perceptions (D)"		
Other Countries	*Commonalities with Japan*		*Differences from Japan*
	China	"They know that advection is occurring (A)" "Some scientists understand the issue (E, F, G)"	"They place priority on the domestic air pollution problem (A, B)" "There are concerns about yellow sand storms (B)" "The Chinese government does not officially recognise the country's involvement (F)" "China seems to feel that Japan is trying to blame it for the issue (D)" "The Chinese become sensitive when others discuss damage sustained by other countries (E)" "They are cautious about providing data (B, E)" "Scientists' custom of holding discussions based on data is still weak (G)"
	Korea	"They know that advection is occurring (A)" "They are actively engaged in countermeasures (D)"	"They view yellow sand as a more serious issue (A, B)" "They are not receptive to Japan-led initiatives (F)"

Note: The letters in parentheses refer to respondent codes.

Table 3 lists responses to the third group of questions pertaining to domestic policies on transboundary air pollution.

Some respondents expressed support for the validity of the multi-effect, multi-pollutant approach in Japan given the "continuing ineffectiveness of regulations against individual precursors in combating the increase in photochemical oxidants" and the fact that "many experts feel the need to address the issue from multiple aspects". Meanwhile, others pointed out the difficulties in implementing this approach, opining that "as Japan's administration in the area of atmospheric environment has been considerably successful thus far by relying on regulations on individual air pollutants, a need to adopt any new rules is not strongly considered", that "there are no reports of any real damage", and that "Japan has not set any policy targets related to acid rain". Actual measures proposed by respondents include introduction of the multi-effect, multi-pollutant approach for the control of ozone precursors and integrated assessments of pollutants, while the main potential barriers and challenges to these measures were said to be the comprehensive collection/analysis of environmental information, and the consensus building including the costs associated with regulation.

On the other hand, most respondents more-or-less supported the idea of promoting air pollution measures in tandem with climate change mitigation policy. Reasons they raised included the win-win nature of SLCF reduction measures in mitigating both air pollution and climate change, and the various existing initiatives being taken in an effort to meet GHG reduction targets. Actual measures that respondents mentioned included not only domestic measures such as fuel conversion initiatives but also the establishment of a shared scientific recognition of SLCFs through the preparatory process of the IPCC's Fifth Assessment Report and the inclusion of SLCFs in the post-Kyoto Protocol framework on climate change. Regarding barriers, it was pointed out that co-benefits cannot necessarily be achieved in all cases. The situations without co-benefits can be categorised into two types: cases where there is little relationship between air pollution measures and GHG mitigation measures, and cases with a trade-off between the two measures. For example, measures to VOC emission reduction from paints fall in the former category. That is, the measures can reduce air pollutants but have little impact on GHG emission reduction. Examples of the latter case include ultra-lean combustion (reduces CO_2 but increases air pollutants) and SO_2 reduction (reduces air pollution but worsens climate change). Other barriers included the differences between actors involved in consensus building processes in the areas of atmospheric environmental policy and global environmental problems, and the gaps between scientists and policymakers.

Table 3 Responses on domestic policies concerning transboundary air pollution

	Multi-effect, Multi-pollutant approach	Co-benefit and Co-control approach
Validity and Feasibility	"Photochemical oxidants continue to rise despite reductions in individual precursors (A)" "To date, emissions regulations for both stationary and mobile sources have targeted multiple pollutants (C)" "Many experts feel the need to address the issue from multiple aspects (E)" "Ideally, integrated management of multi-media approach, beyond the multi-pollutant approach, should be employed. In addition, energy policy should be also considered (G)" *Negative opinions* "Japan's regulations on individual air pollutants have been considerably successful thus far, so a need to adopt the new approach is not well recognised (D, F)" "There are no policy targets on acid rain (D)" "There are no reports of any real damage (E)"	"There are already various existing measures designed to achieve GHG reduction targets, some of which are being implemented (A)" "SLCF reduction measures have a win-win relationship (D, F)" "In addition to linking air pollution and climate change mitigation policies, measures must also be tied to energy policy (G)"
Concrete Policies	"It may be possible to adopt multi-effect, multi-pollutant policies in the area of ozone control (A, D, F)" "Measures based on an inventory of pollution sources (C)" "Integrated assessment of pollutants (F)"	*Domestic* "Upgrades to high efficiency boilers (A)" "Fuel conversion (A)" "Awareness raising for eco-driving (A)" "Shift to clean diesel (F)" "Combustion technology (F)" *International* "Enhancing wider scientific recognition (F)" "Promotion of measures based on a precautionary approach (F)" "Creation of a new framework including SLCF(F)"
Barriers and Challenges	*Treatment of scientific data* "Comprehensive collection and analysis of environmental information (G)" "Development of an integrated assessment model and establishment of critical loads (A)" "Estimation of health risks (C)" *Consensus-building* "Public consensus on losses associated with regulation (C)" "Differences between the perceptions of experts and the general public (E)" "Differences in agencies in charge (G)"	*Cases without co-benefits* "Air pollutants that are not emitted at the same time as GHGs (A)" "Trade-offs between air pollution and climate change (D, F)" *Consensus-building* "Differences in stakeholders involved in consensus-building between atmospheric environmental policy and global environmental problems (C)" "Gaps between experts in the air pollution and climate change communities (D, E, F)"

Note: The letters in parentheses refer to respondent codes.

Responses to the second half of the third group of questions, i.e., the questions on international cooperation, can be found in Table 4. Responses on desirable frameworks for international cooperation on transboundary air pollution can be categorised broadly into three groups: those on the expansion and/or utilisation of the Acid Deposition Monitoring Network in East Asia (EANET), those on the use of scientific knowledge, and those dealing with the expansion of target substances.

Proposals for the expansion and/or utilisation of EANET included adding target substances (oxidants in particular), expanding the scope of activities (beyond monitoring), and expanding cooperative frameworks (to include cooperation with universities). Barriers and challenges unique to East Asia included: insufficient capacity to deal with air pollution in East Asia; perception by other countries that EANET is under Japan's leadership; and the lack of forums

for political discussion similar to the South Asia Co-operative Environment Programme (SACEP) and the ASEAN Senior Officials on the Environment (ASOEN). In particular, several respondents said that it would be difficult to adopt the same kinds of approaches employed by the LRTAP Convention into Asia, due to various differences such as degrees of economic growth, political systems, and income levels of the countries in the source regions. As for China, some opined that it is not always prudent to discuss transboundary air pollution directly and that measures need to be clearly presented by first addressing the issue of domestic precursor emissions in China.

Table 4 Responses on the framework for international cooperation

Questions	Overview of Responses
Desirable Framework for Cooperation	*Expansion and/or utilisation of EANET* "Share monitoring data and expand target substances (B)" "Expand beyond monitoring (B)" "Complement EANET by institutionally cooperating with university research centres (E)" "Raise awareness and create examples of how the system can be effectively utilised (E)" *Use of scientific knowledge* "Collection of scientific data, risk assessment, impact assessment (C)" "A cooperative framework that facilitates sharing of environmental information (G)" "Coherent cooperation from monitoring to control technologies (F)" *Expansion of target substances* "Multi-effect, multi-pollutant approach (F)" "Measures targeting Regional Commons (G)" *Effectiveness* "A framework that enables each country to substantially reduce its emissions of air pollutants (A)"
Barriers and Challenges	*Conditions in Asia* "Insufficient capacity to deal with air pollution in East Asia (A)" "Perception by other countries of EANET as a Japanese initiative (F)" "Lack of a political forum for discussion (F)" (In particular, regarding the difficulty of adopting LRTAP approaches in Asia) "Differences in the degree of economic development and political systems (B)" "Relatively poor countries are sources of pollution (G)" "Difficulty to adopt the polluter pays principle for political, diplomatic and historical reasons, (G)" "The custom of holding discussions based on scientific knowledge is not sufficiently shared among the scientists in all the countries in Asia (G)" *Considerations toward China* "The transboundary aspect should not be too much emphasised (A)" "Discussions should focus on precursors, rather than overemphasising oxidants (B)" "It is necessary to clearly present countermeasures which are easy to understand (B)"

Note: The letters in parentheses refer to respondent codes.

4. Discussion

This chapter, drawing on the findings above, first identifies and discusses the commonalities and differences among the perceptions of the respondents. Second, commonalities and differences among the perceptions of domestic stakeholders and neighbouring countries, which were identified by the respondents, are summarised. Third, major barriers to adopting selected domestic policy measures and options to develop the international cooperation framework are discussed. Finally, measures that will be needed in order to overcome these barriers are explored.

4.1 Commonalities and differences in respondents' own perceptions

The survey results showed that the respondents had more or less shared perceptions regarding the following three points:

- Transboundary air pollution is considered certain from a qualitative point of view.
- Damage from transboundary air pollution is likely to get worse in the future while the current impacts do not seem to be very serious.
- Photochemical oxidants and particulate matter are seen as two priority air pollutants.

In contrast, responses on the geographical scale of advection and scope of transboundary air pollution differed from respondent to respondent.

Underlying the shared perception of the "qualitative certainty" of transboundary pollution seems to include increase in the public interest and subsequent promotion of research in the related area, which was prompted by the expansion of the area subject to photochemical oxidant warnings. Specifically, the incident in May 2007 when photochemical oxidant warnings were issued across a wide area of the country from Kyushu to eastern Japan seems to have triggered the interest. In July 2007, the Ministry of the Environment established the Committee on Photochemical Oxidants and Tropospheric Ozone, assembling experts in the related area. In December of that year, the Committee issued an interim report on the latest information it had collected and immediate challenges. In this sense, 2007 could be called the year in which measures and recognition on photochemical oxidants were substantially advanced.

"Yellow sand" storms from the Asian continent are a visible phenomenon which has a longer history of recognition by the public than oxidants. The responses to this survey suggest that $PM_{2.5}$ is drawing more attention not only from the perspective of yellow sand storms but also in relation to the newly established environmental standards.

As for the current state of damage, the experts surveyed do not recognise the situation as serious, despite of the fact that 1,910 people in 14 prefectures submitted damage reports in 2007, the highest number since 1985. This seems to be due to the fact that damage reports contain self-reported symptoms including eye irritations which are not necessarily an indication of

severe respiratory conditions. As several respondents pointed out, there is neither a sufficient number of clear observations on the level of damage, nor enough research data on the impact of pollution, so the extent of damage cannot be clearly ascertained at this point in time.

Multiple respondents commonly pointed to photochemical oxidants and particulate matter as major pollutants, while other substances (persistent organic pollutants, mercury, methane, ammonia) and multi-component system were also mentioned by a few respondents. As explained earlier, the reasons these substances were seen as problems appear to have linkages with the issuance of warnings for oxidants, the increased frequency of yellow sand storms, and the government's establishment of standards on fine particulate matter.

The prevailing perception on the geographical scope of advection is that substances enter Japan from the Asian Continent. Oxidants were likely mentioned due to widely known research results on advection from East Asia, including a press release by the National Institute for Environmental Studies (NIES 2007). Regarding particulate matter, the above perception seems to be influenced by a number of studies on the origins of yellow sand and advection. Although two groups of respondents said that the transport of oxidants is occurring on a hemisphere-wide basis, respondents from most groups did not even mention the hemispheric scale. The fact that only a few respondents touched on the hemispheric transport of air pollution, regardless of the increase in the research papers published throughout the world on the source-receptor relationships in the hemispheric intercontinental transport of pollution, might suggest poor recognition of the international discussion on this issue within Japan and the strong impact of the impressions of advection from the Asian Continent.

4.2 Commonalities and differences among domestic stakeholders from the respondents' viewpoints

The respondents' understandings of the perceptions of other stakeholders (scientists, the media, industry and the general public) are as follows.

- Scientists, more or less, share the same perceptions on transboundary air pollution.
- The media's coverage of the issue is sensationalist.
- Industry recognises the existence of transboundary air pollution and expresses some interest in the issue.

Differences of opinion arose on questions concerning the media's interest in and understanding of the issue, industry's views on the problem and the level of awareness among the general public.

As Table 2 shows, respondents mostly agreed that there was a shared awareness among scientists to some degree. It is noteworthy that one group pointed out the difference in opinion between atmospheric chemists and meteorological physicists in that the former group recognises

transboundary air pollution while the latter group's interest is still low. This seems to be related to the gap between experts in the air pollution and climate change communities that will be discussed below.

Opinions on media coverage were uniformly negative, criticising its sensationalistic reporting. One respondent suggested that this is partly due to the fact that environment is usually covered by reporters in city news departments, not science news departments. While no one mentioned it in the interviews, another possibility which cannot be ignored can be the heightened political and economic tension between Japan and China as China's economy continues to grow and its international presence increases. There were two types of responses on media interest: those who felt the media was highly interested in the issue and those who felt they showed no interest at all. The latter group of respondents said that the media sees the issue of air pollution in Japan as already overcome. Another opinion was that the media's interest was focused more on the issue of climate change than on air pollution.

One common response regarding industry is that it does express interest in the issue. This is probably due to the fact that transboundary air pollution affects not only the companies that emit pollutants, but also many different kinds of companies. Among others, companies that emit pollutants should have a high interest as they receive requests to scale down related operations when photochemical oxidant warnings are issued. One specific example of efforts by the related industries mentioned during the interviews was the Japan Auto-Oil Program (JATOP), a joint research initiative between the automobile and oil industries. This research aims to reduce CO_2 emissions, diversify fuels and reduce gas emissions in an effort to preserve the atmospheric environment and is subsidised by the Ministry of Economy, Trade and Industry (METI). Respondents believe that perceived views are different from industry to industry, as there are companies that are regulated as air pollutant emitters, companies whose operations are affected by poor air quality, and companies that provide goods and services related to air quality policy measures. Since the results of these interviews consist only of responses by experts and policymakers and are not responses received directly from industry representatives, further research on the actual perceptions of various industries will be necessary.

The prevailing view regarding the general public was that they are not very interested in the issue. However, a respondent from Kyushu said that residents of the region are still very concerned about photochemical smog, which reveals that perception is significantly different in the areas where the residents directly experienced the warnings associated with transboundary air pollution.[8] One of the other respondents, who was not from Kyushu, commented that people who are highly environmentally conscious seemed to be aware of transboundary air pollution. While media coverage has some kind of impact on the perceptions of the general public and there were remarks on the sensationalism of media coverage as already mentioned, no respondent expressed the view that the public perception is emotional.

[8] In the spring of 2007, pollution warnings resulted in the cancellation of sports festivals at 85 elementary schools in Kitakyushu city, thereby raising the citizens' interest in transboundary air pollution (information provided by an interviewee).

One possible reason for the aforementioned differences in the perceptions of domestic stakeholders as understood by the respondents is that scientific research outcomes do not effectively reach the media or the general population due to a lack of adequate frameworks for science-related communication. Scientific researchers have in fact rapidly accumulated a body of scientific knowledge on transboundary air pollution in recent years. In addition, regional differences in perception may reflect the different degrees of impacts caused by advection. Finally, it should be emphasised that the observations herein were not drawn from opinions directly collected from the media, industry and the general public, but are rather the perceptions of the survey respondents.

4.3 Commonalities and differences in neighbouring countries from the respondents' viewpoints

Regarding the respondents' views of the perceptions of neighbouring countries, specifically China and Korea, respondents held a shared awareness that both countries possess information on the existence of the transboundary advection of air pollutants. They mentioned trilateral government meetings and international research conferences, such as the Tripartite Environment Ministers Meeting among Japan, China and Korea (TEMM) and the Model Intercomparison Study in East Asia (MICS-Asia), as venues for information sharing.

However, several points on how China's and Korea's perceptions differ from Japan's were raised. First of all, some respondents pointed out that the Chinese government does not officially recognise the existence of a transboundary air pollution problem. Another respondent opined that China does not place as much emphasis on transboundary air pollution as it does to domestic air pollution and yellow sand. Geographical location may be the primary reason why China's recognition of transboundary air pollution seems relatively passive. Since China is located on the windward side of the westerlies, the country itself tends to suffer little impact from transboundary air pollution.[9] Second, since China is facing serious domestic issues of urban air pollution and yellow sand storms, one could infer that it does not have room to take other countries' situations into consideration. This is compounded by the fact that scientists are divided over the extent of the transboundary advection of air pollutants. In a survey conducted by IGES with stakeholders in China, it was found that some scientists and policymakers in China feel that foreign (namely, Japanese) scientists overestimate the impact of transboundary advection. Therefore, it is believed that China is sensitive about discussions on the impact of transboundary air pollution in the absence of a wide consensus on the extent of its impact at this stage.

The biggest difference between Korea and Japan is in their respective recognition regarding the air pollutants of primary concern. The Korean government takes the yellow sand issue more seriously, and the Korea Meteorological Administration issues warnings when storms are

[9] However, according Nagashima *et al.* (2010), China was found to be affected by the transboundary transport of pollution from East Siberia and the Indochina Peninsula.

observed (Iwasaka 2006). When the most severe warnings are issued, people are ordered to remain indoors. In 2002 and 2006, two instances of "super yellow sand" were observed with respective densities of 2,070 μg/m^3 and 2,015 μg/m^3.[10] It was also pointed out by one of the respondents that even though Korea and Japan are geographically leeward to continental air pollution, the countries have not been in accordance with each other in the discussion related to the creation of a framework for international cooperation. Korea has shown its willingness to take the lead on international cooperation on transboundary air pollution, and the Korean Ministry of Environment and the National Institute of Environmental Research spearheaded the Joint Research Project on Long-Range Transboundary Air Pollutants in Northeast Asia (LTP). However, when it comes to EANET, one respondent indicated that Korea's participation is tepid. One likely factor underlying this might be the lack of motivation for Korea to actively cooperate to EANET, which Korea perceives to be led by Japan, arousing a sense of competition.

Given this, factors that lead to the differences in each of the three countries' perceptions seem to include geographical circumstances, resistance to admitting involvement in transboundary air pollution, and competition over the leadership of international frameworks. As with the observations on other stakeholders' perceptions, they should be handled with caution, since the perceptions of neighbouring countries are based only on opinions expressed in interviews with Japanese survey respondents. Further detailed research which compares these results with survey results from each of the related countries will be needed to identify gaps in perception between Japan and its neighbouring countries.

4.4 Barriers and challenges related to domestic policies

Respondents generally supported adopting stronger domestic policies (i.e., adopting a multi-effect, multi-pollutant approach and promoting air pollution measures in tandem with climate change mitigation policy). Nevertheless, they also indicated several barriers that could make it difficult to implement these policies.

Multi-effect, multi-pollutant approach

While the multi-effect, multi-pollutant approach was considered to be useful by multiple respondents, some potential difficulties in realising its implementation were also raised. Two specific policy measures that were proposed were the adoption of the multi-effect, multi-pollutant approach to address ozone, and introduction of the integrated assessment of pollutants.

Discussion of the barriers of this approach generally emphasised two points. First, Japan currently has no system assessing the multi-effect nature of atmospheric pollution. Second, it would be difficult to build a consensus on emissions regulations, and an agreement would need to be reached among various stakeholders including industry, the general public and government agencies.

[10] Korea has a three-stage yellow sand warning system, and the most severe level (Level 3) is declared when yellow sand density exceeds 1,000 μg/m^3 for longer than two hours (Iwasaka 2006).

So, what steps could be taken to overcome these barriers? In order to overcome the first barrier, "multi-effects" would need to be put on the policy agenda. In Europe, setting reduction targets for multiple pollutants was possible as the parties to the Gothenburg Protocol first agreed on three specific impacts (multi-effects) of pollution, namely, acidification, eutrophication and ground-level, ozone, which are linked with multiple pollutants. In Japan, acid rain seems to have a low possibility to be put on the policy agenda, as no evidence was found tying transboundary impacts to actual damage even after several scientific studies were conducted in response to a temporary social concern on acid rain (personal contact with an interviewee). Ground-level ozone might have higher possibility to get on the policy agenda, as the exceedances of photochemical oxidant standards have not shown improvement over time. However, at present, immediate progress in the ozone related policy seems difficult considering the limited social and political interest in the issue at this stage. As for ozone, there are still many unknowns regarding its generation, since it is affected by not only the transboundary transport of pollution from the Asian Continent but also several other factors including the influx of ozone from the stratosphere, the intercontinental transport of ozone from Europe and North America, and the local generation of ozone from the domestic emission of precursors (Ohara 2011). Therefore, in order for the issue of photochemical oxidants to get on the policy agenda, it is imperative to advance scientific knowledge about air pollutants and their multiple effects. Another possible issue that could be put on the policy agenda is the advection of fine particulate matter. A monitoring network is currently being developed as part of the implementation of the newly established standards on fine particulate matter, and the monitoring includes component analyses. If the monitoring of the nationwide status of attainment of the standards would show that they were difficult to meet, then the issue of fine particulate matter would draw more attention.

Consensus-building, the other barrier mentioned by respondents, would play an important role if the multi-effect, multi-pollutant approach were to get onto the nation's policy agenda. The key would be to obtain consensus from the industries that would be affected especially regarding their business operations. As the contribution of transboundary air pollution becomes recognised, industry would find it unacceptable to be subject to new regulations based on analysis taking into consideration only domestic emissions. In fact, in the implementation of existing regulations, some considerations of transboundary air pollution have actually been given to companies – for example, the level of reductions requested of large-scale emitters when the photochemical oxidant warnings were issued were re-examined in the Kyushu region.[11] In the future, it will be necessary to enact effective measures while taking into account the impact of transboundary air pollution. Also, how to deal with uncertainties when building a consensus will be a big challenge. Even if research into the cause-and-effect relationships between pollutants and their effects makes rapid progress, it is impossible to reduce uncertainty to zero since multiple effects occur within a complex mechanism. To hammer out a consensus on

[11] *Asahi Newspaper* (Morning Edition). "Fukuoka and Kumamoto to relax photochemical smog emission reduction, consideration of incoming foreign pollutants for companies (in Japanese)" 19 April 2008, p1.

criteria for judgement under uncertainties that all stakeholders can agree on, it might be necessary to examine the consensus-building process itself.

Promoting air pollution measures in tandem with climate change mitigation policy

In contrast to the responses to the multi-pollutant, multi-effect approach, almost no respondents raised difficulties related to implementation of air pollution measures in tandem with climate change mitigation policy (co-benefit and co-control approach). This implies that, amid increasing efforts to fight climate change, respondents recognised the significance of associating those initiatives with air quality policy which share the same emission sources.

As for specific policies, respondents discussed both domestic measures (on combustion efficiency and fuel conversion) and international measures (on targeted substances and frameworks such as precautionary principles). Related barriers could be summed up into two major points, the first being the fact that co-benefits do not necessarily exist in all cases, and the second being consensus-building.

The first step in overcoming these barriers is to assess the air pollution measures that bring co-benefits and those that do not. As the concept of co-benefits is relatively new, there are risks of confusion in discussions among individuals with different policy benefits in mind. Therefore, in order to make a progress in discussions on co-benefits, it is necessary to sort the expected effects of each policy on reducing air pollutants and/or GHGs. One particular approach might be to categorise measures by their degree of contribution to air quality and climate change and present them in a policy matrix.

Among the suggested challenges related to consensus-building was the gap between the air pollution and climate change communities. Considering that the combustion of fossil fuels is a major contributor to air pollution and climate change, the gap implies inefficiency of policies. One mentioned reason for such gap in the scientific community was the difficulty in expanding their scope of research due to the evaluation measures emphasising the number of published journal articles. It would be no overstatement to say that differences among policymakers arise from the vertical divisions of the various agencies and departments. Improving this situation will require fundamental changes to bridge between science and policy as well as among policies, including evaluation systems of scientists and cross-spectral coordination among government agencies and departments.

4.5 Barriers and challenges pertaining to development of a framework for international cooperation

One particularly noticeable opinion on the preferred framework for international cooperation was the expansion and/or utilisation of EANET. Suggestions by respondents included, specifically with regard to the treatment of scientific information, data collection and evaluation, sharing of environmental information, and coherent cooperation from monitoring to control technologies.

The first barrier mentioned related to the expansion and/or utilisation of EANET was the capacity to deal with air pollution in East Asia. More specifically, it would be next to impossible to expand or utilise EANET if the capacities of participating countries are still insufficient. The second barrier is perception of EANET by other countries as Japan-led, as touched on earlier. If Japan attempts to expand or utilise the network by itself, it might not be effective unless other countries follow along and accept Japanese leadership. In fact, although efforts have been made to strengthen EANET, including the adoption of the "Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia" in 2010, neither China nor Korea showed explicit support for expanding the Network's scope of cooperation, for example, the inclusion of countermeasure technology. In addition to the insufficient capacity mentioned above, one respondent indicated that another barrier is that the custom of holding discussions based on scientific knowledge is still not well established.

In addition, it is necessary to consider the differences between Europe, where LRTAP is considered to be successful, and Asia. LRTAP is highly acclaimed as a successful case of international cooperation resulting in actual emissions reductions, and Agenda 21, which was adopted by the United Nations Conference on Environment and Development in 1992, declared that the lessons of LRTAP should be shared with other regions in the world.[12] Nevertheless, none of the interviewees offered positive opinions on adopting the same methods used in LRTAP into Asia; rather, several interviewees pointed out difficulties related to such adoption. Reasons for these views include both economic and political factors. Economically-speaking, the level of economic development in Asia is different than that in the EU at the time of LRTAP's launch. In particular, the biggest emitters are relatively poor countries in the Asian case. Some respondents believed that the Polluter-Pays Principle (PPP) would be more difficult to be accepted in Asia compared to Europe, due to differences in diplomatic history and the degree of diffusion of democratic norms.

Also emphasised was a need for a system to manage the regional commons, which includes not only the air quality issue but also other issues, by utilising an institution such as a regional scientific panel on air pollution modelled on the IPCC. Such a system would need to be developed based on discussions held in a political forum, as the topic is very sensitive since it extends beyond pollution and encompasses resource issues. Another challenge would be the sharing of scientific knowledge related to the mechanisms of regional environmental issues among countries, which is a precondition to establishing a framework to manage the regional commons.

To address those barriers, in the first place, it is necessary to explore measures that give sufficient consideration to the unique political and economic landscapes in Asia. While Europe was able to reach an agreement that includes reduction rates, Asia, as some respondents'

[12] Excerpt from Agenda 21 is as follows: [9.26] The 1979 Convention on Long-range Transboundary Air Pollution, and its protocols, have established a regional regime in Europe and North America, based on a review process and cooperative programmes for systematic observation of air pollution, assessment and information exchange. These programmes need to be continued and enhanced, and their experience needs to be shared with other regions of the world.

reluctantly suggested, does not seem ready for that level of agreement under the current conditions. Aside from EANET, frameworks for international cooperation on transboundary air pollution in East Asia include LTP and the joint research on photochemical oxidants agreed upon at the 9th TEMM. As mentioned earlier, EANET has not been able to expand substantially beyond acid rain monitoring, despite efforts to strengthen its functions. Cooperation under LTP and the joint project under TEMM remains limited to research and cannot immediately lead to an international agreement, although cooperation in research is very important.[13]

If an international cooperation framework cannot include an agreement on countermeasure technology, its effectiveness in reducing pollution would be limited. One option for creating an effective framework for international cooperation could be to further reform EANET and explore ways to strengthen cooperation, ensuring the active involvement of China and Korea. The advantage of this approach is that it makes use of an existing framework, but looking at recent negotiations on strengthening the EANET, its political feasibility seems to be low. Since other existing frameworks of international cooperation are focused on research, it might be necessary to consider a possibility of developing a new framework. In designing a new framework for international cooperation, efforts will be needed to give sufficient consideration to ensure that all participating countries have a feeling of ownership. Any framework seen as being dominated by one specific country would, as the experience of the EANET shows, invite the risk of creating another overlapping framework plagued with inefficiency. The next important point is to build a cooperative framework tailored to the actual situation in Asia. The countries involved must explore ways to adopt frameworks and measures that they all can agree with, after having sufficiently analysed the success factors of LRTAP and giving due consideration to the unique conditions in Asia. The third issue is the venue for discussion. Given that transboundary environmental issues are diverse and that their relationships with other economic activities are complex, this paper suggests that it seems to be more realistic to discuss the creation of a framework in tandem with discussions on Asian integration, such as the East Asian Community Initiative, rather than as a stand-alone issue.

While addressing the creation of a framework for international cooperation, it is also imperative to continue efforts to strengthen air quality management capacity in developing countries. Reducing air pollutant emissions in the source regions will not only directly improve the health of local citizens, but also lead to lower levels of pollution in the receptor regions. Therefore, it is obvious that offering cooperation in the area of emission reduction from factories and automobiles in China would bring benefits to Japan and Korea (Yanagi 2010). In particular, it is important to actively pursue these kinds of initiatives without waiting for an agreement on an international framework, as the growth in emissions is accelerating in China in recent years.

[13] Under LTP, each country brings together its respective research results in the fields of transboundary air pollution monitoring and modelling (Kim 2012). In comparison, under the TEMM-initiated research on photochemical oxidants, the researchers from three countries jointly conduct researches in the area of the field campaign, quality assurance/quality control (QA/QC) of ozone monitoring, and ozone trend analysis in North East Asia (ACAP).

In either case, the major prerequisite for these efforts is the sharing of scientific knowledge on the transboundary pollution problem. As mentioned above, progress is being made on cooperation as evidenced by the TEMM agreement to cooperate on scientific research concerning photochemical oxidants. It is critical to utilise such scientific knowledge into efforts to create an international framework as well as domestic policies, while continuing efforts to accumulate further knowledge. To achieve this, it would be beneficial to promote effective communication of scientific information not only through the national and international policymaking processes but also through dialogues with relevant stakeholders, including companies and the public, and to create an epistemic community encompassing a wide array of stakeholders.

5. Conclusion

The major findings drawn from this study regarding perceptions on transboundary air pollution among scientists and policymakers in Japan include the following points:

- Respondents' perceptions were found to be similar in terms of the qualitative certainty of transboundary air pollution, its potential for worsening, and the major pollutants that contribute to the problem. However, opinions were divided over the geographic scale of advection and the scope of substances involved.

- When asked about the awareness of other domestic stakeholders, respondents shared common views with regard to the commonality among scientists' perceptions, the sensationalism of the media, and the high interest held by industry. In contrast, opinions were split on matters such as the interest and understanding of the media, each industry's view of the problem, and recognition among the general public.

- Even though Japan, China and Korea all have information on transboundary air pollution, some experts believe that China is comparatively passive about the issue and that Korea and Japan differ on the substances they see as the primary concern and their attitudes toward frameworks for international cooperation.

- Barriers to the adoption of a multi-pollutant, multi-effect approach as part of Japan's policy related to the issue included the lack of a system assessing the multi-effect nature of atmospheric pollution and the difficulty in reaching an agreement on emissions restrictions. On the other hand, limitations mentioned for promoting air pollution measures in tandem with climate change mitigation policy (i.e., the co-benefit and co-control approach) are related to the fact that that measures do not always come with co-benefits and the difficulty in building a consensus between the divergent climate change and air pollution communities.

- Barriers to the development of a framework for international cooperation on transboundary air pollution include the lack of the capacity in many East Asian countries to deal with air pollution despite their economic growth, the reluctance of some countries to cooperate with existing international frameworks initiated by other countries, and the difficulty in adopting the same measures used by LRTAP in Asia given its different political and economic circumstances.

This study uncovered several future policy issues, the first of which is the creation of an epistemic community. There is no question about the importance of further research to elucidate how transboundary pollution arises and advects and the mechanisms underlying its impacts. Furthermore, the research results should be reflected in the domestic policies of the related countries and in the strengthening of the international cooperation framework. In such a process, creation of an epistemic community would be an important key. More specifically, attempts

should be made to connect stakeholders from different fields by promoting information sharing and cooperation between the air pollution and climate change communities, aggregating existing scientific knowledge, and presenting clear policy suggestions. The issue of transboundary air pollution is very complex: there are multiple substances to be addressed; secondary formation, which is influenced by weather conditions, need to be taken into consideration; major emission sources of precursors are mobile sources (such as automobiles) and small-scale sources (such as paint factories); and the impact of substances originating from natural phenomena including yellow sand is significant. As such, it is not easy to convey scientific information to stakeholders in a simple manner. Yet, the maximum effort should be made to communicate the science to other stakeholders. From the perspective of domestic policy, creation of an epistemic community would enhance the chances for adoption of multi-effect, multi-pollutant approach and promoting air pollution measures in tandem with climate change mitigation policy. Internationally, an international initiative which synthesises the latest scientific knowledge by taking a neutral stance and presents to policymakers in a clear manner is needed to make a breakthrough in the current lack of agreement among the nations of Asia differ on the science underlying transboundary air pollution.

Next, regarding the creation of a framework for international cooperation, it will be necessary to reach an agreement on measures tailored to the Asian situation while keeping in mind the issue of ownership. Measures need to be examined and agreed considering Asia's unique political and economic background. Also, the design of the system should accommodate a sense of ownership felt by all participating countries without giving significant bias to any specific party. If an agreement through an existing framework cannot be reached, it might be necessary to consider developing a new framework. While promoting international negotiations for development of a cooperation framework, it is crucial to continue cooperation by taking currently realistic and feasible actions, for example, through capacity development in atmospheric management in emitting countries and collaboration on emission technology.

Finally, the results of this study, as noted above, were drawn through qualitative analysis of the commonalities and differences in perception of a limited number of experts and the barriers and challenges they have raised. Hence, this research is not a comprehensive and quantitative assessment of the perceptions of Japan's scientists and policymakers. Based on the findings of this study, a desirable course of action going forward is to refine the survey questions and hold surveys with a larger sample in order to obtain a better understanding of the perceptions of transboundary air pollution in Japan. In addition, to widen the scope of resources that can be used for considering possible frameworks for international cooperation, future research will be needed regarding the perceptions of the other stakeholders that were not directly covered by this study. In particular, if the perception gap can be analysed by comparing the responses obtained from this survey and other surveys addressing other stakeholders, such analyses might have implications to facilitate the progress of negotiations on international cooperation.

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Appendix: Survey Form

Global Environment Research Fund (S-7)
Scientific Analysis of Regional Air Pollution and Promotion of Air Pollution Management in East Asia Considering Co-benefits

Theme 3
Research on an international framework and co-benefit approach to promote air pollution control in East Asia

Sub-theme 2
Research on restrictive factors and barriers to the promotion of negotiations in major related countries based on the countries' environmental policy trends and their underlying determining factors

Survey on Perceptions of Transboundary Air Pollution

1. The following questions pertain to **your own perceptions** of transboundary air pollution:

   a. Recent research points to the possibility of air pollutants being transported from the Asian continent. What are your views on the **scientific certainty** of this research and the **severity of the problem**? In particular, which **air pollutants** do you consider as major contributors to transboundary air pollution?

   b. Where do you think the pollutants you mentioned in the previous question **originate,** and which regions do you think are **suffering** from high concentrations of said pollutants?

   c. What **impact** does transboundary air pollution have on Japan?

2. The following questions pertain to **other stakeholders' perceptions** of transboundary air pollution:

   d. Please express your opinions on the **perceptions of scientists** regarding a though c above.

   e. Please express your opinions on the **perceptions of the media** regarding a though c above.

   f. Please express your opinions on the **perceptions of industry** regarding a though c above.

   g. Please express your opinions on the **perceptions of the general public** regarding a though c above.

   h. Please express your opinions on the **perceptions of neighbouring countries (China, Korea, etc.)** regarding a though c above.

3. The following questions focus on **domestic policies concerning transboundary air pollution and the barriers and challenges pertaining to international cooperation**.

   i. Currently, measures have been taken to address the individual air pollutants. Do you think it would be possible, for Japan to adopt a **multi-effect, multi-pollutant approach**? Specifically, what kind of policies do you think can be introduced? What do you think are the barriers and challenges of the **multi-effect, multi-pollutant approach**?

j. Likewise, what are your views on the potential for **promoting air pollution measures in tandem with climate change mitigation policy**? What kind of policies do you have in mind and what do you think are the barriers and challenges?

k. **International cooperation on transboundary air pollution** includes examples such as joint monitoring of air quality by EANET. In the future, what kind of **framework for international cooperation** do think is desirable? What barriers or challenges would there be in making the framework you have in mind face a reality?

l. If there are any **other items** you feel are important with regard to transboundary air pollution, please provide your opinions.

Finally, please indicate whether we may include your name in our report as having cooperated with this survey and interview.

Thank you for your cooperation.

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