EANET and Clean Air for Sustainable Development

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Acid Deposition Monitoring Network in East Asia

(EANET)

Third Report for Policy Makers: EANET and Clean Air for Sustainable Development

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Authors: Acid Deposition Monitoring Network in East Asia (EANET)

Publisher's name and address: Acid Deposition Monitoring Network in East Asia (EANET) Secretariat,
Regional Resource Centre for Asia and the Pacific (RRC.AP),
Asian Institute of Technology (AIT), 58 Moo 9,
Phaholyothin Rd., Klongluang, Pathumthani 12120 Thailand
Phone: +66-2-524-6242 / 524-6244
Fax: +66-2-516-2125
URL: http://www.rrcap.ait.asia
URL: www.eanet.asia

This report has been prepared based on the available reports, scientific data from the EANET monitoring, assessment and research, supplemented by information obtained from various sources which are duly acknowledged.

The contents of the report do not necessarily reflect the views, policies or opinions of any participating country and organization.

The term East Asia used in this report refers to Northeast Asia and Southeast Asia unless otherwise stated.

Foreword

The Third Report for Policy Makers (RPM3): "EANET and Clean Air for Sustainable Development" was produced by the Acid Deposition Monitoring Network in East Asia (EANET). The preparation of this publication started in early 2013 and was completed by the end of 2014.

This is the third report of a series of publications produced by the EANET specifically for policy makers to provide them with updated information on the state of the atmospheric environment with focus on deposition of major acidifying species and related chemical substances in East Asia, future trends, and recommend possible actions that may be taken by individual countries as well as regionally to improve the atmospheric environment. The information and data provided in the RPM3 is sourced from recent internationally recognized publications.

The theme of the RPM3, namely, **EANET and Clean Air for Sustainable Development** is very appropriate in current times when development is taking place at a rapid pace in most parts of Asia. The EANET's aims are to promote regional cooperation in efforts to monitor changes in the atmospheric environment, and encourage countries to take appropriate mitigative and preventive measures for a cleaner atmospheric environment. Reducing acid deposition and related air pollution is a positive step towards sustainable development.

As the Chairperson of the Fifteenth Session of the Intergovernmental Meeting on the EANET (IG15) and on behalf of the Secretariat and the Network Center, I would like to express our thanks to the National Focal Points (NFPs) of the EANET participating countries for their assistance and input to the RPM3. Various experts and resource persons from within and outside the EANET have also made valuable contributions in the development of this RPM3. The Working Group on Future Development of the EANET (WGFD), the Scientific Advisory Committee (SAC) and the Intergovernmental Meeting (IG) during their sessions have all provided useful guidance and comments which enabled the successful finalization of the RPM3.

It is hoped that the RPM3 will serve as a useful guide to policy makers of the EANET participating countries in their important role of ensuring clean air and a sustainable future for the region.

Ms. Araya Nuntapotidech
Chairperson of the IG15

PREFACE

Emissions of air pollutants from combustion of fossil fuels continue to increase in Asia due to increasing energy demands. From past experience in Western countries, substantial increases in the combustion of fossil fuels for power generation and transportation can improve economic conditions but can also, if not controlled, have important negative consequences for human health and environmental quality through transboundary transport of pollutants. Effective approaches to controlling and reducing pollution are crucial to avert increased environmental degradation and associated health impacts while reducing poverty and providing economic stability for the population.

Policy makers have an important role to play in safeguarding the environment through the implementation of sufficient legislative and policy tools and ensuring that there is compliance of environmental laws and regulations. The Acid Deposition Monitoring Network in East Asia (EANET) is a scientific initiative, established to promote regional cooperation in addressing acid deposition and other related atmospheric pollutants. Since the commencement of its regular phase activities in 2001, the EANET has been providing many valuable scientific inputs to policy makers to assist them in decision making on mitigation of air pollution and other related environmental protection issues. Reports specifically for the policy makers have been published once in every four years in order to convey important scientific information directly to the decision makers of the participating countries.

The first issue of the Report for Policy Makers published in November 2005 announced the EANET's goals, its achievements during the first 5 years of operation and future plans. The second Report for Policy Makers published in November 2009 reported promotion of timely action to attain better air quality management by integrating prevention and mitigation of air pollution and acid deposition. The objectives of the third Report for Policy Makers of the EANET are to provide an update on progress and activities of EANET, trends of the regional atmospheric environment, to inform on new emerging issues concerning the environment and the results of relevant scientific studies. This report also highlights the recent achievements of the network. It is hoped that the report would provide policy makers in the participating countries of the EANET and other relevant organizations with a sound scientific basis for decision making to improve local and regional air quality, and ensure sustainable development of the region.

EXECUTIVE SUMMARY

Clean air is critical for life. Even small amounts of pollution make air unhealthy to breathe. Air pollution is recognized as a major health risk affecting mainly the very young, elderly and people suffering from heart and respiratory disease. Millions of premature deaths occur each year as a result of exposure to air pollutants, in particular ambient fine particulate. In addition to the impacts on human health, air pollution also causes degradation of the environment. The yield loss of crops due to air pollution, particularly vegetation damage from exposure to high levels of tropospheric ozone, affects the income of the farming community. Remedying environmental disasters such as air pollution, acidification, eutrophication and loss of biodiversity require actions that are costly, complex and often difficult to implement. Thus diligent continuous monitoring of the state of our environment and taking early and effective preventive measures are of the utmost importance.

As a result of the rapid rate of economic development in Asia, the air quality, as determined by the concentrations of the major pollutants in the atmosphere, has further deteriorated in recent years and is projected to further decline over the next 40 years. The situation is more serious in the urban cities where the levels of PM10 had significantly exceeded the World Health Organization (WHO) annual mean guideline in the past decade. The WHO has estimated that 7 million premature deaths annually are linked to air pollution thereby confirming that air pollution is now the world's largest single environmental health risk. Based on the projections by the United Nations, the total population in Asia will exceed 5 billion by the year 2050 and approximately 65% of the population will be living in the cities. This will result in a growing number of people at risk of premature death.

There are a number of successful on-going initiatives and emerging networks within Asia working to reduce regional atmospheric pollution. Enhanced strategic cooperation between these initiatives building closer relationships with the governments of countries within East Asia is important for policy action to ultimately reach agreement on effects-based emission reductions of air pollutants in East Asia.

Although EANET has progressed and achieved considerable success in the last decade, the current environmental issues present an opportunity for the EANET to play a bigger role in the region. It would appear timely for the EANET to consider expanding of its scope as provided for in the Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET) by adopted a step-wise approach. The vision is to progress from monitoring and assessment of acid deposition to include other related chemical substances; joining forces with other regional initiatives for a cleaner atmospheric environment, and sustainable development in East Asia.

EANET – A BRIEF INTRODUCTION

The Acid Deposition Monitoring Network in East Asia (EANET) is an intergovernmental regional network established for promoting cooperation among countries in East Asia to address acid deposition problems.

Objectives:

1. To create a common understanding of the state of acid deposition problems in East Asia
2. To provide useful inputs for decision-making at local, national and regional levels aimed at preventing or reducing adverse impacts on the environment caused by acid deposition
3. To contribute to cooperation on the issues related to acid deposition among the participating countries

Acid deposition as defined in the Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET) means deposition of major acidifying species and related chemical substances. Presently ozone and particulate matter (PM) are included in the monitoring components of the EANET under "related chemical substances".

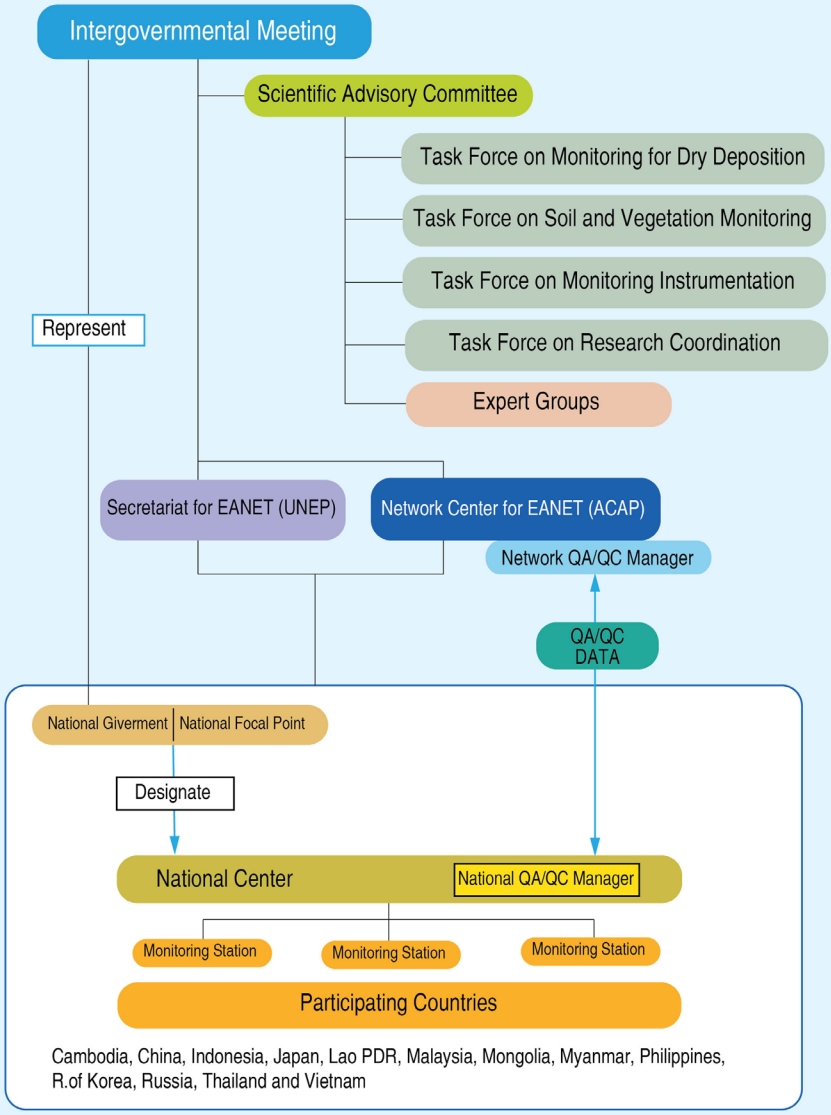
Thirteen countries in the East Asian region are participating in the EANET activities, namely Cambodia, China, Indonesia, Japan, Lao P.D.R., Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Russia, Thailand and Vietnam. Currently the United Nations Environment Programme (UNEP) has been designated as the Secretariat for the EANET. The Regional Resource Centre for Asia and the Pacific (RRC.AP) in Pathumthani, Thailand carries out the Secretariat functions as agreed by the Chair of the Intergovernmental Meeting (IG) and UNEP. The Asia Center for Air Pollution Research (ACAP) in Niigata, Japan has been designated as the Network Center for the EANET.

Since 2001 the EANET has been conducting monitoring, analysis, and evaluation and assessment of data and information from the network of monitoring sites in the participating countries. The network also promotes scientific research, conducts capacity building and public awareness programmes, and facilitates the exchange of information related to acid deposition and air pollution to assist policy makers in decision making to mitigate atmospheric pollution and its impacts. The EANET has gained international recognition for its success in promoting regional cooperation on acid deposition in East Asia.

The IG meets annually to make decisions on the implementation of the Network's activities while the Scientific Advisory Committee (SAC) has been established to provide advice on the scientific and technical aspects to the IG and develop the periodic assessment reports. The activities of the EANET are funded by voluntary financial contributions from the participating countries.

The EANET publishes a Data Report annually, Periodic Reports on state of acid deposition in the region once in five years and the EANET Science Bulletins biennially which reports the results of recent scientific research conducted on acid deposition and related air pollutants and their impacts.

Institutional Framework of the EANET



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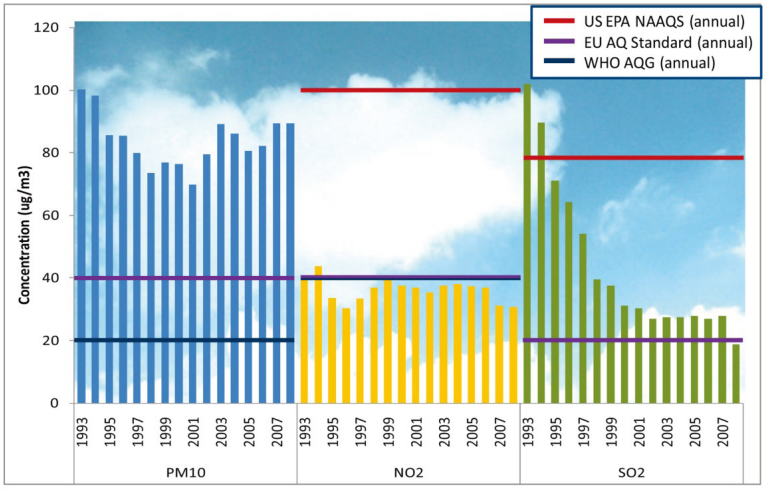
1. OVERVIEW OF AIR QUALITY IN ASIA

1.1 CURRENT STATE OF GLOBAL AND REGIONAL AIR QUALITY

Due to growing awareness of the serious effects of air pollution, countries throughout Asia have taken action to address the problem of air pollution over the past two decades. Many countries have adopted National Ambient Air Quality Standards for several air pollutants such as SO_2, and PM10, implemented measures to reduce emissions from specific sources, notably motor vehicles, industries and power plants, and taken action to relocate industries away from populated areas.

While Europe and North America have witnessed success from their efforts to reduce air pollution, the actions and policies implemented so far in East Asia appears to be less effective in improving regional air quality to healthy levels and achieving sustainable development. The 2010 Clean Air Initiative for Asian Cities (presently Clean Air Asia) report on status and trends revealed that in 2008, only two cities had annual average PM10 levels within the WHO Air Quality Guidelines (AQG) of 20 µg/m^3 while about 58% of the cities had annual PM10 levels exceeding even the WHO Interim Target-1 (IT-1) of 70 µg/m^3. The average of annual average PM10 concentration for 230 cities is 89.5 µg/m^3, i.e. approximately 4.5 times higher than the WHO AQG. As there is no existing AQG set by WHO for annual average SO_2, when the 24-hr WHO AQG for SO_2 was used as a comparison with the annual average SO_2 concentrations of the cities, and it was found that 24% of cities did not even meet the 24-hr WHO AQG. 27% of the cities surveyed had annual average NO_2 concentrations above the WHO AQG (**Figure 1**).



AQ = air quality; µg/m^3 = micrograms per cubic meter; US EPA = United Stated Environmental Protection Agency; NAAQS = National Ambient Air Quality Standards; EU = European Union; WHO = World Health Organization; AQG = air quality guidelines; PM_{10} = Particles with aerodynamic particle diameters of 10 micrometers or less; NO_2 = Nitrogen dioxide; SO_2 = Sulfur dioxide.

Source: CAI-Asia, 2010. [Note: Air quality data is compiled by CAI-Asia Center from official sources (publications, personal communications) for 243 Asian cities – as of April 2010.]

Figure 1: *Average of Annual Average Ambient Concentrations of PM10, NO_2 and SO_2 in Selected Asian Cities (1993-2008)*
Source: CAI-Asia, 2010
Note: *The USEPA annual standard of 78 µg/m^3 for SO_2 was revoked after 22 June 2010.*
The EU AQS annual standard of 20 µg/m^3 for SO_2 is for protection of vegetation.

In a more recent study by Clean Air Asia, it was reported that urban air quality has further worsened. Based on the annual average PM10 levels in 310 Asian cities in 2010, seven out of 10 cities in developing Asia have poor air quality levels (**Figure 2**). This study also revealed that average concentration of PM10 which have somewhat stabilized in recent years, is again on the rise. Concentrations of SO_2 which were on the decline in the last decade now show an increasing trend (**Figure 3**). The levels of PM10 in the cities of Asia well exceeded the WHO health-based daily guidelines.

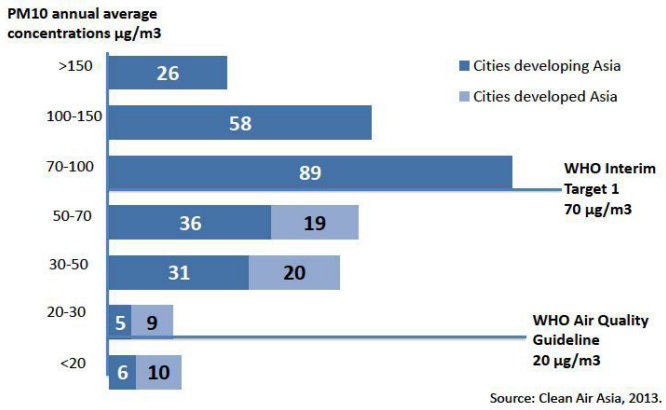


Figure 2: *Number of cities in Asia with poor air quality for PM10 in 2010*
Source: Clean Air Asia, 2013

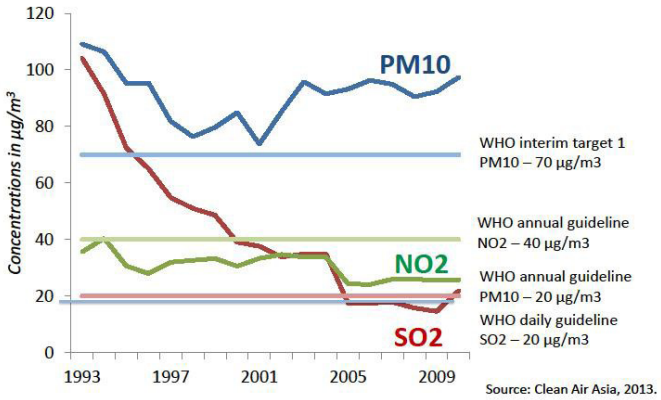


Figure 3: *Trend of major pollutants in Asian cities during 1993-2010*
Source: Clean Air Asia, 2013

From air pollution studies conducted by the Task Force on Hemispheric Transport Report, HTAP 2010, it was revealed that anthropogenic NOx emissions from East Asia (as defined in the caption) in the year 2005 was comparable to levels recorded in Europe and in North America (**Figure 4**).

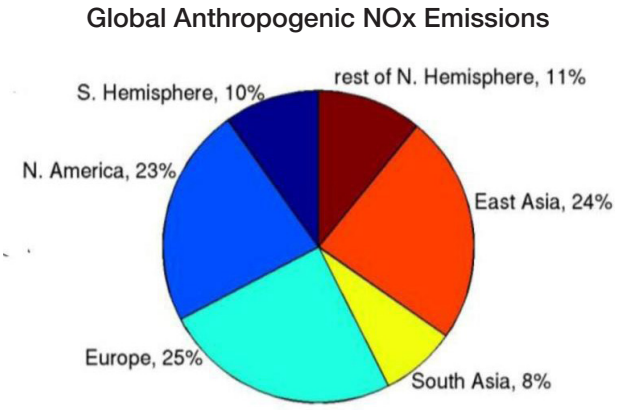


Figure 4: *2005 Global Anthropogenic NOx Emissions*
Note: *East Asia is the area bounded by (approximately) latitude 15°N-50°N and longitude 90°E-160°E*
Other parts of Southeast Asia are included in S. Hemisphere
Source: HTAP, 2010

1.2 URBAN AIR QUALITY – A RISING CONCERN

Figure 5: Transboundary haze affecting a city in Southeast Asia

Based on statistics from the United Nations, 45% of the populations in Asia currently live in cities (**Figure 6**). The total population in Asia is projected to increase more rapidly than other regions in the world exceeding 5 billion by the year 2050. Demographic trends indicate that the urban/rural ratios will continue to increase with more than 65% of the population living in the urban centres by 2050 (**Figure 7**).

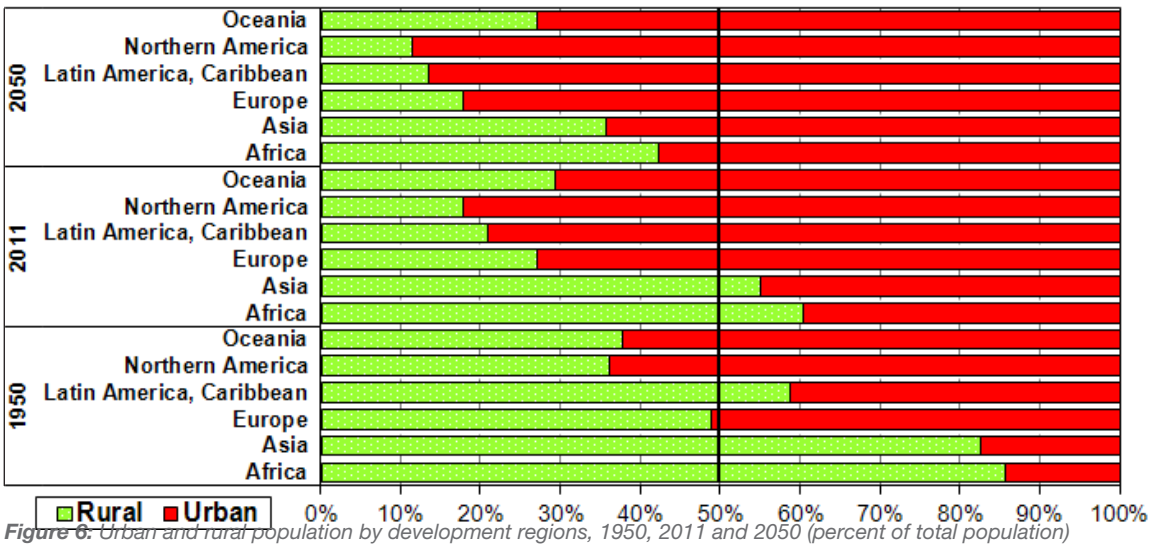


Figure 6: Urban and rural population by development regions, 1950, 2011 and 2050 (percent of total population)
Source: UN, 2012

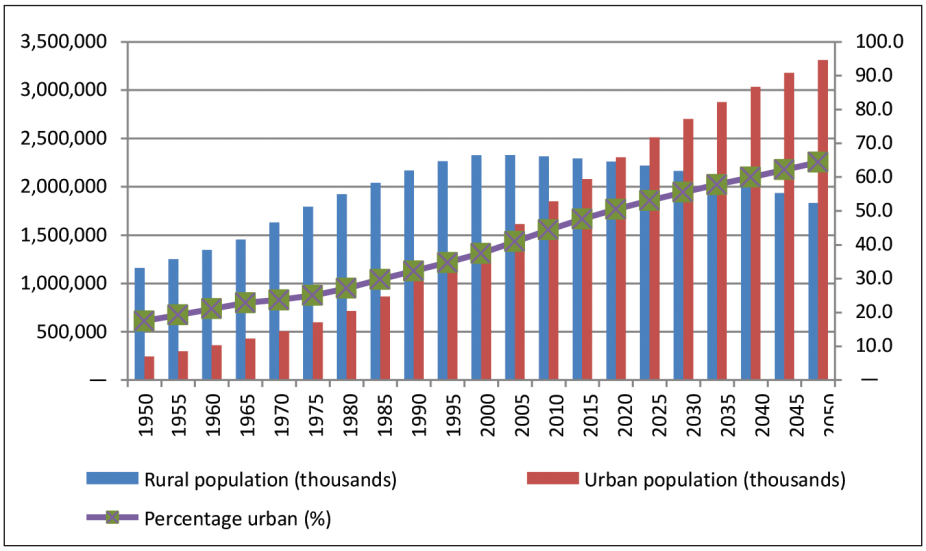


Figure 7: *Rural and Urban Populations in Asia*
Data source: World Urbanization Prospects, the 2011 Revision, United Nations Department of Economic and Social Affairs

Despite the implementation of aggressive legislative and policy tools, air pollution in the urban centres of East Asia remains a serious concern. Photochemical smog frequently obscures the city skyline. The smog could linger for days in the absence of strong winds or rain enabling dispersal. During the dry season, severe haze from widespread forest and land fires affect the livelihoods of the population in Southeast Asia. In the cities, the problem is compounded by traffic and industrial pollutants exposing the urban population to higher health risk. In countries where traditional methods of cooking are still practiced by low-income households, black carbon and ozone contribute to indoor air pollution and are considered major environmental issues. The urban centres are also the highest emitters of greenhouses gases from man-made sources.

The World Health Organization (WHO) International Agency for Research on Cancer (IARC) has recently classified diesel exhaust as a known human carcinogen. Since the majority of the populations in the megacities live within 50 meters of a major road, exposure to particulate matter and NOx from diesel exhausts is expected to cause more respiratory infections, reduced lung function, and asthma which may lead to death.

In October 2013, the WHO took a further step of classifying outdoor air pollution as carcinogenic to humans (Group 1) and noted a positive association with an increased risk of bladder cancer. Particulate matter, a major component of outdoor air pollution is also classified as carcinogenic to humans as the IARC evaluation showed an increasing risk of lung cancer with Increasing levels of exposure to particulate matter and air pollution. Given the scale of the exposure affecting people world-wide, and the large populations living in the urban regions, this important step by WHO should send a strong signal to the international community and government agencies to take action to reduce anthropogenic sources of outdoor air pollution, in particular urban air pollution, without further delay to avoid increasing cancer deaths.

Urban air can influence regional air quality since the longer-lived pollutants emitted from urban centres are mixed in the ambient air and transported by the wind to other areas and beyond national boundaries.

1.3 PROJECTIONS OF AIR POLLUTION TRENDS

Emissions of most anthropogenic air pollutants including greenhouse gases have been increasing globally and are expected to continue to rise in the coming years due to escalating fossil fuel consumption (**Figure 8**). Many studies have been conducted on future trends of emissions from various regions in the world using various scenarios. Among the most comprehensive results are the findings from the Task Force on Hemispheric Transport of Air Pollution as reported in HTAP 2010.

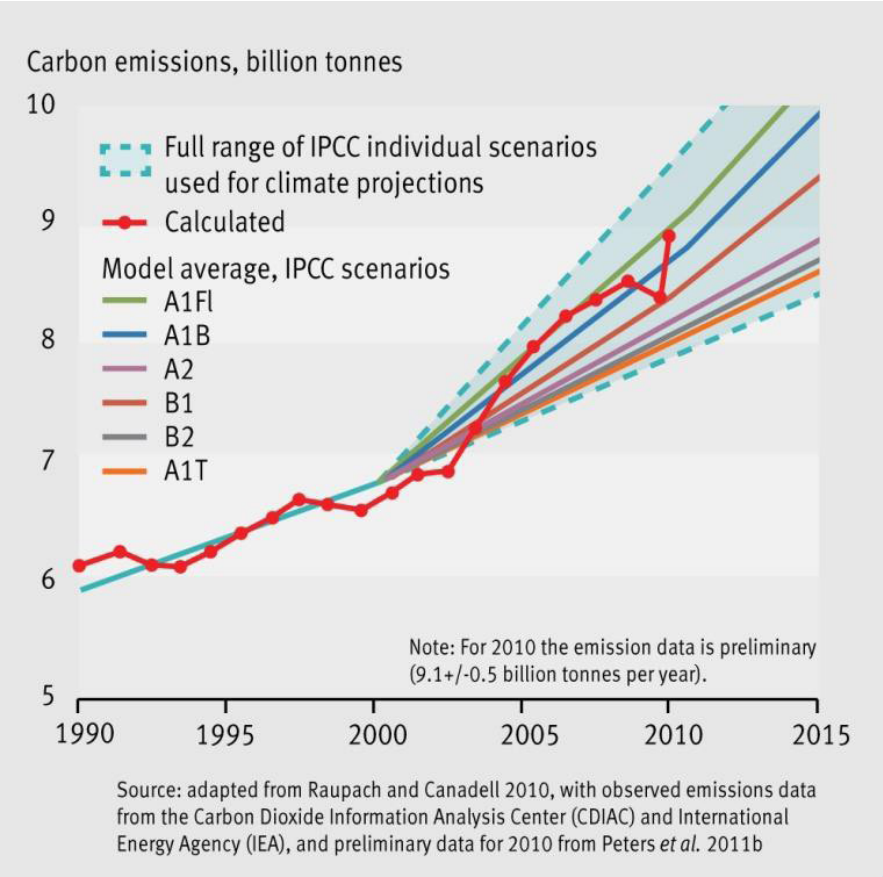


Figure 8: *Trends in fossil fuel emissions calculated and IPCC scenarios, 1990-2015*
Source: UNEP, 2012

The HTAP 2010 assessment on emission trends of SO_2 from 1850-2000 with four Representative Concentration Pathway (RCP) scenarios from 2000 – 2050, developed using hemispheric transport models shows a general declining trend for SO_2 concentrations in East Asia (Northeast Asia) although emissions from some countries in Asia increased during the period 2000-2005. It is projected to further decline (**Figure 9**).

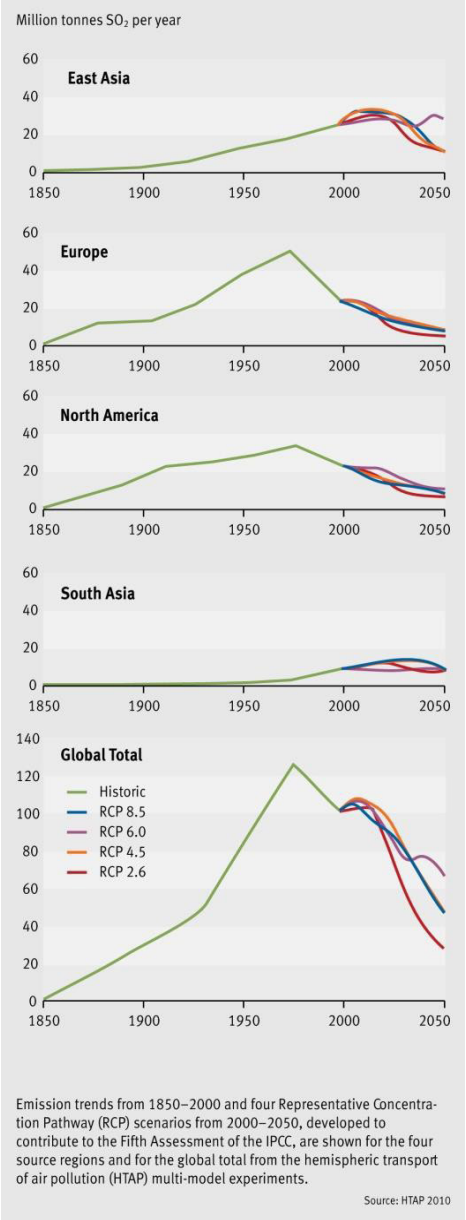


***Figure 9**: Regional trends in sulphur dioxide emissions, 1850 – 2050*
Source: HTAP, 2010

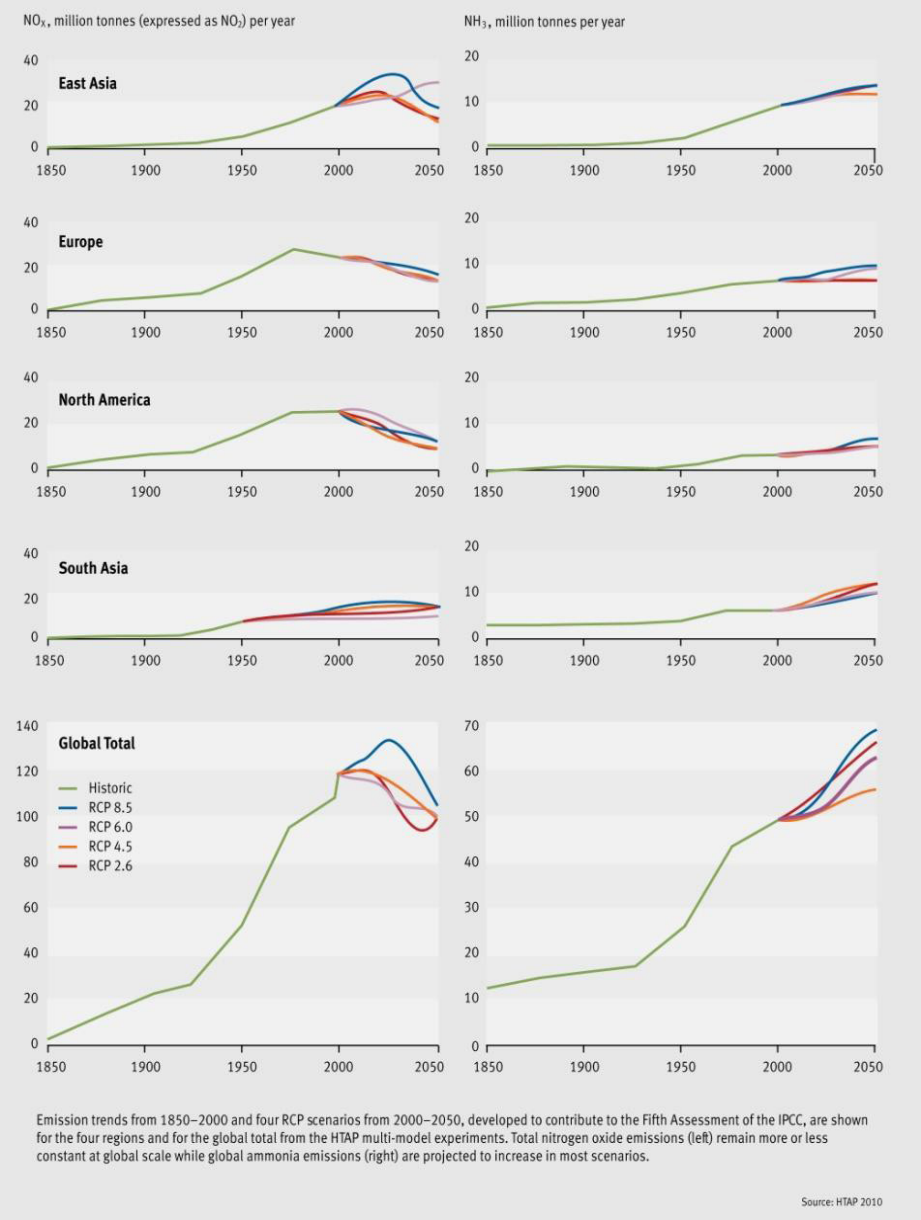


***Figure 10:** Regional trends in emission of nitrogen oxides and ammonia, 1850 - 2050*
Source: HTAP, 2010

In the HTAP 2010 assessment on trends of nitrogen oxides emissions it was found that globally total emissions increased until around 2000 and is expected to remain more or less constant after. In East Asia (Northeast Asia) however, emissions have continued to increase rapidly in the past two decades and the projections show that both nitrogen oxides and ammonia emissions are likely to increase further in the short term while in the case of nitrogen oxides a decline could be expected in the longer term (**Figure 10**).

In the same assessment, the use of six global photochemical models to assess the implications of emission changes between 2000 and 2050 for a variety of emission scenarios has produced variable results on future changes in tropospheric ozone (**Figure 11**). It shows that the outlook for ozone concentrations is heavily dependent on global and regional emission pathways.

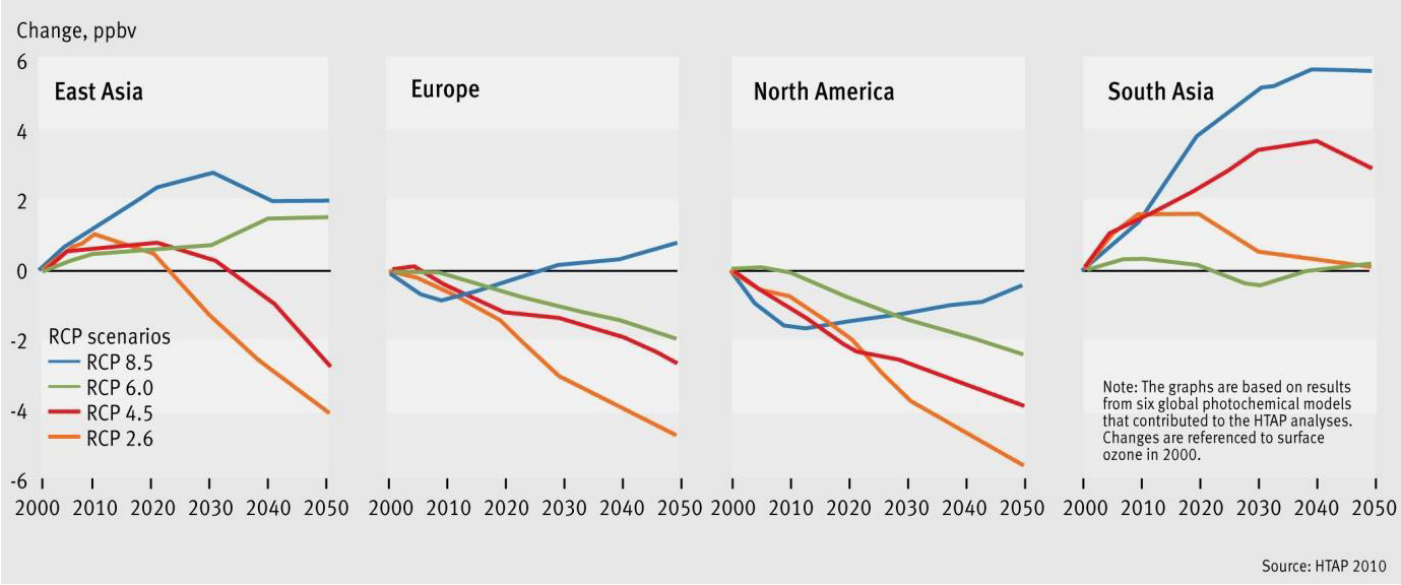


Figure 11: *Projected changes in surface ozone concentrations over polluted regions of the northern hemisphere, 2000 - 2050*
Source: HTAP, 2010

2 POLLUTANTS OF CONCERN AND THEIR POTENTIAL ADVERSE EFFECTS

2. POLLUTANTS OF CONCERN AND THEIR POTENTIAL ADVERSE EFFECTS

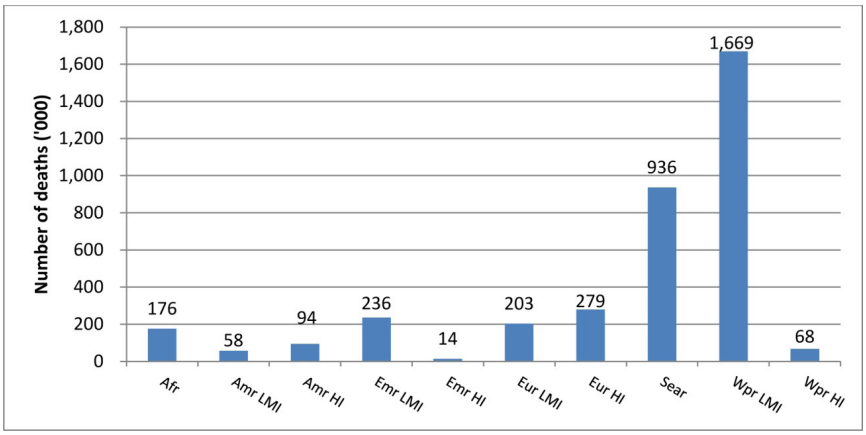
2.1 AIR POLLUTION THREATS TO HUMAN HEALTH AND FOOD SECURITY

Very large populations in developing Asia are exposed to high concentrations of air pollution, mainly from combustion of fossil fuels. The combustion products consisting of a mixture of pollutants - fine particulate matter and gases (such as O3, SO_2, NO_2), have been found to adversely affect human health causing chronic cardio-vascular disease, respiratory infections and lung cancer.

The Health Effects Institute (HEI) has carried out a new systematic analysis, the 2010 Global Burden of Disease (GBD), which looks at all major global health risks (HEI, 2012). It was found that outdoor air pollution in the form of fine particulates annually contribute to over 3.2 million premature deaths worldwide. Outdoor air pollution now ranks among the top 10 risks factors globally. The GBD 2010 also estimated that 0.2 million deaths worldwide can be attributed to outdoor ozone pollution in 2010, mostly in the developing countries.

In March 2014, the WHO reported that around 7 million people died as a result of air pollution exposure in 2012 (WHO. 2014a). This finding more than doubles previous estimates and confirms that air pollution is now the world's largest single environmental health risk. The study also revealed a stronger link between both indoor and outdoor air pollution exposure and cardiovascular diseases, such as strokes and ischaemic heart disease, as well as between air pollution and cancer. This is in addition to air pollution's role in the development of respiratory diseases, including acute respiratory infections and chronic obstructive pulmonary diseases.

About 88% of the deaths occur in low- and middle-income (LMI) countries, which represent 82% of the world population (WHO. 2014b). Regionally, low- and middle-income countries in the WHO South-East Asia and Western Pacific Regions had the largest air pollution-related burden in 2012 (**Figure 12**), with a total of 3.3 million deaths linked to indoor air pollution and 2.6 million deaths related to outdoor air pollution. Reducing air pollution could therefore save millions of lives.



AAP: Ambient air pollution; Amr: America; Afr: Africa; Emr: Eastern Mediterranean; Sea: South-East Asia; Wpr: Western Pacific; LMI: Low- and middle-income; HI: High-income

Figure 12: *Total deaths ('000) attributable to ambient air pollution in 2012, by region*
Source: WHO. 2014b

The vast majority of air pollution deaths are due to cardiovascular diseases as shown below in the breakdown of deaths attributed to specific diseases:

Outdoor air pollution-caused deaths – breakdown by disease:

- 40% - ischaemic heart disease;
- 40% - stroke;
- 11% - chronic obstructive pulmonary disease (COPD);
- 6% - lung cancer; and
- 3% - acute lower respiratory infections (ALRI) in children.

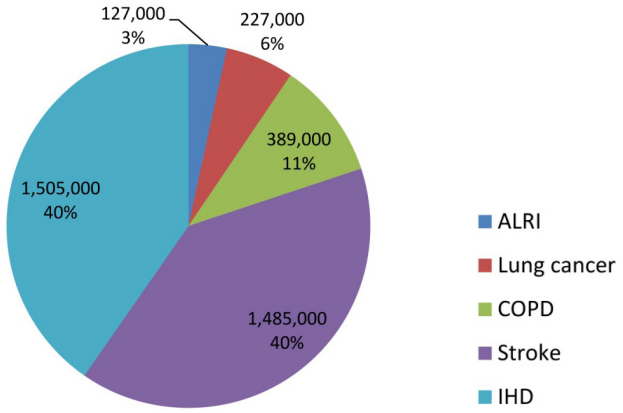


Figure 13: *Deaths attributable to Outdoor Air Pollution in 2012, by disease*
Source: WHO. 2014b

Indoor air pollution-caused deaths – breakdown by disease

- 34% - stroke;
- 26% - ischaemic heart disease;
- 22% - COPD;
- 12% - acute lower respiratory infections(ALRI) in children; and
- 6% - lung cancer

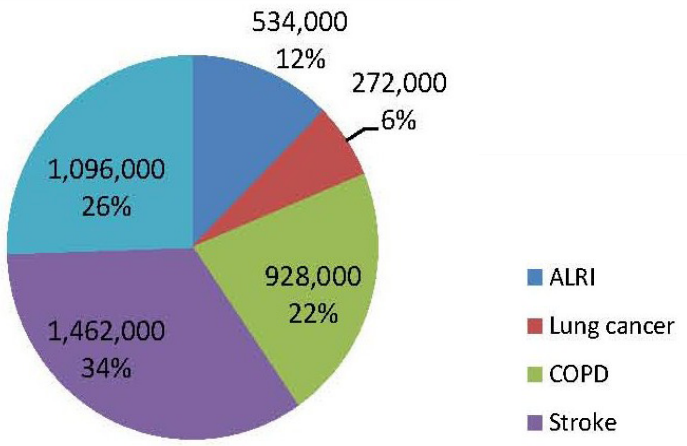
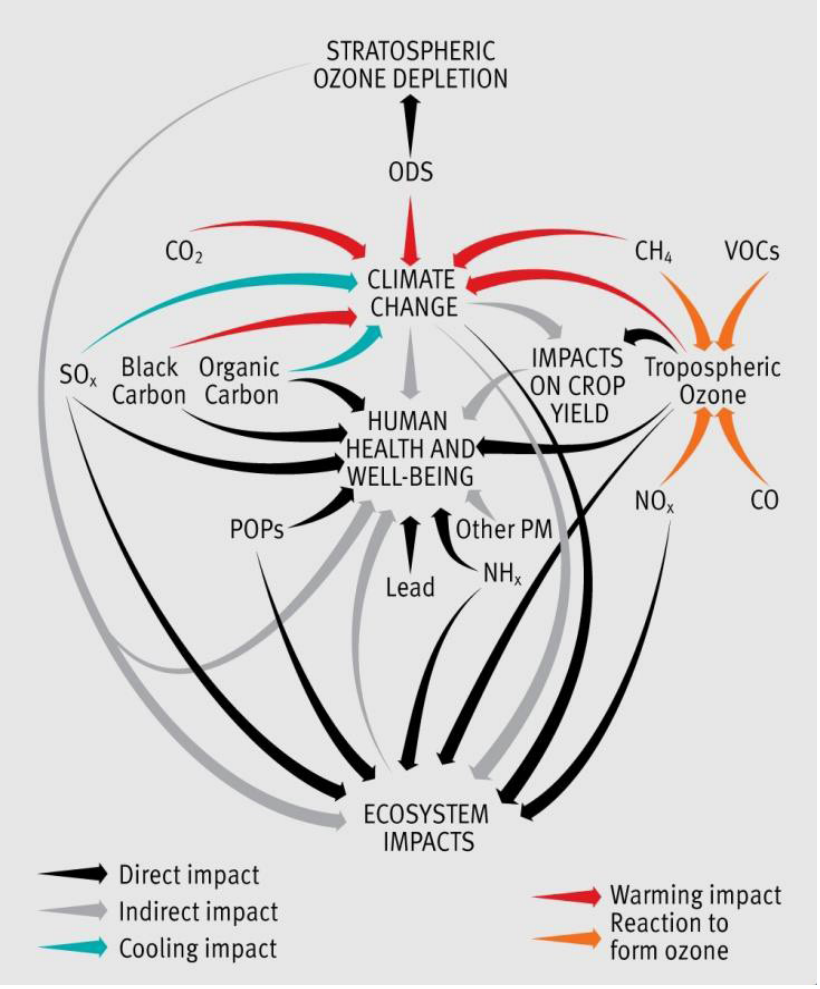


Figure 14: *Deaths attributable to Indoor Air Pollution i*
Source: WHO. 2014b

There has been a substantial increase in the number of studies on the effects of short-term exposure to pollution (particularly to PM10) in Asia; however studies on the chronic effects of long- term exposure are still rather limited. In a study by the Health Effects Institute's (HEI) Public Health and Air Pollution in Asia Program 2010 (PAPA 2010) it was found that a 10 μg/m^3 increase in PM10 concentrations was associated with an increase of 0.6% in the daily rate of death from all natural causes. In Asia, this proportional increase in daily mortality was observed at levels of exposure which were several times higher than the record in most large Western cities. An increase of 10 μg/m^3 in ozone concentration is reported to increase the risk of death by 0.3-0.5%. Ozone can also have chronic health effects resulting in permanent lung damage. However more local epidemiological research should be conducted reflecting East Asian concentrations of particulate matter and ozone so that the uncertainty in risk estimation can be reduced.

Ozone is also the most important air pollutant causing damage to vegetation, diminishing crop yields and forest productivity and altering net primary productivity. Estimates suggest that ozone–induced yield losses range between 3 and 16% for four staple crops – maize, wheat, soybean and rice – which translates into annual global economic losses of US$14-26 billion (HTAP, 2010). Researchers in East Asia have found that the yield response functions may differ from North America and some crops (wheat and rice) showed a greater sensitivity in Asia (EANET, 2011c). The development of fundamental data sets such as crop distribution and calendar is crucial to obtain more reliable risk assessment of crop yield loss as well as exposure response function of crops in East Asia.

2.2 INTER-LINKAGES OF ACID DEPOSITION AND AIR POLLUTION WITH OTHER ATMOSPHERIC ENVIRONMENTAL ISSUES



Air quality, stratospheric ozone depletion and climate change are closely related, as individual pollutants can have multiple impacts on health, crop yields, ecosystems, cooling or heating of the atmosphere and stratospheric ozone depletion, all with the potential to affect human well-being. Many sources also emit multiple pollutants that can both affect air quality and cause climate change (**Figure 15**). One such link arises from the atmospheric emissions of sulfur which results in both (1) an increase in acid deposition, and (2) an increase in tropospheric levels of sulfate aerosols, which in turn, scatter solar radiation, modify clouds and their properties and may mask global warming caused by greenhouse gases (Jonas et al., 1995).

Figure 15: *Impacts of and links between selected substances emitted to the atmosphere*
Source: UNEP, 2012

Addressing sources of pollution can deliver both air quality, climate and other atmospheric environment benefits. For instance, whereas reducing acid precursor may lessen sulfate and nitrate aerosols which are primary constituents of PM2.5, reducing ozone and aerosols/particulate matter emissions could reduce air pollution and acid deposition risk and since these pollutants contribute to climate change, it would also slow down the process of global warming, and mitigate possible disruption of rainfall patterns. Despite the strong inter-linkages, most governments address the issues separately, due to various reasons. Depending on which measures are implemented there could be co-beneficial or antagonistic outcomes and, unless a more integrated approach is adopted, there is a risk that different atmospheric policies could work against each other.

However, in some cases, acid deposition (as acid rain) could be good for forests. According to scientists at Michigan Technological University's School of Forest Resources and Environmental Science, moderate increases in temperature and nitrogen deposition from atmospheric pollution may actually improve forest productivity.

Ambient particulate matter smaller than 2.5 μm (PM2.5) is a complex mixture of extremely small particles and liquid droplets with a broad compositional range, and may have primary and/or secondary sources mainly from transportation, wind-blown dust, burning of biomass and industrial activities. Black carbon, a component of (PM2.5), is a product of the incomplete combustion of fossil fuels, biofuels and biomass.

2.3 TRANSBOUNDARY NATURE OF AIR POLLUTION

Air pollution does not recognize national borders. Many countries have their own sources of air pollutants and are also receiving air pollutants transported from neighbouring and distant countries through pathways such as air and water, causing damage to the country's environment. Even the most remote places on earth are not spared from the effects of transboundary air pollution. The pollutants of concern can be grouped according to their effects:

Acidification & eutrophication: SOx, NOx, VOCs, ammonia
Health and ecosystem: fine particulate matter, tropospheric ozone, heavy metals (cadmium, lead, mercury), POPs
Climate change: CO_2, CH_4, tropospheric O_3, N_2O, CFC11& 12, HCFC22 & 134a, aerosols such as black carbon

Examples of transboundary air pollution in the Asian region are the long-range transport of mineral dust, the high ozone concentrations affecting Northeast Asian countries during Spring/Summer, the regional haze episodes from forest and land fires in Southeast Asian countries and Atmospheric Brown Clouds (ABCs) over parts of Asia and other regions. Acid deposition, observed in some regions of East Asia, is also a transboundary pollution issue (EANET, 2011c).

As air pollution sources and overall emissions increase throughout Asia and become more dispersed, regional and transcontinental transport of air pollutants and related health issues become of greater concern. It is estimated that long-range transport of particulates may be responsible for 380,000 premature deaths worldwide, of which 75% are attributable to mineral dust PM2.5 (HTAP, 2010).

A number of regional/international efforts are underway to deal with these issues:

- Acid Deposition Monitoring Network in East Asia (EANET)
- Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia
- Association of Southeast Asian Nations (ASEAN) Agreement on Transboundary Haze Pollution
- United Nations Economic Commission for Europe Convention on Long-range Transboundary Air Pollution (CLRTAP)
- The Global Atmospheric Pollution Forum (GAP Forum)
- Joint Forum on Atmospheric Environment in Asia and the Pacific
- Regional Forum on Environment and Health in Southeast and East Asian Countries
- Long-range Transboundary Air Pollutants in Northeast Asia (LTP)
- North-East Asian Subregional Programme for Environmental Cooperation (NEASPEC)
- Atmospheric Brown Clouds (ABC) Project
- Framework Convention on Environmental Protection for Sustainable Development in Central Asia
- Asian Co-benefits Partnership (ACP)
- Clean Air Asia (Former CAI-Asia)
- International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA)

Cooperation at the regional and international level involving multi-stakeholders is essential to addressing transboundary air pollution issues. An initial understanding of the science involved is important for formulation of mitigation strategies and adoption of appropriate tools that would ultimately serve to improve regional air quality.

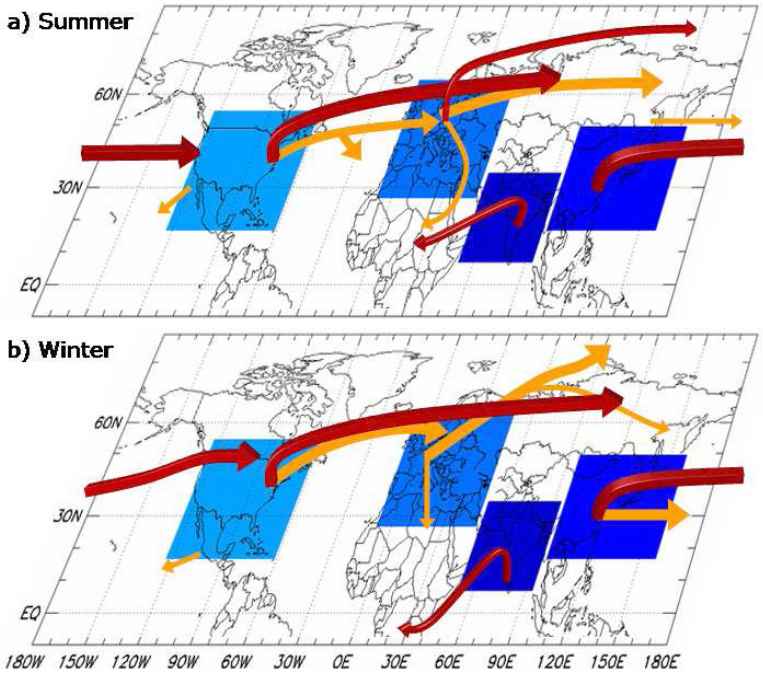


Figure 16: *Intercontinental transport pathways in the Northern Hemisphere.*
The coloured boxes indicate the four source and receptor regions used in HTAP intercomparison Experiment Set 1. The arrows approximate magnitude of main transport pathways in summer (June, July, August) and winter (December, January, February), based on modelled average carbon monoxide transport over 8-10 day periods. Light arrows indicate transport generally near ground level (less than 3 km above the surface) and dark arrows indicate transport higher in the atmosphere (more than 3 km above the surface). Adapted from Figure 2 of Stohl and Eckhardt (2004), with kind permission of Springer Science and Business Media
Source: TF HTAP 2007

3 PROGRESS AND MAJOR ACHIEVEMENTS OF THE EANET

3. PROGRESS AND MAJOR ACHIEVEMENTS OF THE EANET

3.1 KEY DEVELOPMENTS IN RECENT YEARS

- **Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)**

The Instrument for Strengthening the EANET, adopted at the Twelfth Session of the Intergovernmental Meeting (IG12) on the EANET in November 2010 has been signed by all 13 participating countries. The Instrument has been operational since 1 January 2012 in accordance with the decision of the IG12. In signing of the Instrument participating countries reaffirmed their strong commitment and support to the Network's objectives and activities.

- **Improvement of Monitoring Activities**

Development and/or revision of three technical manuals for the EANET - the Technical Manual on Dry Deposition Flux Estimation, Technical Manual for Wet Deposition Monitoring in East Asia -2010, and Technical Manual for Inland Aquatic Environment Monitoring in East Asia -2010, have been completed and uploaded on the EANET website. The development of a Technical Manual for Air Concentration Monitoring by a newly formed Expert Group commenced in 2011 and was also completed and uploaded in September 2014. A Strategy Paper on Future Direction of Monitoring for Dry Deposition and Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances have also been developed in 2010 and 2014 respectively and are made available on the EANET website.

The EANET continues to conduct Inter-laboratory Comparison Projects annually to monitor and improve performance of the national chemical laboratories participating in sample analysis. Data Reports are also produced annually and distributed to the member countries.

- **Expansion of the Monitoring Network**

Currently the network has 54 monitoring sites in 13 countries comprising 20 remote, 13 rural and 21 urban sites. Monitoring of wet deposition is carried out in all the 54 sites, dry deposition monitoring is conducted in 46 sites in 13 countries, monitoring of soil at 28 forests in 19 areas, forest vegetation monitoring at 24 forests in 18 areas in 10 countries and inland aquatic environment monitoring is conducted at 18 lakes/rivers in 10 countries. The newly developed catchment scale monitoring is being conducted at 1 site in Japan, and Philippines will also start soon. The annual Data Reports from 2001 to 2013 have been published after adoption by the Session of the Scientific Advisory Committee (SAC) and are made available on the EANET website.

- **Periodic Reports on the State of Acid Deposition in East Asia**

Following the publication of the First Periodic Report on the State of Acid Deposition in East Asia (PRSAD1) in November 2006, the Second Periodic Report on the State of Acid Deposition in East Asia (PRSAD2) was completed in December 2011 and distributed to participating countries and other related organizations at the beginning of 2012. Both reports are available on the EANET website.

- **Improvements to Administrative and Financial Management**

For greater transparency and better management of the EANET activities, the Revised Guidelines on Administrative and Financial Management for the Secretariat and the Network Center has been developed and approved in 2012. The Revised Guidelines on administrative part consist of a set of rules of procedures of the meetings, working procedures, including principles of distribution of the EANET documents and criteria for uploading priority documents to the EANET website, personnel management and guidelines for fellowship awards. The Revised Guidelines on financial management part provide guidance on budgeting, voluntary financial contributions, preparation of financial statements, audit reports, management of savings and others. Voluntary financial contribution from the participating countries has been implemented based on the (Revised) Guidelines.

- **Medium Term Plan for the EANET (2011–2015)**

Implementation of the activities of the Medium Term Plan for the EANET (2011 -2015) started in January 2011. The plan focuses on strategies that will enhance the network capabilities in monitoring and assessment, developing scientific research on atmospheric environment and dissemination of knowledge and information to strengthen policy relevance of the EANET activities. A Mid Term Report on the Implementation of the Medium Term Plan reporting on the status of implementation has been developed in 2013.

- **Fellowship Research Program**

It has been the practice of the EANET to award fellowships each year to young researchers from participating countries to conduct research in specific areas at the Network Center under the guidance of a senior researcher of the Network Center for a period of 1 to 2 months. In 2011 researchers from China and Malaysia, in 2012 a researcher from Thailand, in 2013 researchers from Mongolia and Thailand, and in 2014 researchers from Mongolia and Russia received the fellowship awards.

- **Technical Support to the Participating Countries**

Technical support missions to the participating countries were made by experts from the Network Center every year to provide technical assistance, exchange information and assist countries in selecting new sites for monitoring activities. Technical missions were made to Indonesia, Lao PDR, Myanmar and the Philippines in 2012, to China, Malaysia, Mongolia and Russia in 2013, and to Malaysia, Indonesia, Republic of Korea, Mongolia and Philippines in 2014.

- **Research Activities**

During the period 2009 -2010, the following three High Priority Research Projects were completed:

- Aerosol deposition studies in forests for improvement of estimation method for dry deposition
- Feasibility study on low cost methodologies for monitoring air concentration
- Analysis of existing data for improving the understanding of the status of acidification in East Asia, on wet deposition, dry deposition and on soil, vegetation and inland aquatic environment

In atmospheric modelling studies, the EANET in collaboration with the Model Inter-comparison Study in Asia (MICS-Asia) has developed the following research plans of the Phase III to carry out:

i) Model inter-comparison
ii) Development of reliable emission inventories

In order to estimate ecological effects of acidic deposition on the forest catchment in Thailand, Malaysia and Japan based on the measurement of elemental budget, a joint research project on catchment analysis has been implemented by the Network Center with Japan, Malaysia and Thailand, with support from the Ministry of the Environment, Japan and other funding agencies. A joint research project between the Network Center and Republic of Korea comparing the 3-stage and 4- stage filter pack method is also in progress. The samples are currently being analyzed and data compiled for later exchange.

To share the research findings of the Fellowship Research Program, joint research projects among the EANET community, and other related researches conducted in the region, the EANET publishes a Science Bulletin biennially.

- **Capacity Building and Public Awareness**

One trainee each from China, Malaysia, and Russia participated in individual training on wet deposition, dry deposition, soil and vegetation and inland aquatic environment monitoring and data management at the Network Center in February/March 2011. Trainees from Lao PDR and the Philippines, trainees from Malaysia, Mongolia, Russia and Vietnam, and trainees from Cambodia, Malaysia and Myanmar participated in the training courses held in late January/February 2012, December 2012 and January 2014 respectively.

Participants from the EANET countries benefitted from several capacity building courses held in recent years:

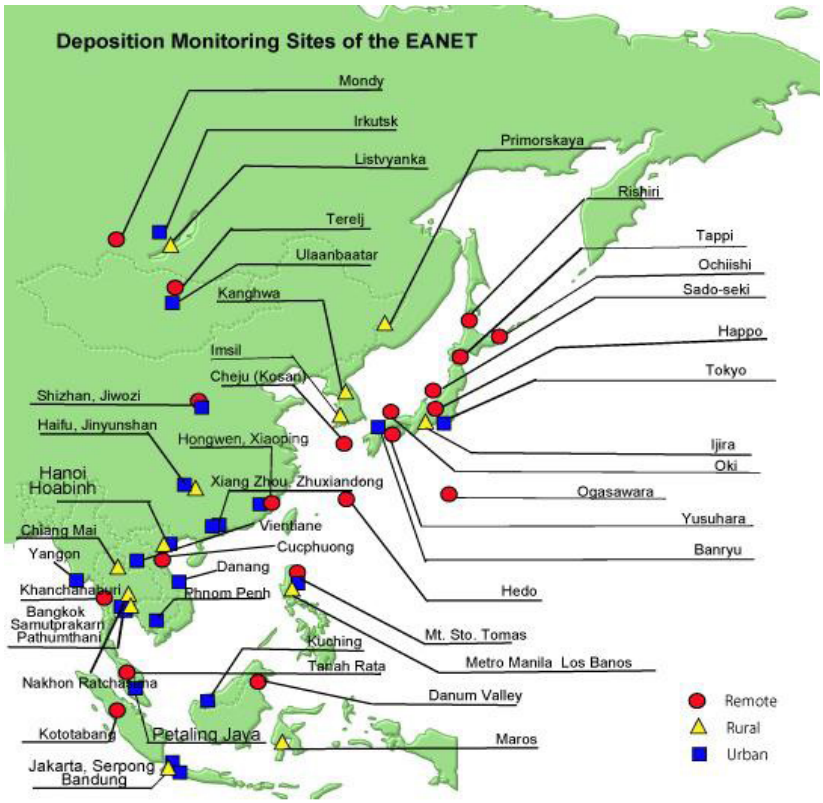
i) First Capacity Building Workshop of the Joint Forum on Atmospheric Environment in Asia and the Pacific, Pathumthani, Thailand, 21-22 July 2011
ii) Tenth Workshop on Public Awareness for Acid Deposition Problems, Niigata, Japan, 29 February – 1 March 2012
iii) Modelling and Emission Inventory Training Workshop, Niigata, Japan, 30 January – 3 February 2012

Public awareness programs and activities in the participating countries are strongly encouraged and whenever possible the EANET experts attended these events to provide assistance and support.

To disseminate the latest information on governments' efforts to manage air pollution in the participating countries, the EANET has developed Fact Sheets for each country which were distributed and also issued on the EANET website. A Newsletter reporting on recent activities of the EANET is produced twice a year.

Figure 17: *EANET Activities*
Source: EANET Network Center

3.2 RESULTS FROM THE EANET MONITORING



A detailed assessment of the EANET monitoring data was conducted for the EANET Second Periodic Report on the State of Acid Deposition in East Asia (PRSAD2) in 2011. The assessment utilized data obtained from 54 monitoring sites in 13 participating countries, of which 20 are remote sites, 13 are rural and 21 are urban sites (**Figure 18**).

Figure 18: *Location of the EANET 54 acid deposition monitoring sites in 2011*
Source: EANET Network Center

Using the criteria that rainwater with pH lower than 5.0 is considered acidic, it was found that 26 sites out of the 42 or 62% of the sites recorded annual average pH lower than this value indicating that precipitation in East Asia is significantly acidic. Values of less than 4.6 were recorded in several locations (**Figure 19**).

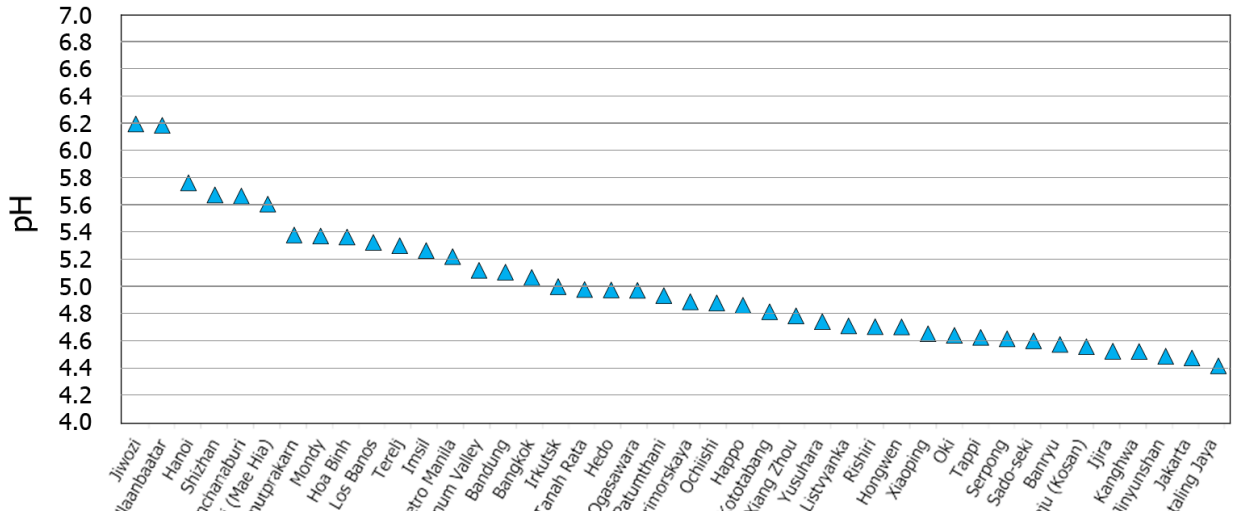


Figure 19: *Five-year average annual mean pH values for 42 sites (2005-2009)*
Source: EANET, 2011c

In many parts of the region, sulphuric acid is the primary contributor to the acidity although the contribution from nitric acid is almost reaching that of sulphuric acid. Wet deposition in East Asia during the period 2005-2009 shows a wide range of concentrations and deposition, indicating the strong influence of geography (**Figure 20** and **Figure 21**). Frequent rain events and heavy rainfall, which is commonly experienced in the tropics, has contributed to the higher average annual wet deposition of sulphate and nitrate observed in tropical urban sites.

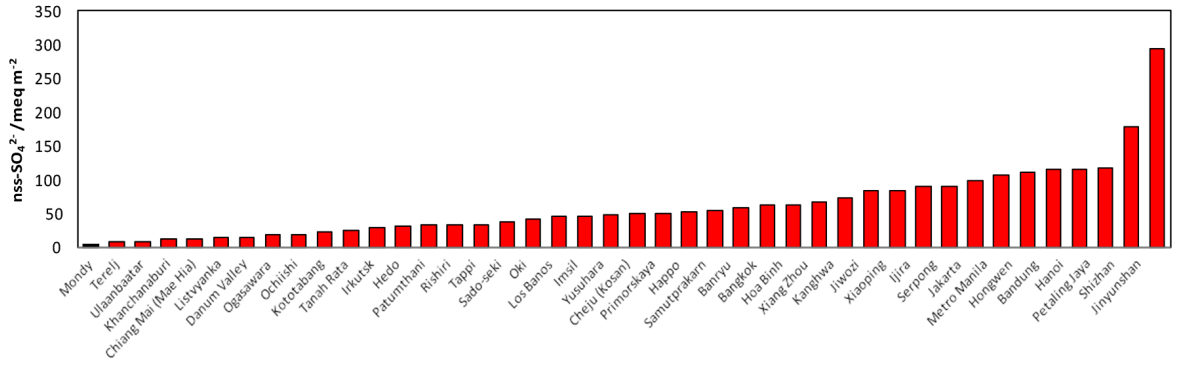


Figure 20: *Five year average annual deposition of nss- SO_4^{2-} (2005-2009)*
Source: EANET, 2011c

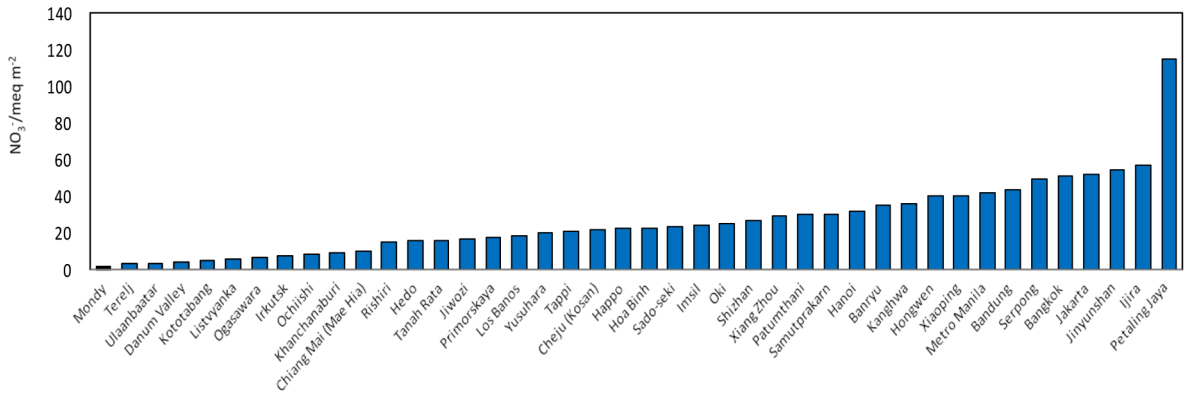


Figure 21: *Five year average annual deposition of NO3- (2005-2009)*
Source: EANET, 2011c

Gaseous concentrations of SO_2, HNO_3 and NH_3 have stabilized in recent years. Some urban sites in Southeast Asia showed significant improvement in SO_2 concentrations. The sulphate concentrations in aerosols were comparatively higher than nitrate and ammonium at all sites in Northeast Asia. This could be the result of secondary reactions involving gaseous sulphur components during long range transport. Distinct seasonal characteristics were also observed in Northeast Asia. Spatial variation in concentrations of gaseous SO_2 and aerosol SO_4^{2-} in 2005-2009 at EANET sites are shown in **Figure 22**.

Based on measurements mainly from sites in Northeast Asia, ozone concentrations exceeded a monthly average of 50 ppb and were even higher than 60 ppb at some sites. Monthly average ozone concentrations from 2005 to 2009 were higher than those for the previous five-year period (2000- 2004) at many sites.

From studies on impacts on ecosystems, trends in changes in the soil, forest and inland water monitoring parameters have been detected. The data suggests possible acidification or nitrogen saturation in the East Asian region. There is however a need to isolate other existing environmental conditions that may have contributed to such an observation. Studies show that the increase in emissions in Asia however will put sensitive ecosystems at risk from the effects of soil acidification (**Figure 23**). Noting that all studies possess some degree of uncertainty, efforts should be made to obtain more site-specific data, such as base cation deposition, S and N retention in soils and ecosystems, base cation uptake via biomass harvesting and weathering rates, to reduce the uncertainties. Regional variations of buffering capacity mainly stemmed from soil type differences depending on geological and climatic conditions as well as topographical and biological factors over a long time scale were also clarified by the EANET (**Figure 24**).

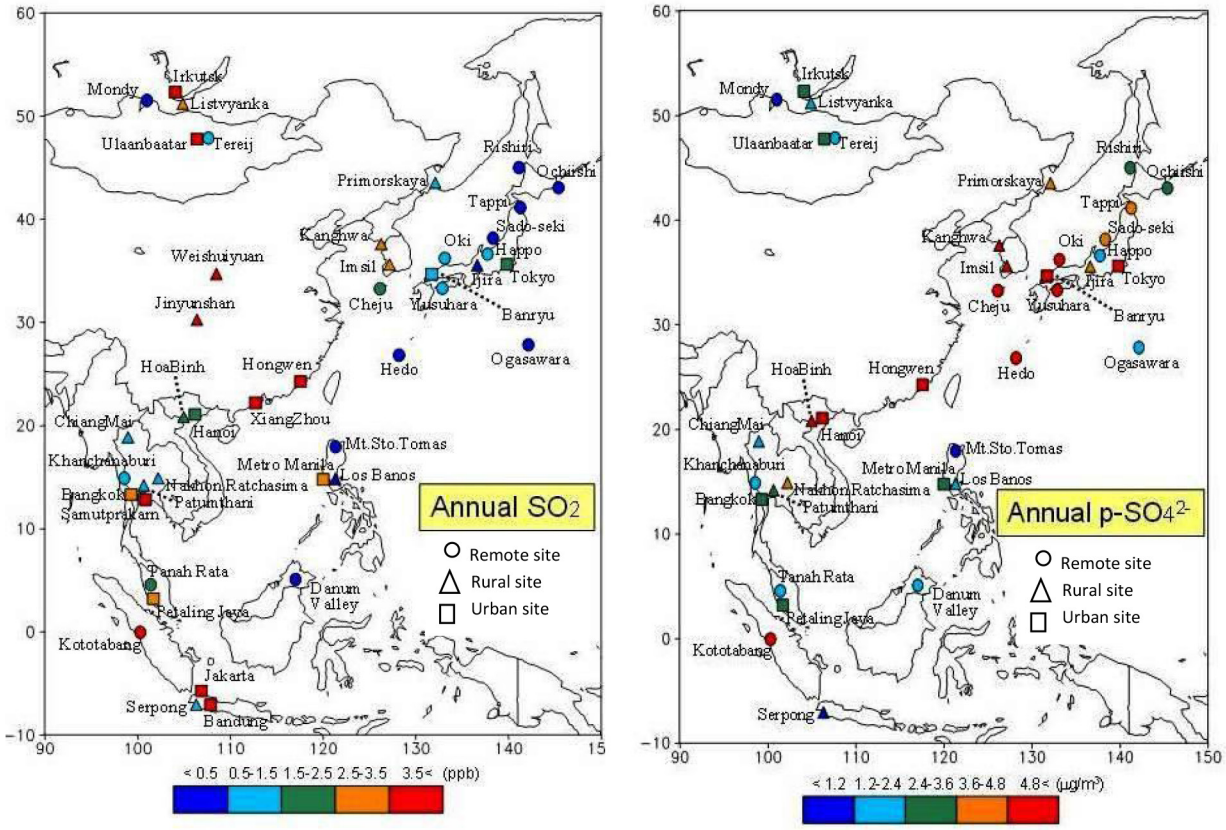


Figure 22: *Spatial variation in concentrations of SO_2 and SO_4^{2-} at EANET sites*
Note: *Concentrations shown are the annual average of 2005-2009*
Source: EANET, 2011c

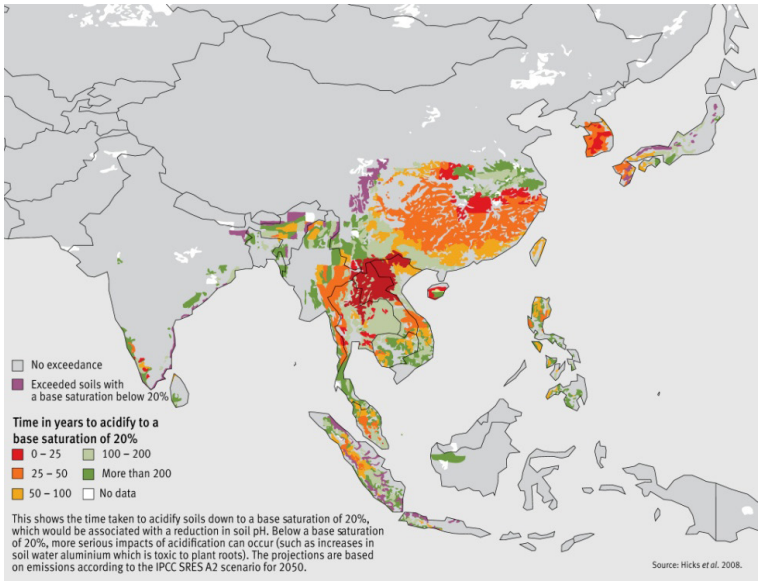


Figure 23: Areas at risk and timeframe for acidification damage in Asia
Source: Hicks et. al, 2008
***Note:** Figure reproduced from GEO5 published by UNEP in 2012*

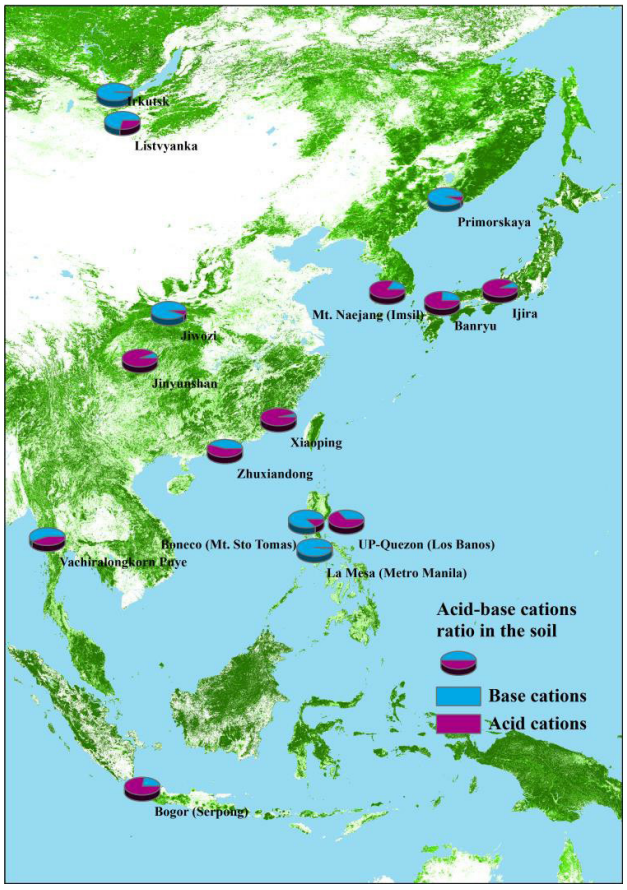


Figure 24: Ratio between base cations (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}) and acid cations (H^{+}+ Al^{3+}) on a negative charge of 0-10 cm soils. Only representative site in each area were displayed. Dense green color shows tree cover. The value is average in 2000-2009.
Source: EANET, 2011c

There are also evidences of decline in certain forests in Japan, China and Mongolia. The possible direct effects of pollutants in tree decline in Mongolia are well documented.

The pH of water in five inland aquatic systems has significantly decreased from year 2000 to 2009. Simultaneously, the concentration of SO_4^{2-} has increased in the five inland waters. Moreover, NO3- concentration has increased in one of them. Acidification and/or eutrophication by leaching of these strong acid anions may be possible reasons. However, further studies are necessary to determine whether other factors could have contributed to the acidification and nitrogen saturation of the inland waters. The promotion of catchment scale analysis by the EANET is an approach to clarify the relationship among components of the ecosystem, including soil, vegetation, inland water and atmosphere (**Table 1**).

Country	site	pH	EC	Alkalinity	SO_4^{2-}	NO_3^-
China	Jinyunsyan Lake	Declining	Increasing	Declining	Increasing	Increasing
	Xiaopin Dam	Declining			Increasing	
	Jiwozi River	Declining	Increasing	Increasing	Increasing	
	Zhuxiandong Stream				Declining	
Indonesia	Patengang Lake	Declining			Increasing	
Japan	Ijira Lake			Increasing		Declining
	Kamagatani River flowing river to Ijira Lake	Increasing		Increasing		
	Kobara River flowing river to Ijira Lake	Increasing		Increasing	Increasing	
	Banryu Lake		Increasing			Increasing
	Banryu Lake 3		Increasing			
Malaysia	Semenyih Dam	Declining			Increasing	
Mongolia	Terelj River			Increasing		
Phillipines	Pandin Lake				Increasing	Increasing
Russia	Pereemnaya River		Increasing		Increasing	Increasing
	Komarovka River			Declining	Increasing	
Thailand	Vachiralongkorn Dam 1 Ban Pong Chang		Declining		Declining	
	Vachiralongkorn Dam 2 Ban Pang Pueng		Declining			Increasing
Vietnam	Hoa Binh Reservoir					

Table 1: *Trends of inland water chemistry*
Source: EANET, 2011c (with modifications)

Note: *Pink- and blue-colored cells indicate significant declining and increasing trends, respectively and yellow-colored cells indicate no trend (by a statistical analysis, seasonal Mann-Kendall test).*

3.3 COUNTRY EFFORTS IN MANAGING ATMOSPHERIC ENVIRONMENT ISSUES

Cambodia

Cambodia started acid deposition monitoring at Phnom Penh City in 2004 and has expanded its activities recently to the monitoring of inland aquatic environment at Krirom National Park in 2011. Rapid industrialization coupled with a growing population and urbanization since 1993 has led to concerns on air pollution. In particular, emissions of harmful gases and particulates from various sources such as:

- Industries- Cambodia is not heavily industrialized country. Most of them are garment factory. The others are light industry such as food and beverages, textile, non-metallic mineral products, wood products, rubber manufacturing, etc.
- Private generators- The electric power supply in Cambodia is inadequate for supporting services, so most of service sectors still widely use their own generators for supporting their businesses.
- Biomass burning- Biomass fuel particularly firewood and charcoal were the main source of energy for cooking for 96.7% of the households in 1999 in the country; they are the cheapest and easily accessible sources of energy used for cooking, and
- Transportation- Transportation have a greatest impact on air pollution due to their dominant role in the fuel consumption and the number of vehicles continue to increase day by day, especially in the Phnom Penh and other big cities have caused the air quality in the industrialized and urban areas to deteriorate although the overall air quality in the country is still generally good. The Department of Environmental Pollution Control which is responsible for environmental protection in Cambodia have their duty to monitor the ambient air quality in the whole country, especially in the big city. Since 1998 Department of Environmental Pollution Control have monitor ambient air quality in Phnom Penh City with the parameters of carbon monoxide, sulphur dioxide and nitrogen dioxide by using Passive Tube sampler. Beside that Cambodia also conducted the periodic testing for motor vehicles emission during the registration. The Department of Environmental Pollution is in the process of revising environmental quality standards at the national level including air quality standards. There is also a plan to upgrade their sub-decree to be the law and extend to other parameter such as PM10.

China

China started EANET monitoring activities from 2001 and currently has monitoring projects on wet deposition, dry deposition, inland water, soil and vegetation in 4 cities, namely Chongqing, Xiamen, Xi'an and Zhuhai in addition to its national acid rain monitoring network. The results during the period from 2005 to 2009 indicate an increase in acidity in some cities while other sites showed an improvement. Higher acidity levels in autumn at the inland sites were attributed to coal-fired heating in winter. Due to strengthening of policies by the government during the Tenth and Eleventh Five Year Plan and increase in investments in environmental protection, the environment quality in China has improved. Industrial restructuring, a number of key projects, improvement of management and release of a series of laws, regulations and standards, industrial, fiscal, taxation pricing policies mainly contributed to the reduction in SO_2 emissions at all the urban sites. Compared to 2001, cities with ambient air quality compliance and SO_2 emission compliance respectively increased from 33.4% to 89.0 and from 80.6% to 96.0% in 2011, cities under acid deposition monitoring with average precipitation pH lower or equal to 5.6 decreased from 36.9% to 31.8%.

Under the Twelfth Five Year Plan (2011-2015) China will intensify environmental protection by accelerating transformation of the mode of economic development through resource conservation and environmental protection, energy saving, policies to reduce greenhouse gas emissions, promote social and economic growth with the population, resources and environment along the path of sustainable development. Pollutant emission reductions will continue with reduction targets set for SO_2 and NO_2 emissions respectively by 18%

and 10%. In addition to the new "Ambient Air Quality Standards" and "Air Pollution Prevention and Control in Key Regions of the Twelfth Five-Year Plan", in order to improve the overall air quality, the State Council of China released in 2013 the "Action Plan on Air Pollution Prevention and Treatment" consisting of 10 major measures. Strategies include policies limiting emissions from power plants, steel, nonferrous metals, chemical industry and building materials industries, enhancing desulphurization and denitration facilities, and strengthening policies controlling emissions from motor vehicles.

Indonesia

Indonesia acid deposition monitoring for dry deposition was carried out by several agencies, namely Meteorology, Climatology and Geophysics Agency (BMKG), Research Centre for Environmental Impact (Pusarpedal) and National Institute on Aeronautics and Space (LAPAN) at Jakarta, Serpong, Bogor, Bandung, Kototabang and Maros sites. In addition, wet deposition was carried out by Environmental Unit, Ministry of Public Work by conducting the inland aquatic monitoring at Situ Patenggang Bandung and Situ Gunung Sukabumi. Other activity was observation for soil and vegetation at the Dramaga Research Forest Bogor, conducted by Research and Development Centre, Ministry of Agriculture and Ministry of Forestry.

Air quality ambient monitoring was conducted by BMKG and Ministry of Environment (MoE) through many stations that installed at various cities in Indonesia. There are emission standards and policies for mobile sources and ambient air pollution. Various programs and activities also have been conducted by MoE such as Evaluation for Urban Air Quality (EKUP). This program consists of activities such as roadside air quality monitoring, emission vehicle testing, traffic performance measurement and fuel quality monitoring. Blue Sky Program also has been implemented in order to enhance the better quality of urban air by implementing sustainable transportation system. At the Forum of Environmentally Sustainable Transport in Bali in 2013, it was agreed that Indonesia in 2013 started to conduct emission inventory as a starting point to measure the burden of urban air quality. The analysis and evaluation of what the inclined of emission from each urban area will be carried out so that the appropriate policies and strategies can be taken.

Japan

Continuous monitoring of acid deposition has been implemented based on the long term monitoring plan for acid deposition by the Ministry of the Environment Japan since 2003. Japan has 12 EANET wet and dry deposition monitoring sites, 2 soil and vegetation monitoring sites, 2 inland aquatic environment monitoring sites and a catchment study site near Ijira Lake. The current status of air quality in Japan is largely good in terms of SOx, NOx and PM10. The challenge remaining is the very low attainment rate of air quality standards for photochemical oxidant (Ox) and PM2.5 and so on. The Ministry of the Environment is focussing on i) photochemical oxidant and PM2.5, ii) transboundary air pollution, and iii) short-lived climate pollutants. Close collaboration with other ministries and relevant departments in the ministry is essential such as with the Meteorological Agency for dust and sandstorm (DSS) monitoring, coordination with the Ministry of Foreign Affairs for international cooperation on transboundary air pollution, and with the departments in charge of climate change within the ministry concerning short-lived climate pollutants.

Lao PDR

Realizing the need to take preventive action against acid deposition, Lao PDR started monitoring activities with the establishment of a wet deposition monitoring site in Vientiane in 2005 and has surveyed a candidate site for inland aquatic environment monitoring at Namhum Lake in 2009. By 2011, both wet and dry deposition monitoring was conducted at the Vientiane site. Environment monitoring activities are carried out by the Environment Quality Monitoring and Hazardous Chemical Center (EQMHCC) under the Water

Resources and Environment Research Institute of Water Resources and Environment Administration (WREA) now changed to Environmental Quality Monitoring Center, under the Natural Resources and Environment Institute (NREI) of the Ministry of Natural Resources and Environment (MONRE). MONRE is responsible for environment quality protection at the national level. The air quality status is considered acceptable in Lao PDR although the effects of climate change have been visible in changes in average temperatures, shifts in seasons and increasing intensity of extreme weather events. After being a signatory to the Kyoto Protocol the government has initiated a number of actions for protection of the environment.

With the efforts to understand the air emission situation in the country, NREI in collaboration with Pollution Control Department of Thailand is planning to set up the first permanent ambient air monitoring station in Vientiane. The monitoring station is expected to start its operation in January 2014. Monitoring will start with two ambient parameters: PM10, and NOx. Lao PDR will also purchase mobile and ambient air monitoring station. Monitoring will start with the following parameters, i.e. PM10, NO, NO2, CO, O3, and VOCs. The monitoring station is expected to be put on board in early February 2015 and monitoring will start within 2015.

♦ Malaysia

Malaysia has been involved in the EANET activities since 2001 and has four monitoring sites for monitoring wet and dry deposition at Tanah Rata, Petaling Jaya, Danum Valley and Kuching, the monitoring and analysis activities are mainly conducted by the Malaysian Meteorological Department and Department of Chemistry Malaysia. There are three sites for monitoring soil and vegetation at Sg. Lallang, Pasoh Forest Reserve and UPM Bintulu, and two sites for inland aquatic environment monitoring sites at Danum Valley and Semenyih Dam. Results show high variability of wet deposition at all sites which is likely due to inherent high rainfall in the tropics.

Local air quality is monitored by the Department of Environment (DOE) from a network of automatic and manual sites. The data collected is used to compute the Air Pollutant Index (API) to inform the public on air quality status. Rules and regulations have been implemented to control pollution emissions in the country in particular the Environmental Quality Act (EQA) 1974 which was amended in 2001 to strengthen the existing regulations to protect and conserve the environment. From time to time a number of legal instruments such as the Environmental Quality (Clean Air) Regulations 1978 were gazetted and enforced to maintain environmental quality. The Malaysian Recommended Ambient Air Quality Guidelines for the major air pollutants has also been developed. Environmental Impact Assessment (EIA) reports are used as a means to include environmental considerations in development project planning. The government enforces related laws by implementing enforcement acts against activities that contravene the laws and regulations. Regular checks for compliance with the Environment Quality (Clean Air) Regulations are conducted throughout the year on activities that are known to emit air pollutants. Emissions of smoke and gaseous pollutants from motor vehicle exhausts are controlled under the Environmental Quality (Control of Emission from Diesel Engines) Regulations 1996 and Environmental Quality (Control of Emission from Petrol Engines) Regulations 1996. Public awareness programmes on pollution prevention are conducted for targeted groups such as industries, development project proponents, local communities, school children and teachers.

Malaysia has taken measures to address transboundary air pollution problems through a number of initiatives, namely, ASEAN Working Groups on Sub-Regional Fire Fighting Arrangement for Sumatra and Borneo, ASEAN Agreement on Transboundary Haze Pollution, Sustainable Development Strategy for Seas of East Asia, EANET and other multilateral and bilateral agreements.

♦ Mongolia

Acid deposition monitoring was initiated in 1998 with wet and dry deposition monitoring at two sites Terelj and Ulaanbaatar, and inland aquatic environment monitoring at one site in the Terelj River. On the

initiative of Mongolian President Ts. Elbegdorj, a law on reducing the capital city's air pollution was drafted and approved by the Great State Khural on February 10, 2011. Pursuant to this law, the National Committee for reducing air pollution was founded to control the air quality, regulate and correlate projects and efforts made by people, economic entities, governmental and non-governmental organizations, which are directed towards reducing the pollution rates and controlling air quality as well as to carry out the governmental policy in this sphere.

Over the recent years, a number of actions have been taken including the development of projects for housing construction in the ger (Mongolian traditional housing unit) areas being the major source of air pollution, building up relevant structures, reducing the rural areas' air pollution rates, providing with low power-consumption products the households living within the "Capital city's air quality improvement zones", giving various incentives as reducing electricity costs in order to heighten citizens' involvements, working out and approving relevant regulations and standards, raising people's awareness of the air quality issues.

Concerning Bayankhongor, Darkhan-Uul, Dornod, Orkhon, Uvurkhangai, Khuvsgul, Sukhbaatar, Khovd provinces which air pollution rates are indicated to far exceed the permissible concentrations, currently programs and plans are being worked out to set up there sub-committees of the National committee to reduce the air pollution. With the implementation of a project for setting up 2 centers for conducting technical inspection of vehicles and purchasing 11 vehicles fully equipped with mobile repair service equipment it is expected that more appropriate conditions would be provided for controlling, registering noxious fumes emitted from the motor vehicles, improving thus the system of responsibility while the vehicles' technical inspections and diagnostics would be carried out at the modern international level.

Actions are taken to encourage the public transport vehicles to shift to gas and diesel combined fuel consumptions, and in order to reduce the rates of emissions from the motor transport 124 public service big buses were equipped with gas and diesel fuel facilities, toxic fume filters were provided for 1,523 cars, 18 trolleybuses, duobus were assembled to be used for public service. Accordingly, the rates of fume releases from big buses have reduced by 25%.

According to the monitoring data conducted by Ulaanbaatar city's air quality control stationary posts during the period from October 2012 till March 2013, the average concentrations for major pollutants discharged into the atmosphere from raw coal application, namely sulphuric acid has diminished by 20.1% as against the results recorded for the same period of the previous year, that of PM by 29.5%. So, as a result of all the actions undertaken to improve the air quality, the air pollution rate has dropped by 20 to 30% as compared with the same period of the previous year.

♦ Myanmar

Wet deposition monitoring is carried out at one site in Yangon (Kaba-Aye) since 2007 to monitor the state of acid deposition in Myanmar. The monitoring is conducted by the Department of Meteorology and Hydrology (DMH). On air quality management in the country there are existing environmental laws and institutional framework for environmental management in the country. The seven key priority areas of environmental issues have been identified through Environmental Protection Assessment (EPA-2009), namely, forest resources degradation, threat to biodiversity, land degradation, water resources and quality status, solid waste management, impact of mining industry and air pollution, and climate change. Some of the challenges in air pollution control in Myanmar include i) no air quality monitoring system and national ambient air quality standard, and ii) no advanced technology and instruments for monitoring. Future plans for environmental management are: a) policy, guidelines and planning; b) environmental pollution control; c) natural resources and environmental sustainability; d) capacity development; e) international cooperation; f) public awareness and participation; g) research and development on environmental conservation.

Philippines

The Philippines participated in EANET monitoring activities since 2001 and currently has 3 wet and dry deposition monitoring sites at Metro Manila, Los Baños and Mt. Sto. Tomas. Soil and vegetation monitoring activities are conducted at 4 sites, namely, at the Mt. Makiling Forest Reserve at the University of the Philippines, Los Baños College, Laguna; at U.P. Quezon Laguna Land Grant located in Siniloan, Laguna; at Boneco Long Term Ecological Research Site in Itogon, Benguet; and at La Mesa Watershed Area at Quezon City. Inland aquatic environment monitoring is carried out in Pandin Lake in Laguna and Ambulalakao Lake in Kabayan, Benguet. The Clean Air Act or Republic Act 8749 is the guiding framework in the effective implementation of air quality management, interventions and programs. Under the Clean Air Act, publication of Air Quality Status Report is required to report the extent of air pollution, per type of pollutant and per type of source, including an analysis of the current situation and identifies trends in air pollution, critical areas activities and projects that require closer monitoring or regulation. Measures for mitigating air pollution include strategies for i) enforcement on motor vehicles, ii) enforcement on stationary/industrial sources, iii) enforcement on area sources, iv) shift to cleaner fuels, and v) public awareness. To further enhance air quality management, the DENR has recently issued the national ambient air quality guideline value for PM2.5 and procured state-of-the-art ambient air quality monitoring stations (real-time) to be installed in key cities nationwide.

Republic of Korea

The acid deposition monitoring sites for EANET are located in Ganghwa, Jeju and Imsil. Recognizing the seriousness of air pollution caused by industrialization, the Korean government has taken comprehensive measures to reduce air pollutant emissions for the last three decades and implemented a national air monitoring program from mid 1970s. Adverse effects of long range transport of air pollutants have become a great public concern along with natural air pollutants and Asian dust. Monitoring at rural and remote sites is for evaluating the effect of long range transport on the air quality. Recognizing that international collaboration is required, Republic of Korea has actively promoted and participated in regional endeavours such as LTP, NEASPEC, EANET, NOWAP and ACE-ASIA which addresses long range transport of air pollutants and other regional air quality problems. Republic of Korea has a ten-year plan to improve urban air quality. The main tasks for air quality management were i) PM2.5 management, and ii) basic plan to improve air quality in metropolitan areas

Russia

Regular atmospheric monitoring in Russia is divided into two types with the following purposes of its performing: for urban air quality management, and evaluation of regional environment pollution. The main aim of air pollution management is to improve air quality in cities. The decline of economical growth in civil, heavy and chemical industry for the period before and the beginning of 2000s coincides with the neoteric implementing of modern effective technologies focused on power and fuel saving principles. These reasons are leading both to decreasing of air pollution in a lot of industrial cities and to improving of regional air quality in Russia.

To identify the particular purposes of urban air quality management an aggregated index of atmospheric pollution was proposed and employed. This index is calculated as a combination of average concentrations of priority pollutants and corresponds to adjusted long-term measurement program. The degree of urban air quality is quantitatively evaluated with the several attributing ranges of this assessment parameter values together with its using for ranking cities along the grade of atmosphere pollution levels. According to the “Governmental report of environment state in Russian Federation in 2011” the air quality is estimated of grades as higher and very high polluted in more than a half cities where monitoring is performed and whose

population is about 60 millions in total. These results are connected with the presence of benz(a)pyrene, formaldehydes, TSP, nitrogen dioxides and phenols in air that are often recorded by measurements. The list of the most polluted cities includes 27 cities by now; however, the number of those cities has decreased by 10 since 2007. Almost all of the listed cities are exposed by mainly industrial emissions. The first ten of them have a population of more than a million each with steel or non-ferrous metallurgy, oil refining or chemical enterprises within their territories.

Recently we can trace an improvement of the situation in the most of large cities through terminating a trend of air pollution increasing as well as reported emission declining that is the result of the taken measures. The reduction of emission was highlighted to have taken place in 56 cities during the last two years. Furthermore, the Government of Russian Federation points the following aims by 2020 out to provide the sustainable process of air quality management: firstly, the reduction of anthropogenic emissions into the atmosphere including greenhouse gases has to be to the level of equal or less than 75% of them in 1990; secondly, the number of cities where the air quality is estimated as higher and very high pollutant shall be decreased by 5 times at least while the number of inhabitants exposed by unfavorable environment conditions should be reduced by 75% compared with 2007.

National system of regional atmospheric monitoring consists of several networks from which the national precipitation chemistry network (with different categories of sites) and EANET monitoring stations are operated in Asian Russia. At the European part of Russia the decreasing trend of acid deposition precursors has being traced as obvious from the 1990s. Unlike this the increasing sulfur oxides atmospheric concentrations is observed at the regional EANET stations while the significant inter-annual variations of average values have taken place. This displays the insufficiency or lack of measures on air quality management both in Asian part of Russia and neighboring countries, whence the transfer of transboundary air pollution could be expected or disclosed.

♦ Thailand

At present, Thailand's national ambient air quality monitoring network consists of 63 air quality monitoring stations, covering 29 provinces in the North, the East, the Central, the Northeast and the South. There are 6 EANET monitoring sites collaborate for EANET network. The monitoring results differ from region to region according to spatial and temporal variations. Thailand air pollution problems are highly related to the distribution of emission sources and the extents, particularly area sources. Atmospheric condition also contributed to the magnitude of air pollution problem. The implementation of air pollution control program in Thailand is principally based on area based management, including the concept of source control strategy and the pollution prevention approaches. Air pollution is sometime considered as local or regional problems such as haze pollution in the North and in the South; therefore, the integrated area based management approach has been implemented in such area. Thailand considered the air pollution problem based on a specific air pollutant as well as the emission source type. At the national level, source emission control strategies are the major approaches. For example, automotive emission control strategies include improvement of fuel quality, set up vehicle emission standards for new and in-used vehicles, enhancement of the preventive and maintenance program, and establishing the mass transit system. Pollution Prevention strategy such as Environmental Health Impact Assessment (EHIA) for the new projects is enforced for some activities. During the past two decades, the continuity of the air pollution control program has resulted in the significant reduction of several air pollutants such as sulphur dioxide, carbon monoxide and lead. At the national level, nitrogen dioxide has shown a steady trend for almost 10 years. The trend of the reduction of PM is also observed in several areas. Seasonal variable and source emission contribution are the key factors to the air quality especially PM level in the critical area. More air pollution control program has to be initiated and implemented with the increase of the complexity of the air pollution problem and the mitigation measures.

Vietnam

Vietnam has implemented environmental monitoring in both national and local levels. According to the Law on Environmental Protection of 2005, the Vietnam Ministry of Natural Resources and Environment is responsible for preparing the national environmental report every 5 years and making the specific report on an environmental problem as water, air or soil every year.

Two main methods for air monitoring consist: Periodically sampling and automatically continuous monitoring station. Monitoring by periodically sampling and analyzing in laboratory is conducted in national level and almost provinces over whole country. These are important data to assess the current situation of air quality in the whole country. Air monitoring by automatic monitoring stations has been started since 2000. From 2000 to 2010, Vietnam had 20 automatic air monitoring stations of which 10 stations were located in Ho Chi Minh city and other 10 stations were installed in 10 different provinces in country (4 of those are located in Hanoi). They are belonged to National Center for Hydro-Meteorology. By 2010, most of these stations stopped working or did not work continuously. Thus, the monitoring data derived from them are low reliability. Since 2010, Ministry of Natural Resources and Environment has installed 7 automatic air monitoring stations in 6 provinces/ cities. Some provinces have begun to invest, and install this kind of station by themself. Presently, these stations have worked stably and provided reliable data on air quality in cities. The monitored parameters are: PM10, PM2.5, PM1.0, CO, NOx, O_3, SO_2.

Besides, Vietnam has implemented a series of management measures to enhance air environment protection including: strengthening the air pollution control from transportation activities by tightening the emission standard for vehicles in road traffic; enhancing vehicle's quality and piloting clean fuel for some vehicles in urban areas; enhancing technical and managing measures to mitigate pollution from production activities, especially from industrial activities; checking, adjusting and issuing Vietnam Standard (QCVN) on air quality and air emission. However, Vietnam currently has not yet implemented 2 important activities in air environment protection which are emission inventory, and development of air quality management plan. Some programs on emission investigation and inventory are only implemented in central agencies or only as pilot programs in a small scale. In provinces, these activities have not yet been implemented. Recognizing the significance of air pollution due to ever-increasing urbanization and industrialization, the Vietnam Environment Administration is now drafting a national strategy for air pollution control.

4 AN INTEGRATED APPROACH TO ADDRESS AIR POLLUTION AND WAY FORWARD FOR COOPERATION UNDER EANET

4. AN INTEGRATED APPROACH TO ADDRESS AIR POLLUTION AND WAY FORWARD FOR COOPERATION UNDER EANET

4.1 INTEGRATING PREVENTION AND MITIGATION OF ACID DEPOSITION, AIR POLLUTION AND RELATED ATMOSPHERIC ENVIRONMENTAL ISSUES FOR WIN-WIN BENEFITS

The acid deposition, air pollution and atmospheric environmental issues can be better addressed by taking an integrated approach. There are obvious co-benefits to be gained from taking complementary measures on air pollution and related atmospheric environmental issues, and there are economic benefits from coordinated emission inventories and reporting. There are also opportunities to address impacts on human health, agricultural crops, and ecosystems in an integrated way. For example, UNEP supported Project Surya (http://www.projectsurya.org/) has demonstrated multiple benefits of improved cook stoves as an alternative to traditional mud stoves. Furthermore, UNEP and WMO reported that reducing some air pollutants can contribute to limiting near-term global warming as well as mitigating impacts on human health and agricultural crops (UNEP/WMO 2011).

Co-control planning or "an integrated multi-pollutant approach for controls" is also recommended for planning control measures that can simultaneously reduce several pollutants, and therefore can be highly cost-effective. Co-control air quality planning offers flexibility of choices for control measures and optimizes trade-offs between pollutants, impacts and benefits. Taking into consideration the development of integrated East Asian regional economic and social level as well as environment mechanism, there should be more emphasis on the current air pollution monitoring ability construction and pollution control of domestic governance in terms of addressing the acid atmospheric deposition and pollution, co-control can be used as an optional approach for decision makers in the future.

The Global Atmospheric Pollution Forum (GAPF), a Sida-funded non-governmental endeavour, supports the development of solutions to air pollution-related problems by promoting effective cooperation among nations at the regional, hemispheric and global scales.

4.2 COLLABORATION BETWEEN INTERNATIONAL, REGIONAL, SUB-REGIONAL AIR QUALITY NETWORKS AND INITIATIVES

Since 2000, the EANET has worked in close cooperation with a number of international organizations which serve to provide the standards for environmental monitoring and assessment. They include:

i) The Global Atmosphere Watch programme of the World Meteorological Organization (WMO/GAW)
ii) The World Health Organization (WHO)
iii) United Nations Environment Programme (UNEP)
iv) The European Monitoring and Evaluation Programme (EMEP), International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forests), and Task Force on Hemispheric Transport of Air Pollution (TF HTAP) of the UNECE Convention on Long-range Transboundary Air Pollution (UNECE CLRTAP)

Additionally, the EANET has established linkages with many regional and sub-regional initiatives, networks and programmes involved in the protection of the atmospheric environment as described in Section 2.3.

An Asian Science Panel on Air Quality (ASPAQ) has been recently proposed to establish common understanding among scientists and policy makers and developing an international initiative for an integrated approach to air pollution among Asian scientists.

There is a need for closer cooperation and coordination among all organizations, initiatives and networks to reduce regional atmospheric pollution in East Asia. They can pool resources to help governments in identifying and implementing key mitigation measures to bring about rapid health and environmental benefits to the population. They can also work together to ultimately develop a regional framework convention on air pollution in Asia for longer term benefits.

4.3 EXPANDING THE SCOPE OF THE EANET

After more than ten years of successful operation, it is timely for the EANET to consider expansion of its scope to meet today's challenges. The recently adopted Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET) includes a provision for "expansion of the scope of the EANET" and many of the activities under the Medium Term Plan for the EANET have paved the way for consideration of new activities that would benefit the community.

Discussion on this topic has been on-going within the EANET for several years with various views expressed by the participating countries, some strongly supported the expansion of the scope of the EANET both on activities and chemical species with emphasis on high priority air pollution species (ozone, PM2.5) taking into account of their impacts to human health, while some other countries supported the EANET to strengthen its activities to acid deposition with a focus on capacity building and improvement of public awareness, and stressed that a step- wise approach to monitoring of ozone and PM2.5 should be adopted. The Scientific Advisory Committee (SAC) of the EANET has requested its Task Force on Research Coordination to conduct a review of the state of air pollution in East Asia, including associated health effects. The review will be useful input for discussions on this topic by the various bodies of the EANET and for the IG in its consideration on the expansion of the scope.

The following points could be considered in the discussions on the expansion of the scope of the EANET:

- The monitoring of acid deposition and scientific assessment in past years has enabled a better understanding of the sources of acid deposition and its consequences on the environment. It is necessary to further consider ways to address the origins of harmful emissions by reaching out to policy developers and decision makers.
- The global spread of atmospheric pollution calls for more attention on urban air pollution, regional/ hemispheric air pollution focusing on ozone and fine particulates.
- The close links between acid deposition and air pollution provide opportunities for the EANET's involvement with other regional initiatives in monitoring and developing measures to mitigate tropospheric ozone and fine aerosols emissions.

The extended assessment of acid deposition including other relevant atmospheric pollutants involved in transboundary and intercontinental transport, and impact studies could be coordinated with regional/ international partners. The EANET would strengthen the cooperation on acid deposition monitoring in response to the air pollution and emerging environmental issues in line with the EANET's mandate, and secure achievements (including financial support) that could sustain its continued operations and development.

5 PRIORITY MEASURES TO ENSURE CLEAN AIR FOR SUSTAINABLE DEVELOPMENT

5. PRIORITY MEASURES TO ENSURE CLEAN AIR FOR SUSTAINABLE DEVELOPMENT

5.1 CALL FOR TIMELY ACTIONS BY POLICY MAKERS

Reducing emissions of air pollutants require actions from local up to regional levels. Knowledge-to-action projects and knowledge action networks are needed to transfer knowledge generated by scientists and countries to local institutions where such knowledge is much needed. Cost effective technologies are available to reduce emissions from a wide range of sources, particularly in the industrial and transport sectors. Complementary actions to reduce acid deposition and improve air quality would therefore be a win-win approach.

Recognizing the achievements attained through the EANET, and aware of the serious impacts of air pollution on human health, ecosystem, and with a common desire for clean air and achieving sustainable development, policy makers are urged to:

- **Support the activities of the EANET on acid deposition and other high priority air pollutants**
- **Raise awareness on scientific aspects of air pollution, including health risks and impacts on environment**
- **Strengthen national monitoring of air pollutants**
- **Use an effects oriented approach in formulation of abatement strategies**
- **Explore the potential for applying differential abatement strategies and responsibilities according to national susceptibility, priorities, institutional and administrative capacity and available resources in a cooperative transboundary context**
- **Adopt a Co-benefits approach which links acid deposition with air quality for mutual benefits**
- **Promote and strengthen collaborative partnerships with international organizations, regional initiatives, and other networks for reduction of air pollutants**
- **Share best practices and technological knowledge and experiences**

5.2 SUPPORTING THE LONG TERM VISION ON URBAN AIR QUALITY BY INITIATIVES IN ASIA AND OTHER REGIONS

At the Fourth Governmental Meeting on Urban Air Quality in Asia organized by United Nations Environment Programme (UNEP) and the Clean Air Asia (former Clean Air Initiative for Asian Cities - CAI-Asia) in Bangkok on 6 February 2013, representatives of the governments of countries in Asia reviewed and discussed the strategies to achieve the Long Term Vision on Urban Air Quality in Asia (LTV): “Healthy people in healthy cities, which put emphasis on prevention of air pollution and which implement effective and appropriate strategies for the abatement of air pollution”.

Clean Air Asia and UNEP are currently collaborating with Asian governments to develop a Guidance Framework on Urban Air Quality in Asia to strengthen the capacity of governments in the management of air quality and control of greenhouse gas emissions. The draft of the Guidance Framework was presented at the Fifth Governmental Meeting on Urban Air Quality in Asia in November 2014.

Recognizing the deteriorating air quality in most cities and recent findings on health impacts, urban air quality management must be made a priority. Collaboration between countries, organizations, networks and experts across Asia and with other regional/global initiatives is crucial.

5.3 SUGGESTIONS ON FUTURE COOPERATION OF THE EANET

The EANET has an important role to provide policy advice and information to the participating countries, regional and global initiatives based upon sound science and assessment. To further strengthen the network the following action plans were suggested at the Fourteenth Session of the Intergovernmental Meeting (IG14) on the EANET under the present scope of the EANET:

- Ozone and PM2.5 monitoring to be added to the monitoring items at the EANET sites with high priority. Practical implementation of the monitoring should follow in a stepwise manner. Pre-existing sites which have already started monitoring ozone and PM2.5 monitoring could be added to the EANET monitoring network.

- Technical support and capacity building for air concentration monitoring including ozone and PM2.5 to be enhanced.

- Research activities on inter-linkages between acid deposition, air pollution, and co-benefits/co-control approach to be undertaken by utilizing external funding.

- Extended assessment of the state of acid deposition and air pollution to be made with the aid of modelling and emission inventories. Assessment of the impacts on human health from exposure to ozone and PM2.5 in combination with monitoring, modelling and emission inventory to be considered for future research activities of the EANET.

- Public awareness activities and the establishment of an epistemic community to be promoted in order to achieve a common understanding among different stakeholders on acid deposition and its inter-linkages with other atmospheric pollution.

- Information on new direction of atmospheric management to be disseminated among the EANET participating countries through enhanced collaboration with international organizations outside the region.

It should be noted that monitoring of ozone and PM are included in the present scope of the EANET as indicated in the Monitoring Guidelines and related Strategy Papers of the EANET. However, not all the participating countries have fully implemented the monitoring of the first priority chemical species and thus the action plan includes the promotion of ozone and PM2.5 monitoring and assessment.

REFERENCES

Ajero, M. and Patdu, K. 2013. Status and Trends of Urban Air Quality in Asia. Clean Air Asia. The Fourth Governmental Meeting on Urban Air Quality held in Asia. Bangkok, Thailand.

BAQ. 2012. Risk assessment for possible impacts of ozone and PM2.5 on human health and crop yield. Better Air Quality (BAQ) Conference. Clean Air Asia Center. Manila, Philippines.

Clean Air Asia. 2013. Status and Trends of Urban Air Quality in Asia. The Fourth Governmental Meeting on Urban Air Quality held in Asia. Bangkok, Thailand.

Clean Air Asia. 2010. Air Quality in Asia: Status and Trends. Clean Air Asia (formerly Clean Air Initiative for Asian Cities (CAI Asia)) Center. The 2010 Edition. Manila, Philippines.

EANET. 2012a. Proceedings of the Fourteenth Session of the Intergovernmental Meeting (IG14) on Acid Deposition Monitoring Network in East Asia (EANET). Pathumthani, Thailand.

EANET. 2012b. Proceedings of the Thirteenth Senior Technical Managers' Meeting (STM13) on the Acid Deposition Monitoring Network in East Asia (EANET). Pathumthani, Thailand.

EANET. 2012c. Proceedings of the Twelfth Session of the Scientific Advisory Committee (SAC12), on the Acid Deposition Monitoring Network in East Asia (EANET). Pathumthani, Thailand.

EANET. 2011a. EANET Science Bulletin (Vol. 2).Acid Deposition Monitoring Network in East Asia (EANET). Niigata, Japan.

EANET. 2011b. The Second Periodic Report on the State of Acid Deposition in East Asia (PRSAD2), Part II: National Assessments. Acid Deposition Monitoring Network in East Asia (EANET). Niigata, Japan.

EANET. 2011c. The Second Periodic Report on the State of Acid Deposition in East Asia (PRSAD2), Part I: Regional Assessment. Acid Deposition Monitoring Network in East Asia (EANET). Niigata, Japan.

EANET. 2009a. Clean Air for a Sustainable Future. The Second Report for Policy Makers (RPM2). Acid Deposition Monitoring Network in East Asia (EANET). Pathumthani, Thailand.

EANET. 2009b. The EANET Science Bulletin (Vol. 1), Acid Deposition Monitoring Network in East Asia (EANET). Niigata, Japan.

EANET. 2005. Goals, Achievements and Way Forward. Report for Policy Makers (RPM) on Acid Deposition Monitoring Network in East Asia (EANET). Pathumthani, Thailand.

HEI. 2012. Outdoor Air Pollution Among Top Global Health Risks in 2010 – Press Release on December 13, 2012. Health Effects Institute (HEI). Geneva, Switzerland.

HEI. 2010. Outdoor Air Pollution and Health in the Developing Countries of Asia: A Comprehensive Review. Health Effects Institute (HEI). The Special Report 18. Geneva, Switzerland.

HTAP. 2010. Hemispheric Transport of Air Pollution 2010. Part A: Ozone and Particulate Matter. Air Pollution Studies No. 17. The Task Force on Hemispheric Transport of Air Pollution (HTAP). United Nations Economic Commission for Europe. Geneva, Switzerland.

Hicks, W.K., Kuylenstierna, J.C.I., Owen, A., Dentener, F., Seip, H.M. and Rodhe, H. 2008. Soil Sensitivity to Acidification in Asia: Status and Prospects. Ambio. 37: 295–303.

Jonas, P.R., R.J. Charlson and H. Rodhe: Aerosols, Climate Change 1994. Radiative Forcing of Climate Change and an Evalation of the IPCC 1992 IS92 Emission Scenarios, J.T. Houghton et al. (Eds), Intergovernamental Panel on Climate Change, Cambridge University Press, U.K., pp. 127-162, 1995

Lim S.S., Vos T., Flaxman A.D., Danaei G., Shibuya K., Adair-Rohani H., Amann M., Anderson H.R., Andrews K.G., Aryee M., Atkinson C., Bacchus L.J., Bahalim A.N., Balakrishnan K., Balmes J., Barker-Collo S., Baxter A., Bell M.L., Blore J.D., Blyth F., Bonner C., Borges G., Bourne R., Boussinesq M., Brauer M., Brooks P., Bruce N.G., Brunekreef B., Bryan-Hancock C., Bucello C., Buchbinder R., Bull F., Burnett R.T., Byers T.E., Calabria B., Carapetis J., Carnahan E., Chafe Z., Charlson F., Chen H., Chen J.S., Cheng A.T., Child J.C., Cohen A., Colson K.E., Cowie B.C., Darby S., Darling S., Davis A., Degenhardt L., Dentener F., Des Jarlais D.C., Devries K., Dherani M., Ding E.L., Dorsey ER, Driscoll T, Edmond K, Ali

SE, Engell RE, Erwin PJ, Fahimi S, Falder G, Farzadfar F., Ferrari A., Finucane M.M., Flaxman S., Fowkes F.G., Freedman G., Freeman M.K., Gakidou E., Ghosh S., Giovannucci E., Gmel G., Graham K., Grainger R., Grant B., Gunnell D., Gutierrez H.R., Hall W., Hoek H.W., Hogan A., Hosgood H.D. 3rd, Hoy D., Hu H., Hubbell B.J., Hutchings S.J., Ibeanusi S.E., Jacklyn G.L., Jasrasaria R., Jonas J.B., Kan H., Kanis J.A., Kassebaum N., Kawakami N., Khang Y.H., Khatibzadeh S., Khoo J.P., Kok C., Laden F., Lalloo R.,

Lan Q., Lathlean T., Leasher J.L., Leigh J., Li Y., Lin J.K., Lipshultz S.E., London S., Lozano R., Lu Y., Mak J., Malekzadeh R., Mallinger L., Marcenes W., March L., Marks R., Martin R., McGale P., McGrath J., Mehta S., Mensah G.A., Merriman T.R., Micha R., Michaud C., Mishra V., MohdHanafiah K., Mokdad A.A., Morawska L., Mozaffarian D., Murphy T., Naghavi M., Neal B., Nelson P.K., Nolla J.M., Norman R., Olives C., Omer S.B., Orchard J., Osborne R., Ostro B., Page A., Pandey K.D., Parry C.D., Passmore E., Patra J., Pearce N., Pelizzari P.M., Petzold M., Phillips M.R., Pope D., Pope C.A. 3rd, Powles J., Rao M., Razavi H., Rehfuess E.A., Rehm J.T., Ritz B., Rivara F.P., Roberts T., Robinson C., Rodriguez-Portales J.A., Romieu I., Room R., Rosenfeld L.C., Roy A., Rushton L., Salomon J.A., Sampson U., Sanchez-Riera L., Sanman E., Sapkota A., Seedat S., Shi P., Shield K., Shivakoti R., Singh G.M., Sleet D.A., Smith E., Smith K.R., Stapelberg N.J., Steenland K., Stöckl H., Stovner L.J., Straif K., Straney L., Thurston G.D., Tran J.H., Van Dingenen R., van Donkelaar A., Veerman J.L., Vijayakumar L., Weintraub R., Weissman M.M., White R.A., Whiteford H., Wiersma S.T., Wilkinson J.D., Williams H.C., Williams W., Wilson N., Woolf A.D., Yip P., Zielinski J.M., Lopez A.D., Murray C.J., Ezzati M., AlMazroa M.A. and Memish Z.A.. 2012. A Comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 380: 2224-60.

Stohl, A. and S. Eckhardt. 2004. Intercontinental Transport of Air Pollution: An Introduction, in Intercontinental Transport of Air Pollution. Springer Science and Business Media B.V.

Task Force on Hemispheric Transport of Air Pollution (TF HTAP). 2007. 2007 Interim Report. TF HTAP. United Nations Economic Commission for Europe (UNECE). Geneva, Switzerland.

UN. 2012. World Urbanization Prospects. United Nations (UN), Department of Economic and Social Affairs, Population Division. The 2011 Revision Highlights. New York.

UNEP. 2012a. Black Carbon e-Bulletin, Volume 4, Number 1. April 2012. United Nations Environment Programme (UNEP). Nairobi, Kenya.

UNEP. 2012b. Global Environmental Outlook (GEO)-5: Chapter 2 Atmosphere. United Nations Environment Programme (UNEP). Nairobi, Kenya.

UNEP. 2011a. Actions for Controlling Short-Lived Climate Forcers. The Synthesis Report, Near-term Climate Protection and Clean Air Benefits. United Nations Environment Programme (UNEP). Nairobi, Kenya.

UNEP. 2011b. Black Carbon e-Bulletin, Volume 3, Number 2. December 2011. United Nations Environment Programme (UNEP). Nairobi, Kenya.

UNEP/Clean Air Asia. 2008. Blue Skies 2030: Background Document on the Long Term Vision for Urban Air Quality in Asia.

UNEP/WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone – Summary for Decision Makers, United Nations Environment Programme (UNEP). Nairobi, Kenya.

WHO. 2014a. 7 million premature deaths annually linked to air pollution – News release on March 25, 2014. World Health Organization (WHO). Geneva, Switzerland.

WHO. 2014b. Burden of Disease 2012. World Health Organization (WHO). Geneva, Switzerland.

WHO. 2012. Health Effects of Black Carbon. World Health Organization (WHO). Geneva, Switzerland. WHO. 2009. Global Health Risk: Mortality and Burden of Disease Attributable to Selected Major Risks. World Health Organization (WHO). Geneva, Switzerland

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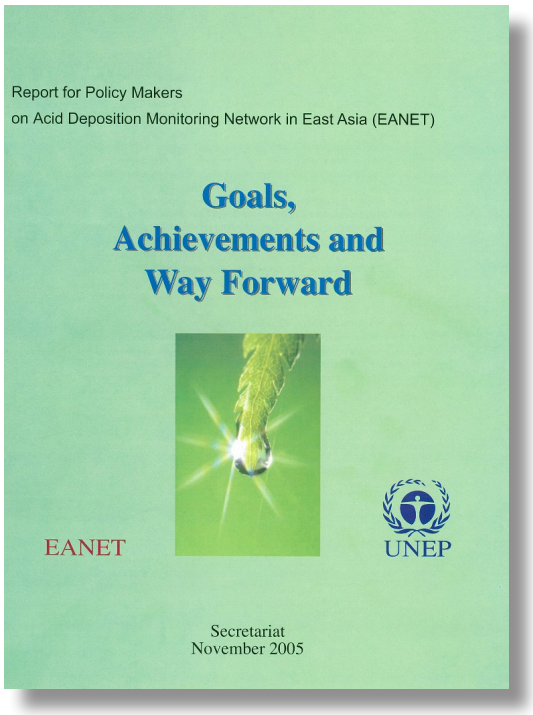

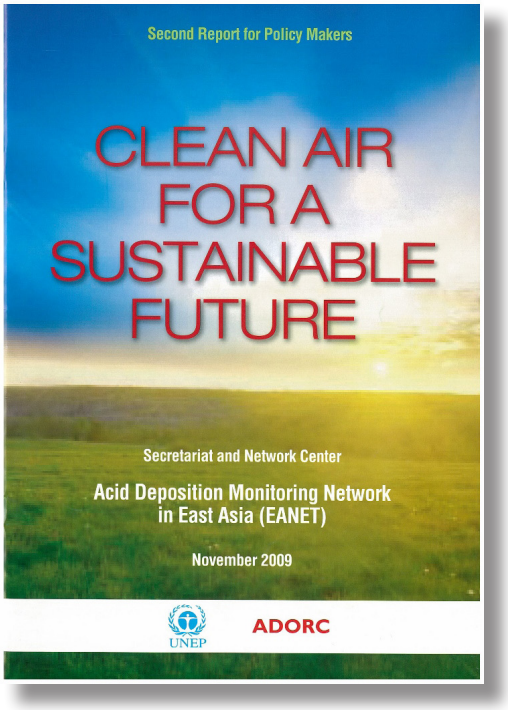

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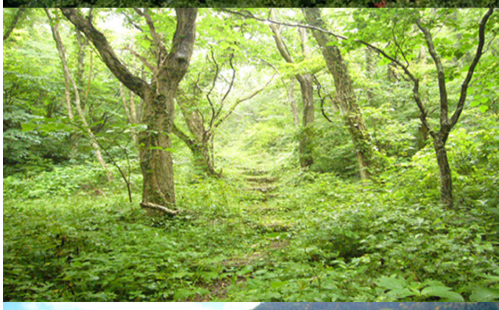


Secretariat

Regional Resource Centre for Asia and the Pacific (RRC.AP)

3rd Floor, Outreach Building
P.O.Box4, Klongluang Pathumthani, 12120, Thailand
Tel: +662-524-5366, 524-6244
Fax: +662-516-2125,25246233
Web: http://www.rrcap.ait.asia

Network Center

Asia Center for Air Pollution Research (ACAP)

1182 Sowa, Nishi-ku, Nniigata Nishi, 950-2144
Japan
Tel: +81-25-263-0550
Fax:+81-25-263-0556
Web: http://www.acap.asia