Data Collection Survey on Air Quality Management Sector

Final Report

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Abbreviation

Abbreviation	
AQI	Air Quality Index
AQMS	Air Quality Monitoring System
ASEA	The Security, Energy and Environment Agency
BC	Black Carbon
CAIP	Cairo Air Improvement Project
CAMe	The Environmental Commission of the Megalopolis (CAMe)
CAMS	Copernicus Atmosphere Monitoring Service
CICA	The Air Quality Information Center (CICA)
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DANIDA	Danish International Development Agency
DONRE	Department of Natural Resources and Environment
EANET	Acid Deposition Monitoring Network in East Asia
ECMWF	European Centre for Medium-Range Weather Forecasts
Euro *x*	European emission standards for vehicle
EEA	European Environment Agency
EEAA	Egyptian Environmental Affairs Agency
EIMP	Environmental Information and Monitoring Programme
ELV	Emission Limit Values
EMCA	The Environmental Management and Coordination Act
EMEP	European Monitoring and Evaluation Programme
EPI	Environmental Performance Index
EU	European Union
GDP	Gross Domestic Product
GNI	Gross National Income
GHG	Green House Gas
GRDP	Gross Regional Domestic Product
HEPA	Hanoi Environmental Protection Agency
IEA	International Energy Agency
JMA	Japan Meteorological Agency
HP	Homepage
IDD	IDD (ds335.0) Historical Unidata Internet Data Distribution
IEECC	Institute of Energy and Climate Change of the State of Mexico
INECC	The National Institute of Ecology and Climate Change
IPCC	Intergovernmental Panel on Climate Chang
JICA	Japan International Cooperation Agency
LAA	The Environmental Analysis Laboratory
LDC	Least Developed Country
LEP	Law on Environmental Protection
LRTAP	Convention on Long-range Trans-boundary Air Pollution
LGEEPA	General Law of Ecological Balance and Environmental Protection
MARD	Ministry of Agriculture and Rural Development
MCMA	Mexico City Metropolitan Area, MCMA

MEP	Ministry of Environmental Protection
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology
MOT	Ministry of Transportation
NCAR/UCAR	National Center for Atmospheric Research | University Corporation for Atmospheric Research
NCCG	Nairobi City County Government
NEMA	The National Environment Management Authority
NOM	Norma Oficial Mexicana
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxides
NOx	Nitrogen Oxides
O_3	Ozone
OECC	Overseas Environmental Cooperation Center
PAOT	Mexico City's Environmental and Land Use Attorney
PM	Particle Matter
PM_{10}	Particulate Matter with a diameter of 10 micrometers or less
$PM_{2.5}$	Particulate Matter with a diameter of 2.5 micrometers or less
PROFEPA	The Federal Attorney for Environmental Protection
PROPAEM	The Environmental Protection Attorney of the State of Mexico
QCVN	National Technical Regulation
RAMA	The Automatic Atmospheric Monitoring Network
REDDA	The Atmospheric Deposit Network (REDDA)
REDMA	The Atmospheric Monitoring Manual Network
REDMET	The Solar Meteorology and Radiation Network
SCCF	Special Climate Change Fund
SDG	Sustainable Development Goal
SEDEMA	The Secretariat of Environment of Mexico City
SEMARNAT	The Secretariat of Environment and Natural Resources
SEPA	Serbian Environmental Protection Agency
SIINEM	Subsistema de Información del Inventario Nacional de Emisiones de Mexico
SLCP	Short-Lived Climate Pollutants
SMA	Secretariat of Environment of the State of Mexico
SO_2	Sulfur Dioxides
TIER	Technology Innovation and Emissions Reduction
TSP	Total Suspended Matter
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
USAID	U.S. Agency for International Development
USEPA	U.S. Environmental Protection Agency
USD	The United States Dollar
UTC	Coordinated Universal Time
VEA	Department of Environmental Quality Management

VND	Vietnam Dong
VOCs	Volatile Organic Compounds
WB	The World Bank
WHO	World Health Organization
WMO	World Meteorological Organization
WMOID	World Meteorological Organization Identification Number
ZMVM	Metropolitan Zone of the Valley of Mexico

1. Summary

The summary and purposes of this survey are as follows.

Overview of the Survey

1. Background	Air pollution caused by industries and traffic is causing serious damage to the health of urban residents in developing countries, where about 76% of the world's population lives. As of 2016, more than 90% of the world's population lives in an environment that does not meet the WHO standard for $PM_{2.5}$, and according to the WHO more than half of them are exposed to $PM_{2.5}$ which is 2.5 times higher than the standard. Japan has been supporting technically and financially the developing countries to improve air quality management based on its experience of overcoming domestic pollution. In many of these countries, the problem is not only the lack of scientific methods or technologies to identify pollutants and sources, but also the lack of basic information to understand the current air pollution situation.
2. Summary	The purpose of this study is to assess the air quality and to examine the needs and possibilities of cooperation with candidate countries around the world, by collecting information on air quality management. In addition, the status of air quality management in multiple countries is compared to find common and unique points, as well as the urgency and priority for cooperation.
3.Target area	The target countries/cities are determined by screening the candidate countries designated by JICA.
4.Goal	The purpose of this project is to conduct a survey and analysis in two stages. **[1st stage]** Basic information on air pollution will be collected in the countries/cities to be surveyed to understand the overview of the current situation, and then the issues on air quality management will be categorized based on their pollution type and improvement of air pollution control measures. **[2nd stage]** By comparing the information obtained in the 1st stage, the countries/cities for further survey are selected based on the criteria considering needs for assistance, and local government system. A detailed survey is conducted in the selected countries to identify the assistance needs and to examine the direction of cooperation in the future.
5.Activity	Criteria were developed to narrow down the list of countries/cities to be surveyed in the first stage of the project from the 43 candidate countries designated by JICA. After consultation with JICA, three new countries were added to the candidate list, which have high possibility of finding sufficient information and have need for assistance. The items to be surveyed in the first stage were arranged in consultation with JICA, and information was collected for 32 countries/33 cities. The collected data were arranged into two formats: the "Overview Sheet," which mainly contains only numerical information so that multiple countries can be compared easily, and the "Individual Sheet" for each country, which contains a detailed description for each item. Based on the information collected, the target countries were grouped using $PM_{2.5}$ exposure values and socioeconomic indicators. As a result, Egypt, Kenya, Vietnam, Serbia, and Mexico were selected as representative countries for the study. In the second stage of the study, a survey was conducted in these 5 countries to collect detailed information and investigate the needs for assistance and the possibility for cooperation. The correlation between socio-economic development, the development of air quality management systems, and air pollution conditions were analyzed by comparing these five countries.

2. Overview of the Survey

2.1. Background of the Survey

2.1.1. Overview of the air quality management sector

2.1.1.1. Urban and Environmental Issues

Since the 1940s the developing countries are experiencing rapid population growth, especially in urban areas, in accordance with the remarkable economic development (Refer to Figure 2-1, which is made by the JST based on UN information materials [1]).

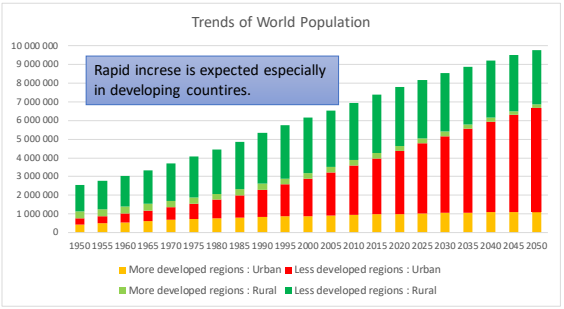


Figure 2-1 Rapid Increase of Population in developing countries

In developing countries, under the circumstances where the urban infrastructure is underdeveloped and environmental conservation measures are inadequate, due to the urbanization such as the rapid increase in urban population and urban development, the urban environment which is shown in Figure 2-2 is greatly transformed and environmental deterioration is being caused.

Air pollution caused by industrial activities, automobile traffic, and socio-economic activities such as households has a great impact on the health of urban residents in developing countries, where about 76% of the global population lives.

Japan has faced serious pollution problems during the period of high economic growth. Therefore, Japan had to gradually overcome them by steadily improving laws and regulations, strengthening the enforcement system, and strengthening pollution control measures based on improvement of environmental science and technology. The knowledge, suggestions, and lessons learned from this experience are required to solve the environmental problems caused by urbanization, which are currently facing many developing countries.

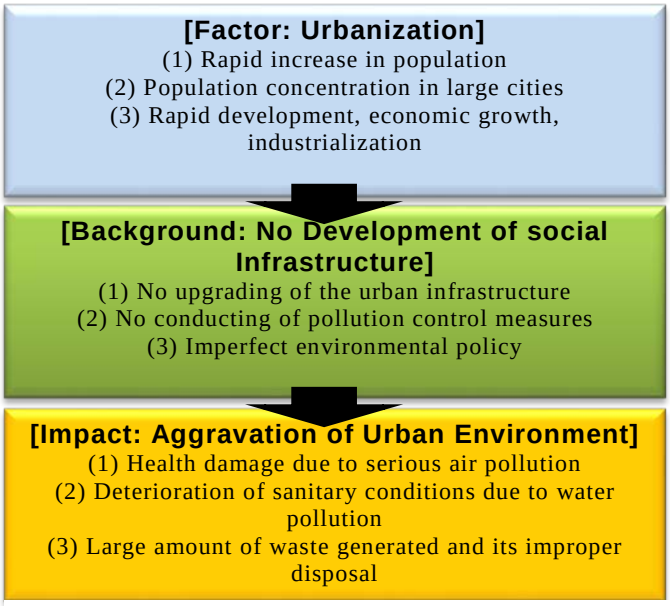


Figure 2-2 Effect of Urbanization to Environment

Based on the experience of Japan, the technical cooperation projects mainly aiming to improve the capacity of government agencies and the grants such as the provision of monitoring and analysis equipment is expected to be continuously the main cooperation content in solving a/ir pollution issues in developing countries. In addition, if the collaboration with bodies such as the urban and regional development sector, transportation sector can be added to the component of the technical cooperative project, it will be

[1] https://population.un.org/wup/Download/

effective for the approach to development issue, and the cooperation project will be able to contribute to the SDGs. Table 2-1 shows the outline of cooperation projects for each scheme in the field of air quality management that have been implemented in the past, and the outline of collaboration with related sectors that are expected in the future.

Table 2-1 Outline of the cooperation for each scheme in air quality management and Outline of expected collaboration with relevant sectors in the future

Classification	Subject	Outline of the Cooperation Project/ component
Outline of cooperation projects for each scheme in the field of air quality management	Technical Cooperation Projects on air quality management	- Projects to support the capacity development and enhancement of the capacity for air quality management of the target country/city administrative organizations: depending on the current state of air pollution and the needs of the government agencies of the partner country, (1) Monitoring of air quality and emission sources, (2) Analysis technology for air pollution structure using emission inventory and simulation, (3) Planning and evaluation of policies and measures, (4) Development of Institutional framework, (5) measures for emission sources, etc. - Collaboration between the above technical cooperation items related to air quality management and policy support such as medium- to long-term environmental management planning and roadmap formulation in cities. - Support in introduction of measures related to pollution reduction, such as emission control measures for large-scale stationary emission sources such as thermal power plants, measures for vehicles considering traffic congestion control, and the dissemination of improved fuels and improved boilers.
	Grants for air quality management	Grant aid that consists of soft components and the provision of analytical equipment related to air quality monitoring/ emission source monitoring.
	Sharing and dissemination of knowledge by utilizing the results of existing cooperation	A cooperation project to disseminate to neighboring countries the achievements and knowledge of the countries that were gained through JICA support in the past. Example: Expanding the achievements and knowledge of Thailand and Vietnam to neighboring countries such as Laos and Cambodia. Example: Sharing knowledge among participating countries of international frameworks such as acid rain monitoring network.
Collaboration with the relevant organizations (including technical cooperation projects and grants)	Air Quality Management on development planning and regional development	- Addition of the component to formulate a development plan for realizing air quality management in the formulation of an urban and/or regional development master plan. - Addition of items and evaluation elements for air quality management in smart city development to achieve aims such as carbon-neutral society, RE100, zero emissions. - Addition of the component of air quality management in the regional development and related pilot projects to achieve green growth.
	Air Quality Management in the Transport Sector	Addition of air quality management components in road maintenance and improvement projects and related technical cooperation projects (for example, low emission examination of air quality management policies and evaluation of air pollution reduction effect such as through promotion of fuel shift by introducing fuel regulations, reduction of air pollution through mitigation of traffic congestion, restrictions on the entry of aging vehicles into urban areas, tax incentives for low emission vehicles). In many countries in this survey, traffic was a major cause of air pollution, especially in urban areas, which suggests that effect of measures in this sector is highly effective for air quality improvement. On the other hand, there were some cases where low household incomes prevented the replacement and maintenance of vehicles, as well as the cases where the

Classification	Subject	Outline of the Cooperation Project/ component
		enforcement capacity of regulations were weak.
	Air Quality Management collaborating with the Energy Sector	- Addition of co-benefit evaluation activities to consider the effect of reducing air pollutant emissions in activities in order to promote the update and efficiency of combustion facilities in the energy conservation promotion project. - Incorporation of the verification of air pollution control measures effectiveness in projects such as promotion of renewable energy considering carbon neutrality, rehabilitation of thermal power plants, and fuel shift. In particular, measures for coal-fired power plant are a pressing issue in Vietnam, Serbia, and other countries surveyed, and the need for such countermeasures is considered to be high.
	Air Quality Management in collaboration with the economic development	The concept of Eco Industrial Park will be added in the project of development facilitation for industrial complexes. The components will be added to support the air pollution emission reductions (promotion of fuel shift, introduction of renewable energy) in combination with measures such as tax incentives.
	Air Quality Management in collaboration with the Agriculture Sector	The components of the project that support composting and resource recovery (biomass energy) as one of the activities of the agricultural sector will be added as measures to prevent air pollution caused by open burning in cultivation areas. The damage caused by open burning is an issue in many Southeast Asian countries and other countries around the world. In Egypt, a project is underway to reduce open burning through educational activities that publicize the dangers of open burning as well as the usefulness of agricultural residues as a commodity.

Source: JICA Survey Team

2.1.1.2. Air Pollution Challenges as Global Issues

The main source of air pollution is the combustion of fossil fuels associated with human activities. This combustion emits CO_2, which is a GHG, as well as other air pollutants. Therefore, the emission sources and air pollution control measures for air pollutants and GHGs frequently overlap.

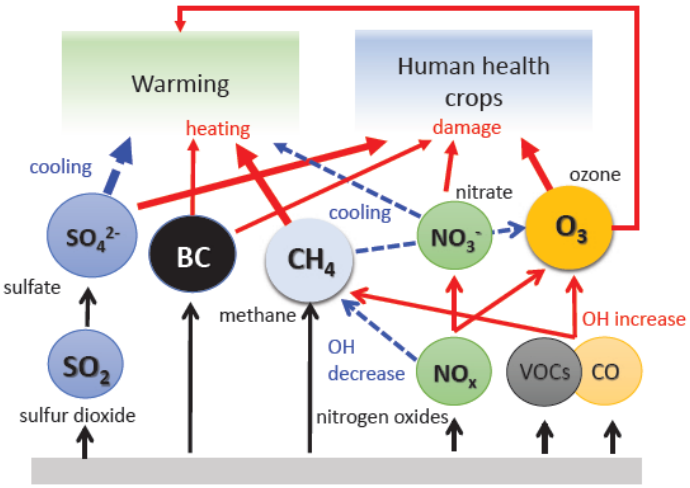


Figure 2-3 Air pollution and Climate Change

Source: http://157.82.240.167/~S12/moej-s12/

The Short-Lived Climate Pollutants (SLCP) such as CO_2 have a relatively shorter lifespan in the atmosphere than GHGs, and are substances that lead to local air pollution. In addition, SLCPs in the atmosphere can also cause increase in global warming. As mentioned above, the SLCPs are substances that affect both global warming and air pollution. In recent years, SLCPs reduction measures have been receiving major attention toward the simultaneous solution for global warming and air pollution[2]. Main SLCPs include soot (BC:

[2] https://www.nies.go.jp/social/topics_SLCP.html

Black Carbon), which is one component of $PM_{2.5}$, and ground-level ozone (O_3), which is the main component of photochemical oxidants. In recent years, it has become clear that emission reduction of SLCPs as well as CO_2 has a beneficial effect on reducing the global warming that will occur over the next few decades. The precursor substances of O_3 are NO_x and VOCs, and these air pollutants are also indirect SLCPs (refer to Figure 2-3). The emission reduction of SLCPs is becoming more important as a measures against climate change and it brings multifaceted benefits, through mitigating the health effects and crop damage from air pollutants.

BC and ground-level ozone as SLCPs have become problems not only in Japan but also worldwide. If the reduction of these substances can be realized as a measure against air pollution, there will be great benefits for both the global environment, local environment, and health impacts.

2.1.1.3. Air Pollution Issues in developing countries

In recent years, due to economic growth and rapid progress of urbanization, air pollution has become apparent in developing countries such as Southeast Asia and South Asian countries. On the other hand, due to the lack of scientific methods and technical capabilities required to identify air pollutants and emission sources, basic information on air pollution status has not been prepared. Furthermore, as the economic development progresses, the air pollution problem is widely recognized by the citizens as a social problem, which makes it a policy challenge, and many developing countries have not been able to adequately deal with the issues of air quality management.

In order to continuously implement air quality management in developing countries, it is necessary to be able to carry out smoothly the cycle shown in Figure 2-4 consisting of (1) Scientific research & determination of cause, (2) Support for the technical aspect to promote measures, (3) Implementation of measures and emission control, and (4) Evaluation.

There are some cases where while a sufficient legal system has been established because of the introduction of the legal systems of developed countries such as the United States and the EU, the implementation of the law may not be effective. These cases are found in many countries such as Mongolia, Kosovo, and Moldova, where the survey team has carried out and still carries out technical cooperation projects. The reasons for these cases are that there are no sufficiently established systems for implementing administrative measures (inspections, regulations, permits, etc.) based on the legal system, lack of equipment and technical capabilities, undeveloped framework of coordination and collaboration with relevant organizations, and no sufficient procedures for establishment of agreements with the private sector and citizens who as operators are emission sources.

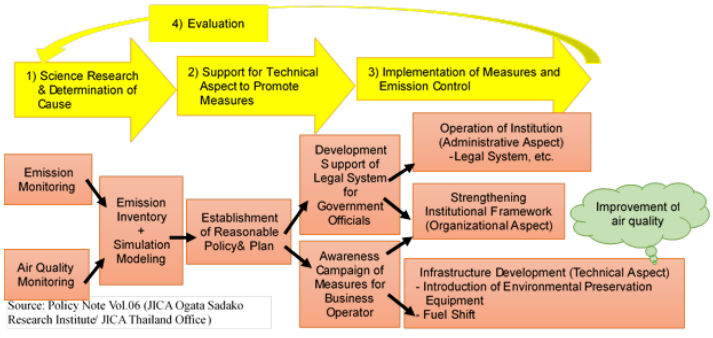


Figure 2-4 Four Phases of Air Pollution Control

In the above case, if there is a lack of some part of this cycle, there is a risk that the whole cycle will not proceed even if other elements are in place. When supporting the developing countries, it is necessary to comprehensively understand the information on air quality management, and then consider the issues and needs. Table 2-2 shows the items related to each process required for air quality management. The relationship between the air quality management process and the first phase survey items B-1 to B-14 (classification B items related to air quality management shown in "Table 3-3 Information Arrangement Policy") is shown.

Table 2-2 Relation between Survey Item and Various Activities on Air Quality Management

Process of air quality management		Correspondence with Survey Item
Scientific Research & Determination of Cause	Clarification of pollution structure by analysis of emission sources contribution	B-12 Air pollution control tools (Emission inventory, Simulation modeling, Source apportionment study, etc.)
Technical support for promoting measures	Formulation of the legal and regulatory framework Strategy and Plan on air quality management Tools for evaluating air pollution control measures	B-1 Legal system, basic laws, individual laws, local level ordinances B-2 Environmental standard B-4 Air Quality Management Policy (Policy, Air Quality Management Plan, Air Measurement Plan) B-6 Administrative organizations in National government or Municipality related to air quality management (jurisdiction, organization chart, number of employees, budget, etc.) B-7 Inter-ministerial collaboration and coordination mechanisms for air pollution control B-8 Air Quality Monitoring System B-12 Air pollution control tools (Emission inventory, Simulation modeling, Source apportionment study, etc.)
Implementation of measures and control of emissions	Monitoring of emission sources Emission control measures	B-3 Air Pollutant Emission Reduction Measures and Emission Standards B-5 Guidelines and manuals related to air quality management B-10 Monitoring system for air pollutant emission sources (Industries, Offices, etc.) B-11 Activities of major industry associations on air pollution control
Evaluation	Air Quality Monitoring Evaluation of air pollution control measures	B-9 Current Status of Air Quality Monitoring B-12 Air pollution control tools (Emission inventory, Simulation modeling, Source apportionment study, etc.) B-13 Review through relevant information such as Energy consumption and GHG emissions data B-14 Status of planning, implementation, and revision of air pollution measures

Source: Survey Team, Policy Note Vol.06 (JICA Ogata Research Institute/ JICA Thailand Office), and Item classification with reference to related items in General Information on the general information of Japanese Training by JICA, Knowledge Co-Creation Program (KCCP) for Group and Region Focus Program [Capacity Building towards Air Quality Management]

2.1.2. Transition in the history of JICA's cooperation in the field of air pollution

2.1.2.1. Review of the support by JICA in air quality management sector

Table 2-3 shows the details of recent supports by JICA in the air quality management sector. In

the field of air quality monitoring, the support with experience and knowledge mainly for the environmental laboratories in Mexico and Romania, has led to the support in installation and enhancement of the capacity for management of air quality monitoring stations in Ulaanbaatar, Tehran, and Kosovo. Regarding the tools for air pollution control measures such as diffusion simulation model and emission source contribution analysis, the knowledge gained through previous technical cooperation projects is being utilized in other projects. In this way, the support content in the air quality management sector has been enhanced and has promoted greater efficiency, and the supports are implemented according to the situation of each country.

Table 2-3 Review of the support by JICA in the air quality management sector

Thailand[3] (2002-2003)	The air pollutant emission inventories in the whole Thailand and Bangkok were prepared, and the air pollution concentrations were evaluated using different simulation models in each region. Based on the results air pollution concentration evaluation, air pollution control measures for automobiles, thermal power plants, residential stationary sources, etc. were formulated.
Mexico[4] (2004-2008)	The project aimed at improving air quality monitoring capacity throughout Mexico was implemented with the Environmental Research and Training Center of Mexico (CENICA: Centro Nacional de Investigacion y Capacitacion Ambiental) as the implementing agency. This project provided support for the capacity development for processes such as air quality monitoring, emission inventory preparation and e air pollution forecast models, management and analysis of air quality monitoring data that integrates all these, and support for the application to policies using these achievements.
Romania[5] (2007-2008)	The project goal was to introduce and disseminate a reliable and accurate air quality monitoring system for monitoring the national air quality level. Mainly the capacity of the staff of the National Environmental Reference Laboratory was strengthened.
Ulaanbaatar City[6] (2010-2024)	For serious air pollution caused mainly by combustion of solid fossil fuels in coal-fired thermal power plants and in household heating, continuous supporting projects from Phase 1 to 3 have been carried out for a long period of time. Activities necessary for air pollution control measures are being implemented in a step-by-step manner, such as maintenance of air quality monitoring equipment, collection of emission source information through the boiler registration system, analysis of air pollution structures, evaluation of air pollution control measure effects, and implementation of measures through pilot projects.
China[7] (2013-2016)	In this project, technical guidance on NOx emission control for stationary emission sources was given to model cities, and improvement effects of measures were grasped using air quality simulation models.
Teheran City[8] (2017-2022)	Emissions from vehicles are the main emission sources of air pollution. The knowledge on air pollution structure analysis and effects of air pollution control measures is obtained through various types of measurements, data collection, simulation model analysis, and so on.
Kosovo[9] (2017-2021)	Analysis of the air pollution structure has revealed that the contribution of solid fuels used in households to air pollution is large, and the effects of air pollution control measures were examined. In addition, the capacity of the relevant staff was enhanced through emission measurement for stationary sources, rehabilitation of the Air Quality Monitoring Stations analyzers, establishment of emission inventory preparation system, calculation of air pollutant diffusion simulation, evaluation of air pollution control measures, etc.
Vietnam (2013-2015)	In "The project for institutional development of air quality management in the Socialist Republic of Vietnam", the arrangement of necessary issues and the roadmap were prepared for the

[3] Project title: Acid Deposition Control Strategy in Thailand
[4] Project title: Strengthening of Air Monitoring Program in the United Mexican States
[5] Project title: The project for strengthening the air quality monitoring capability of the National Reference Laboratory of the National Environmental Protection Agency in Romania
[6] Project title: Capacity development project for air pollution control in Ulaanbaatar city in Mongolia (from phase 1 to phase 3)
[7] Project title: The Project for Total Emission Control of Nitrogen Oxide in Atmosphere
[8] Project title: Project for Capacity Development on Air Pollution Control in Tehran Municipality
[9] Project title: Capacity Development Project for Air Pollution Control in the Republic of Kosovo

	province and city in order to formulate and implement the air quality management plan in the future.

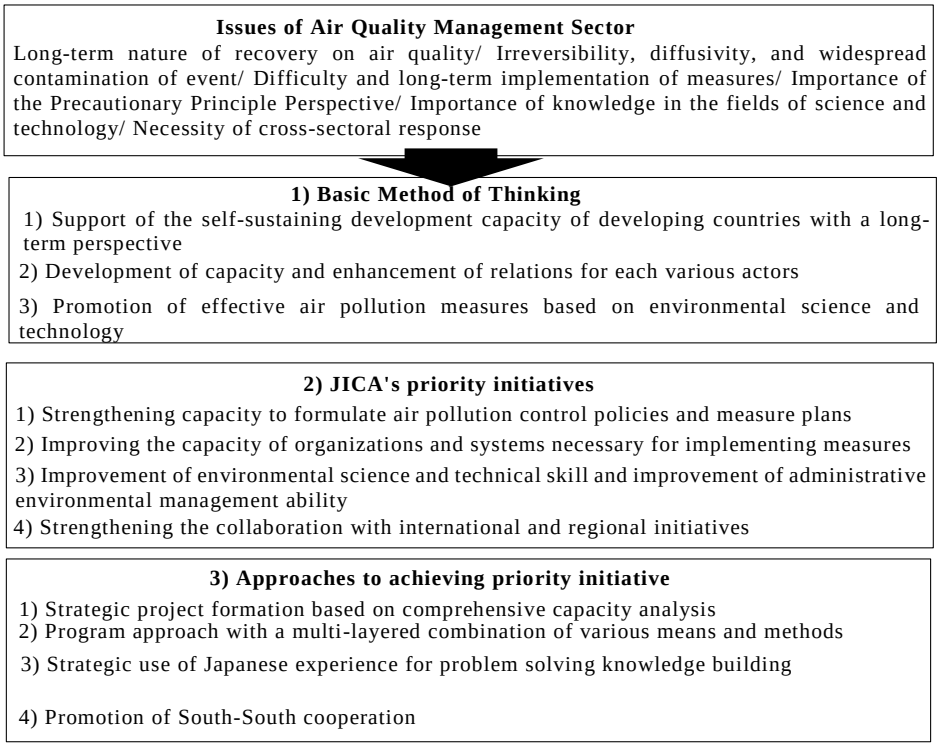
In this way the knowledge and lessons learned from each project are being applied to other projects. However, the project has not been evaluated objectively from a sufficiently broad perspective of the urban environmental management system and the transition of socio-economic development. In addition, analysis and comparative evaluation between projects are not sufficient. As a result, there are no sufficient ex post facto evaluations such as examining commonality and specificity. Therefore, the possibility of expanding the content of support provided to other countries by each project has not been fully examined.

2.1.2.2. Current issues of JICA on air quality management sector

The direction of JICA's cooperation[10] is broadly categorized into the following areas; 1) Quality growth and correction of disparities, 2) Sharing of universal values and promotion of peacebuilding, 3) Enhancement of efforts for global issues and aid tide, 4) Expansion and deepening of strategic partnerships, and 5) Support for active participation and advance into society of women in developing countries. Among them, in the air quality management sector, the air pollution problem is handled as a global issue and a health problem to citizens in developing countries. It is also necessary to support the development of human resources and economic and social infrastructure that will lead to self-help efforts, and the strengthening of governance capabilities of the partner countries by utilizing Japanese knowledge and experience. Based on the recognition shown in Figure 2-5, JICA supported the air pollution control measures through technical cooperation projects and grant aid in target countries mainly with a certain degree of economic development, such as China, Thailand, Vietnam, Mongolia, Iran, Kosovo, and Mexico. In recent years, under the recognition of current situation described above, there are increasing needs to support air pollution control measures in developing countries such as Southeast Asia and South Asian countries. Since the socio-economic status of developing and emerging countries varies it is necessary to consider cooperation needs and future cooperation possibilities from a socio-economic perspective. However, it is difficult to grasp and compare the actual conditions of environmental management policies in many countries where the information dissemination is not sufficient. For the implementation of efficient and effective cooperation, it is necessary to consider and understand the commonality, peculiarity, urgency and priority for support by analyzing and comparing the air pollution status of each country, and the actual conditions of air quality management (experience, knowledge, human resources, funds, etc.).

[10] https://www.jica.go.jp/about/direction/index.html

Furthermore, by extracting groups that are the most effective to support from correlation analysis with basic socio-economic indicators, it is possible to more efficiently select and examine future support target countries. In addition, JICA has been cooperating in the field of air quality management with many countries. By developing human networks and strategic partnerships accumulated in Japan and foreign countries, and contributing to mutual learning and mutual development, the supporting phase is entering at the stage of further promotion of South-South cooperation and triangular cooperation that will lead to the establishment of new development partners. It is also necessary to consider these direction of JICA's cooperation.



Source: Edit of "Effective Approach for development issues" (JICA, December 2005) and JICA's issue-specific guidelines: "Environmental Management (Air/ Water)" (July, 2009)

Figure 2-5 Issues in the field of air quality management and direction of efforts

2.2. Purpose of the Survey and Implementation Approach

In this survey, at first the survey target countries/cities will be determined by screening the candidate countries in the world, where the needs for air pollution control measures are expected. For target countries/cities, the basic information on air pollution is collected, the current situation and issues are understood, and then they are classified based on the categorization of issues and the implementation status of air pollution control measures (first stage). After comparing and examining the basic information of each country/city, the representative countries/cities are specified, and through the surveys and interviews by local consultants in those countries (2nd stage) further investigation is carried out in five selected countries/cites to obtain detailed information to specify the support needs and study the direction of cooperation. In addition, by analyzing and comparing the status of air pollution based on common items for multiple countries/cites, the commonality and specificity as well as the urgency and priority of support will be examined.

2.3. Survey Team and Personnel Planning

The survey formation such as job assignment and assigned area is shown in Table 2-4, and personnel planning for each survey member are shown in Table 2-5.

Table 2-4 Survey member, Job assignment, Assigned area

Position	Name
Team Leader/ Environmental Management Policy	TABATA Toru
Air Quality Management 1 (Technology Analysis)	EDO Ei
Air Quality Management 2 (Policy Analysis)	SAKURAI Sachiko
Air Quality Information Survey 1	FUJIWARA Yuzuru
Air Quality Information Survey 2	NAKAGAWARA Hiroaki
Assistant/ Environmental Management Policy	TACHI Yoya

Table 2-5 Personnel Assignment

Job Assignment	Name	Company Name	Rating	2021 5	6	7	8	9	10	11	12	2022 1	2	Person/Month Overseas	Domestic
Team Leader/ Environmental Management Policy	TABATA Toru	SUR	3	5	5	5		10		5		15	5		2.50
Air Quality Management 1 (Technology Analysis)	EDO Ei	SUR	3					35							1.75
Air Quality Management 2 (Policy Analysis)	SAKURAI Sachiko	NK	3					35							1.75
Air Quality Information Survey 1	FUJIWARA Yuzuru	SUR	4					35							1.75
Air Quality Information Survey 2	NAKAGAWARA Hiroaki	NK	4					35							1.75
Assistant/ Environmental Management Policy	TACHI Yoya	SUR	4												(2.50)
															9.50
														9.50	
	Period of submission of each report			△ Working	△ Plan Inception			△ Progress Report				△ Draft Final Report	△ Final Report		

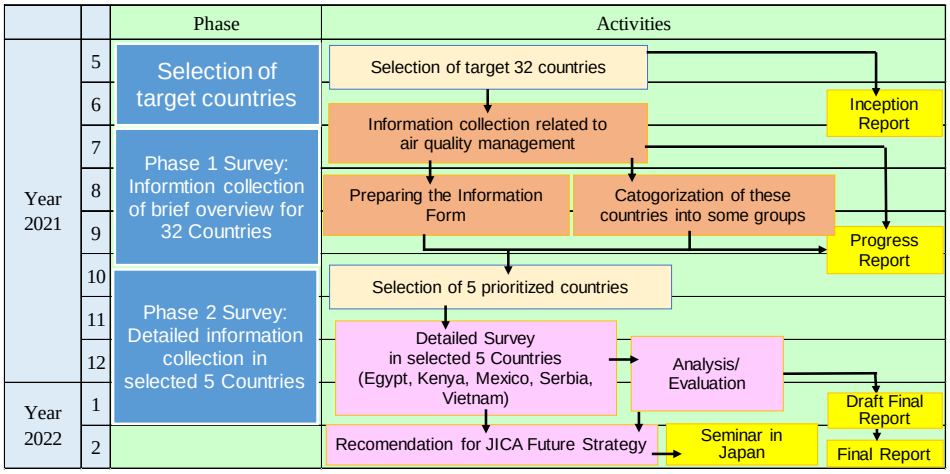
Explanatory Note

SUR: Suuri-Keikaku Co., Ltd. NK: Nippon Koei Co., Ltd.

Domestic work Work by own company defrayment

2.4. Schedule

The flow chart of assignment implementation is shown in Figure 2-6, and the Work Plan is shown in Figure 2-7.



Source: JICA Survey Team

Figure 2-6 Assignment Flowchart

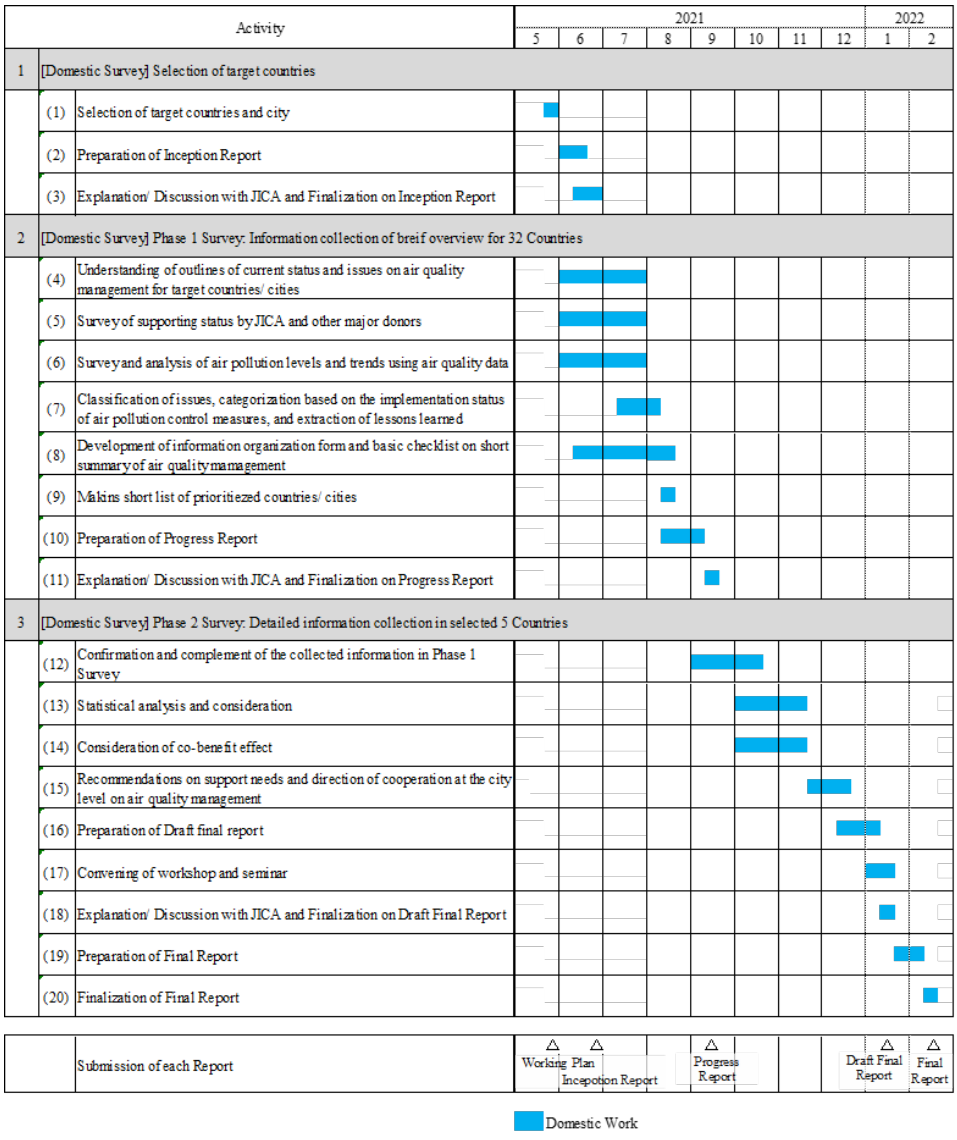


Figure 2-7 Work Plan

3. Overview of air quality management in the surveyed countries/cities

3.1. Screening Criteria

The criteria shown in Table 3-1 were developed to select the target countries/cities for the first stage of the survey among 43 candidate countries designated in the specification by JICA.

In the process of selecting countries for the survey, countries other than the 43 candidates were taken into consideration, which have high possibility of finding sufficient information and needs for assistance. As a result, the survey team and JICA agreed to add three countries to the candidate list. The approach of setting criteria, including the addition of candidate countries/cities, is as follows.

1. From the viewpoint of ease of information collection, the countries that have experience in JICA's environmental management projects were selected, especially focusing on the field of air quality management. Based on the existing survey materials it is assumed that detailed information can be collected in these countries and this can serve as a benchmark for multi-country comparison.
2. The 22 countries that have participated in the training program on air quality management, “Capacity Building for Air Quality Management,” over the past 10 years were all added to the list as it is expected that a certain amount of information can be collected from the Country Reports, and that there is a need for support since they are willing to participate in the training.
3. Regardless of the possibility of collecting information, we thought that we should try to collect information in countries where air pollution is particularly serious and the need for assistance is assumed to be high. Therefore, we added the top three countries in terms of pollution contribution in each region of the world based on the WHO statistics.
4. Countries that are mentioned in the Ministry of Foreign Affairs’ “Country Development Cooperation Policy” are considered to have high needs and potential for cooperation in the environmental field, this means the countries mentioning “urban environment” and/or “air pollution” in the priority areas (medium-term goals) of the policy.
5. Based on other surveys which were conducted by the consultants involved in this survey, additional countries were proposed to the list where enough information and a need for support is expected.

Table 3-1 Criteria for the First Stage of the Survey

	Criteria	Possibility of Information	Countries
1	Countries where JICA's assistance or research in the field of air quality management is ongoing or has been carried out in the past.	・ Based on the existing survey materials, detailed latest information can be collected. ・ Additional information can be easily collected since the C/P has already been identified. ・ C/P is identified and additional information can be easily collected.	Mongolia, Iran, Kosovo, Uganda, China, Thailand, Mexico, Vietnam
2	Countries that have participated in the JICA training course "Capacity Building for Air Quality Management" in the past 10 years	・ It is assumed that a certain amount of basic information can be collected from the Country Reports prepared during the training.	Cambodia, Thailand, Vietnam, Malaysia, China, Mongolia, Afghanistan, India, Sri Lanka, Pakistan, Argentina, Ecuador,

		・ Since the trainee is in charge of the air quality management, it is expected that the investigation in the second stage can be carried out smoothly.	Chile, Brazil, Mexico, Sudan, Algeria, Iran, Egypt, Morocco, Kosovo, Bosnia and Herzegovina 22 countries
3	The top three countries in each region of the world in terms of air pollution according to World health statistics 2020 (WHO).	・ The countries where air pollution is assumed to be serious should be surveyed, from the perspective of support needs, regardless of its accessibility to the data.	Vietnam, Thailand, Laos, China, Mongolia, Nepal, Bangladesh, Chile, Mexico, Ecuador, Sudan, Uganda, Nigeria, Algeria, Iran, Egypt, Serbia, Bosnia and Herzegovina
4	Countries that are mentioned in the Ministry of Foreign Affairs' "Country Development Cooperation Policy"	・ Countries that are mentioned in the Ministry of Foreign Affairs' "Country Development Cooperation Policy" are considered to have high needs and potential for cooperation in the environmental field, this means the countries mentioning "urban environment" and/or "air pollution" in the priority areas (medium-term goals) of the policy.	Vietnam, Nepal, Argentina, Brazil, Ecuador, Kenya, Iran, Kosovo
5	[Additional Proposal] Countries where sufficient information can be expected, and have JICA project experience of and needs in the field of environmental management.	Moldova: Basic information is available because the survey team member is participating in the ongoing JICA survey [11] in the field of air environment. North Macedonia: The country is a neighboring country of Kosovo, where the survey team is currently implementing a technical project, so it is relatively easy to collect information. JICA project to provide air quality monitoring station has been carried out. The contact person has already been identified. Albania: The country is a neighboring country of Kosovo where the survey team is currently implementing a technical project, so it is relatively easy to collect information. The contact person has already been identified.	Moldova, Albania, North Macedonia

Source: JICA Survey Team

3.2. Selection of the target countries/cities for the 1st stage survey

Table 3- shows the results of the selection of countries for the study based on the above criteria. The 32 countries/33 cities selected in this table are planned to be the target countries for the 1st stage survey, including the additional countries proposed above. Since Vietnam is an important target country that meets all the criteria from 1 to 4 above, two cities, Hanoi and Ho Chi Minh City, were selected as the target cities.

[11] Data collection survey on Urban environment sector in the Republic of Moldova

Table 3-2 Screening for 1st stage survey

Region	Country	City	Remarks (target cities, etc.)	Criteria					Candidates for 1st Stage Survey
				Countries participated to JICA training course	Countries with top-three highest PM2.5 in each region	Experience of JICA Cooperation or Surveys regarding air quality management	Refers in the Ministry of Foreign Affairs' national development cooperation policy	Additional propose	
Southeast Asia	Vietnam (**Propose targets for 2 cities in 1 country**)	Hanoi	capital. The survey team has experience of JICA technical professionals related to	○	1	○	○		○
		Ho Chi Minh, Da Nang, etc., 1 other	Largest population. The survey team has experience of making GHG inventory in the JICA project,						○
	Cambodia	Phnom Penh	capital	○					○
	Thailand	Bangkok	Under environmental policy investigation	○	2				○
	Malaysia	Kuala Lumpur	capital	○					○
	Samoa	Apia	capital. The population is about 36,000.						―――
	Papua New Guinea	Port Moresby	capital.						―――
	Fiji	Suva	capital. The population is about 85,000. The largest city with a population is Nashinu (about 88,000 people).						―――
	East Timor	Dili	capital. The population is about 150,000.						―――
	Laos	Vientiane	capital		3				○
	Indonesia	Jakarta	The capital is too big. Other local city should be a target ?						―――
	Philippines	Manila	capital						―――
East Asia	China	Beijing	capital	○	1	○			○
	Mongolia	Ulaanbaatar	Capital: A technical cooperation project by JICA is underway. Can be a benchmark of this survey	○	2	○			○
South Asia	Afghanistan	Kabul	capital	○					○
	India	New Delhi	Capital: There are many large cities, but only the capital is targetted here.	○	2				○
	Sri Lanka	Colombo	The largest city. The capital, Sri Jayawardenepura Kotte, is adjacent to the city of Colombo	○					○
	Nepal	Kathmandu	Capital: Air pollution (PM2.5) is the most serious in the world.		1		○		○
	Pakistan	Islamabad	Capital: There are many big cities such as Karachi, but only the capital is targeted.	○					○
	Bangladesh	Dhaka	Capital: Air pollution (PM2.5) is the most serious in the world.		3				○
Latin America	Argentina	Buenos Aires	Capital: Concentration is progressing.	○			○		○
	Brazil	Brasilia Sao Paulo Rio de Janeiro	(Capital: Not applicable) Target city (Not applicable)	○			○		○
	Chile	Santiago	Capital	○	1				○
	Mexico	Mexico City	Capital	○	2				○
	Ecuador	Quito Guakyakil	Capital: Inland, assuming serious air pollution (Not applicable) Possibility of insufficient atmospheric environment data. Port cit	○	3		○		○
	Jamaica	Kingston	capital						―――
	Dominican Republic	Santo Domingo	capital						―――
Africa	Sudan	Khartoum Omdurman Khartoum North	Capital: Target city. In the future, it is assumed that the following two cities shoul (Not applicable) Because it is adjacent to the capital. (Not applicable) Because it is adjacent to the capital.	○	3				○
	Uganda	Kampala	Capital: A survey by another JICA project is underway. It can be one of the benchmarks.		2	○			○
	Ethiopia	Addis Ababa	capital						―――
	Kenya	Nairobi,Mombasa	Under development of capital economic zone				○		○
	Coat Jiboir	Abidjan	Former Capital: The center of the economy with a population of 4.7 million. The capital is Yamoussoukro, with about 356,000 people.						―――
	Nigeria	Lagos	The capital is Abuja (population of about 980,000), but the largest city is Lagos (about 8 million), which is the old capital, so Lagos is selected.		1				○
	Mozambique	Maputo	capital						―――
Middle East	Algeria	Algiers	capital	○	2				○
	Iran	Tehran	Capital: A technical cooperation project by JICA is underway. This survey benchmark country	○	3	○	○		○
	Egypt	Cairo	capital. There are other big cities such as Alexandria, but they are excluded.	○	1				○
	Morocco	Rabat	capital. The largest city is Casablanca. Urbanization is not so advanced.	○					○
	Tunisia	Tunis	capital						―――
	Palestine	East Jerusalem	capital. It is difficult to set the target area.						―――
Europe	Kosovo	Pristina	Capital: A technical cooperation project by JICA is underway. This survey benchmark country	○		○	○		○
	Ukraine	Kyiv	capital						―――
	Serbia	Belgrade	capital		3				○
	Bosnia-Herzegovina	Sarajevo	capital	○	2				○
	North Macedonia	Skopje	Capital: experience of JICA Cooperation **(Additional proposal)**		1		○	○	○
	Albania	Tirana	Capital: Experience of JICA Cooperation **(Additional proposal)**					○	○
	Moldova	Shishinau	Capital: Experience of JICA Survey (Ongoing). It can be one of the benchmarks.**(Additional proposal)**					○	○
			total	22	20	6		3	**33**

Source: JICA Survey Team

3.3. Information Collection

Information on the selected countries was collected through surveys of documents and websites. In addition to the survey items designated by JICA, basic socioeconomic indicators, natural conditions, security information, etc. were additionally collected in order to prepare the necessary data for analysis and indicators to select countries for the second stage survey.

(a) Survey Process

The information collection survey was conducted mainly through desk survey using the Internet to collect information from websites and literature. Although the sources of information vary from country to country, basic information is first obtained from sources that have parallel summaries for many countries, such as issue-specific training country reports, Air Quality Policies 2015 (UNEP), and the Environmental Infrastructure Overseas Development Platform (Ministry of Environment [12]). The main source of information collection is by category. The main sources of information collection are described below for each category.

In the information collection process, the following points of concern were established and implemented so that the work level of each person in charge could be matched and information could be collected based on a common understanding.

Note on Information Collection Process
- Clearly state the source of the information (i.e., add the material number (1), (2), etc. for each piece of information, and summarize the corresponding source in the table at the bottom).
- Names of ministries, agencies, and laws, should be written in English if its source is written in English, or in both Japanese and English (as far as possible).
- Distinguish clearly “the data is Not Found” from “the data does Not Exist”
- If there’s no data at city level, data at country level is acceptable. It should be stated clearly if the information is mentioned for a specific city.
- It should be clarified how old the information is.
- Information of the category B in the item list in Table 3-3 should be summarized by source type as far as possible. The emission source type should be categorized as follows;
  - Industry (Steel, Cement, Small factory, etc., hopefully industrial type)
  - Power Plant
  - Transport
  - Ship, Aviation
  - Households
  - Open burning

(b) Direction for Organizing Information

The data to be collected can be divided into 2 types; those that can be expressed as numerical information from statistics and those that are qualitative described information. If both data are compiled into a single table, it will be difficult to list and compare between many countries. In order to create a document with listability, only numerical data is arranged in the "Overview Sheet" and the "Individual Sheet" is prepared for each country to describe the qualitative information that cannot be described in the Overview Sheet. The direction for organizing information is shown in Table 3-3.

Summary of the Overview Sheet is indicated in 3.4.1. Complete Overview Sheet is attached as Annex 1, and the Individual Sheet as Annex 2.

[12] https://www.oecc.or.jp/jprsi/

In addition, in order to clarify the source of each piece of information, a list of cited references was created in the "Individual Sheet" to clarify the reliability of the source material and whether the information is old or new.

Table 3-3 Direction for organizing information

No.	Item	Content	Overview Sheet	Individual Sheet
A-0	Urban environment	Major issues on environment, emission sources, characteristics of the city		○
A-1	Population	Population	○	
A-2	Area	Area	○	
A-3	GDP(GNI)/capita	GDP/capita	○	
A-4	Urbanization	Urbanization	○	
A-5	Economic growth	Economic growth	○	
A-6	Major Industry	Production by Industry	○	
A-7	Energy Consumption	Energy Consumption by fuel type	○	
A-8	Air pollution-related diseases	Air pollution-related mortality	○	
A-9	Night light	Average night light at target city (from Satellite data)	○	
A-10	Literacy	Literacy (2018)	○	
A-11	Social maturity	Under-five mortality rate (number of deaths per 1,000 live births) 2018	○	
A-12	SDG Index	SDG Index (2021)		
A-13	Environmental Performance Index	EPI (2020)	○	
B-1	Legislation system	Existence of basic law on environmental pollution (year of enactment) Existence of individual laws on air quality management (year of enactment) Existence of ordinance on air pollution control in the target city (year of enactment)	Yes/No	○
B-2	Air quality standards	Existence of air quality standards	Yes/No	○
B-3	Air pollutant control measures and emission standards	<u>Industry</u> Existence of emission standards for boilers, etc. Existence of regulatory standards for fuel use and quality <u>Vehicle</u> Existence of emission standards for automobiles (EURO regulations, etc.) Existence of automotive fuel quality standards (EURO regulations, sulfur content, lead regulations, etc.) Existence of regulations on import of used vehicles	Yes/No	○
B-4	Policy for air quality management	Existence of basic policy/policies on environmental protection (country/city) Existence of basic policy/policy on air quality management (country/city) Availability of air quality measurement plan Existence of other policies and plans related to air quality		○

B-5	Guideline, Manual related to air quality management	Existence of guidelines and manuals for air quality measurement Existence of guidelines and manuals for exhaust gas measurement and factory audits	Yes/No	○
B-6	Administrative organizations in national / city level involved in air quality management	Existence of a central government agency in charge of air quality management Existence of city departments in charge of air quality management		○
B-7	Interagency collaboration and coordination mechanisms for improving air quality	Existence or non-existence of an interagency joint committee on air quality management, etc.		○
B-8	Air quality monitoring system	Existence of Air Quality Monitoring Station (AQMSs) and their number Measurement items of air pollutants ($PM_{2.5/10}$, NOx, SOx, etc.) Availability of an annual report on air quality Existence of environmental analysis laboratory	Yes/No Number of AQMS	○
B-9	Current Status of Air Quality Monitoring	Outline of monitoring data of each air pollutant		○
B-10	Monitoring system at source (factories and workplaces)	Existence of monitoring system for factories (e.g., exhaust gas audit, mandatory monitoring)		○
B-11	Status of efforts by major industries in the country/city	Approximate percentage of businesses in major industries that are taking measures Size of businesses subject to regulation in major industries		○
B-12	Status of development of air pollution control tools	Frequency of preparation, publication, and updating of air pollutant emission inventories Examples of atmospheric dispersion simulations Examples of PM composition analysis and receptor modeling		○
B-13	Energy consumption	Energy consumption by fuel type	○	
B-14	GHG emission data	GHG emission data by Industry	○	
B-15	Status of planning, implementation, and revision of air pollution measures	Changes in major air pollution-related laws and programs		○
B-16	Conventions, international frameworks, etc.	Status of accession to air pollution-related treaties, EU accession orientation, etc.		○
C-1	Assistance by Japan	Amount of aid in yen loans/grant aid/technical cooperation (FY2018 and type, 100 million yen)	○	
C-2	Economic Cooperation with Major Donors (Buy)	Amount of aid to the top three countries (FY2017, millions of dollars)	○	
C-3	Achievements in Economic Cooperation with International Organizations (Multi)	Amount of support from the top three organizations (FY2017, million dollars)	○	
D-1	Available monitoring data of PM, O_3, NO_2, SO_2, CO, and hazardous substances	$PM_{2.5}$ annual average, change over time	○	○
E-1	Altitude	Elevation of a representative point of the target city (Extract the elevation of the meteorological	○	

		observation point or the center of the target city)		
E-2	Annual average temperature	Annual average temperature at representative point, monthly average	○	
E-3	Annual average wind speed	Annual average wind speed at representative point, monthly average	○	
E-4	Solar radiation	Average solar radiation at representative points	○	
F-1	Public safety	Safety Information provided by Ministry of Foreign Affairs	○	
F-2	Political and social stability	Political stability and absence of violence rank 2019 (Expressed as a percentile value out of approximately 210 countries analyzed, with a value indicating closer to 100 is better)	○	
Add	Population / City	Population / City	○	
Add	Population density	Population density	○	
Add	Existence or non-existence of measures related to automobile exhaust gas control (existence of vehicle inspection system, exhaust gas control, restrictions on imported vehicles)	Euro regulation	○	
Add	Availability of automobile fuel standards and regulations (sulfur concentration in ppm)	Euro regulation	○	
Add	Enrollment rate (universities and other higher education)		○	
Add	Indicators of government public health policy	Doctor/ 1000 people	○	

※ “Add” in the leftmost column means added item after the format is confirmed.
Source: JICA Survey team

(c) Survey Items and result

The survey items and an outline of the survey results for each item are described as follows. The numerical data that can be compared across countries is described in the "Overview Sheet," and qualitative information that cannot be described therein is compiled in the "Individual Sheet" for each country as Annex 2.

Category A：Socioeconomic Indicators

The items collected as socioeconomic indicators and their sources are shown in Table 3-. Quantitative data can be collected except for "A-0 Overview of the Urban Environment". Information such as "A-3 GDP per capita," "A-4 urbanization rate," and "A-7 energy consumption" were also correlated with $PM_{2.5}$ exposure values (see 3.5 for analysis results).

Table 3-4 Summary of Information in Category A：Socioeconomic Indicator

No.	Item	Content	target	Source
A-0	Urban environment	Major issues on environment, emission sources, characteristics of the city	Country・City	UNEP "Air Quality Policies", information by web search
A-1	Population	Population	Country	World Population Prospect 2019 (UN Population Division) 2020 data
A-2	Area	Area	Country	UN- Demographic Yearbook System 2019 (km^2)
A-3	GDP(GNI)/capita	GDP/capita	Country	UN- National Accounts - Analysis of Main Aggregates (data of 2019)
A-4	Urbanization	Urbanization	Country	2018 Revision of World Urbanization Prospects (data of 2020 estimate)
A-5	Economic growth	Economic growth	Country	UN- National Accounts - Analysis of Main Aggregates (data of 2019)
A-6	Major Industry	Production by Industry	Country	UN- National Accounts - Analysis of Main Aggregates (AMA) (USD, data of 2019) (d)
A-7	Energy Consumption	Energy Consumption by fuel type	Country	IEA statistics
A-8	Air pollution-related diseases	Air pollution-related mortality	Country	WHO: Ambient and household air pollution attribute death rate (per 100 000 population), 2016
A-9	Night light	Average night light at target city (from Satellite data)	City	Version 4 DMSP-OLS Nighttime Lights Time Series by NOAA
A-10	Literacy	Literacy (2018)	Country	WB Databank
A-11	Social maturity	Under-five mortality rate (number of deaths per 1,000 live births) 2018	Country	UNICEF The State of the World's Children 2019
A-12	SDG Index	SDG Index (2021)	Country	Jeffrey D. Sachs et.al., Sustainable Development Report 2021
Add	Environmental Performance Index	EPI (2020)	Country	EPI website

Source: JICA Survey team

Category B：Air Quality Management

The listed items collected on air quality management and the summary of their results are shown in Table 3-. In collecting the information, the country reports on "Capacity Building for Air Quality Management," the JICA training course for the period from 2010 to 2020, Air Quality Policies (UNEP), the Overseas Environmental Infrastructure Cooperation Platform (OECC), and the Environmental Performance Review (UNECE) were used as basic materials. Also, previous reports and documents of the target countries and cities were obtained mainly through Internet searches, and were used as references.

While it was relatively easy to obtain information on basic items such as policies, environmental standards, and emission standards in most of the countries, it was difficult to find information on B-7 "Interagency cooperation and coordination mechanisms for improving air quality" and B-11 "Status of efforts by major industries" in many of the target countries. This may be because it is difficult to assume which organization has such information and how and where they publish them. Another reason may be that such activities are actually rare in developing countries.

In addition, countries within the same framework, such as EANET for Southeast Asia and the Environmental Performance Review (UNECE) for Central European countries (candidate countries for EU membership), can easily obtain information on common formats and make inter-comparisons.

In most of the countries, information at the national level was available, but information at the city level could not be found. It can be inferred that there is less public relation at the city level than at the national level, and even when there is, it is often only in the local language.

Table 3-5 Summary of Information in Category B：Air Quality Management

No.	Item	Content	Target
B-1	Legislation system	Existence of basic law on environmental pollution (year of enactment) Existence of individual laws on air quality management (year of enactment) ・Existence of ordinance on air pollution control in the target city (year of enactment)	・The existence of the Basic Environment Law or equivalent laws was confirmed in all countries in this category. ・On the other hand, it was difficult to collect information on laws and ordinances regarding air pollution control due to the different legal systems in each country, and it was also difficult to compare between multiple countries. ・When available, the law and the chapter title in individual tables was summarized.
B-2	Air quality standards	Existence of air quality standards	・The existence of environmental standards for general air quality was confirmed in most countries in this category. ・The existence of air quality standards was confirmed in most countries.

No.	Item	Content	Target
			・When available, the target air pollutants, limit values, averaging times, etc. are listed in individual Sheets.
B-3	Air pollutant control measures and emission standards	Industry Existence of emission standards for boilers, etc. Existence of regulatory standards for fuel use and quality Vehicle Existence of emission standards for automobiles (EURO regulations, etc.) Existence of automotive fuel quality standards (EURO regulations, sulfur content, lead regulations, etc.) ・ Existence of regulations on import of used vehicles	・In most of the countries, the existence of emission standards related to industry was confirmed. ・On the other hand, there were some countries where it was difficult to confirm the existence of emission standards, and there were also some countries where it was confirmed that there were no emission standards (e.g. Uganda) in the countries where JICA projects related to air quality are currently being implemented. ・While it was relatively possible to confirm automobile emission regulations in Southeast Asia and Europe, it was difficult to collect information in some countries, especially in non-English speaking countries such as Latin America and Africa. ・As quantifiable indicators, when possible, we extracted the equivalent of the EURO regulations of each country and the sulfur content in fuel, and included them in the format for organizing information.
B-4	Policy for air quality management	Existence of basic policy/policies on environmental protection (country/city) Existence of basic policy/policy on air quality management (country/city) Availability of air quality measurement plan ・ Existence of other policies and plans related to air quality	・It was relatively easy to collect information in the countries where JICA's technical cooperation projects were implemented, as well as in Southeast Asia and Europe. In non-English speaking countries such as Latin America and Africa, it was difficult to collect this kind of information.
B-5	Guideline, Manual related to air quality management	Existence of guidelines and manuals for air quality measurement • Existence of guidelines and manuals for exhaust gas measurement and factory audits	Same as above
B-6	Administrative organizations in national / city level involved in air quality management	Existence of a central government agency in charge of air quality management • Existence of city departments in charge of air quality management	• The information can be obtained in almost all countries. • When available, Organizational chart, number of personnel, etc. are listed in Individual Sheets.
B-7	Interagency collaboration and coordination mechanisms for improving air quality	Existence or non-existence of an interagency joint committee on air quality management, etc.	It was difficult to collect this information, except the countries where JICA project is implemented.

No.	Item	Content	Target
B-8	Air quality monitoring system	Existence of Air Quality Monitoring Stations (AQMSs) and their number Measurement items of air pollutants ($PM_{2.5/10}$, NOx, SOx, etc.) Availability of an annual report on air quality ・Existence of environmental analysis laboratory	• Information on AQMSs and their number can be obtained in many countries, except for Africa. On the other hand, in many countries it was difficult to collect information on the types of monitoring stations, monitored pollutants, and measurement accuracy. • Information on annual air quality reports and environmental analysis laboratories can be obtained in several countries.
B-9	Current Status of Air Quality Monitoring	Outline of monitoring data of each air pollutant	• There were variations between countries in accessibility to this information. AQMSs networks have been established in some countries, and no measurement has been conducted at all in other countries. In some cases, even in countries where monitoring stations were well established, there was no information to be disclosed because there was no awareness or technology to analyze and utilize the monitoring data.
B-10	Monitoring system at source (factories and workplaces)	Existence of monitoring system for factories (e.g., exhaust gas audit, mandatory monitoring)	Same as above
B-11	Status of efforts by major industries in the country/city	Approximate percentage of businesses in major industries that are taking measures • Size of businesses subject to regulation in major industries	• It was difficult to collect this information, except the countries where JICA project has been implemented.
B-12	Status of development of air pollution control tools	Frequency of preparation, publication, and updating of air pollutant emission inventories of Examples of atmospheric dispersion simulations • Examples of PM composition analysis and receptor modeling	• It was difficult to collect this information, except the countries where JICA project is implemented.
B-13	Energy consumption	Energy consumption by fuel type	Same as A-7
B-14	GHG emission data	GHG emission data by Industry	The information can be obtained from「CO_2 emissions without LULUCF / LUCF, UNFCCC」, except for Pakistan and Kosovo.
B-15	Status of planning, implementation, and revision of air pollution measures	Changes in major air pollution-related laws and programs	• This information could be obtained partially, but it was difficult to compare the progress between multiple countries.
B-16	Conventions, international frameworks, etc.	Status of accession to air pollution-related treaties, EU accession orientation, etc.	

Source: JICA Survey team

Category C: Economic Cooperation Results

The data on economic cooperation shown in Table 3- was collected based on the Official Development Assistance Country Data Collection (Ministry of Foreign Affairs of Japan). The data was suitable for multilateral comparisons, since the data was obtained from a single source for all countries, and the year of the data was the same.

On the other hand, it should be noted that the data does not correspond to the size of the actual support in the field of environmental management, since the target is at the national level and it includes the support in all sector, not only environmental management.

Table 3-6 Summary of Information in Category C：Economic Cooperation

No.	Item	Content	Target	Source
C-1	Assistance by Japan	Support amount in yen loans/grant aid/technical cooperation (FY2018 and total, 100 million yen)	Country	the Official Development Assistance Country Data Collection (Ministry of Foreign Affairs of Japan)
C-2	Assistance by Donors (bilateral)	Support amount of top three countries (FY2017, million yen)	Country	the Official Development Assistance Country Data Collection (Ministry of Foreign Affairs of Japan)
C-3	Assistance by Donors (Multilateral)	Support amount of top three organizations (FY2017, million yen)	Country	the Official Development Assistance Country Data Collection (Ministry of Foreign Affairs of Japan)

Category D: Air Quality Monitoring Data

The following data was collected as air quality monitoring data. The data was available from the website. Specification of the data is as follows.

C-1 Available monitoring data of PM,O_3,NO_2,SO_2,CO, Harmful substances
○Name: SDG Indicator 11.6.2 Concentrations of fine particulate matter ($PM_{2.5}$)①
○Spec:
・Year: 2010 ~ 2016
・Country：194 countries
・Area definition types: Urban, Rural, Total
・ $PM_{2.5}$ Annual average (FactValueNumeric), Maximum (FactValueNumericHigh), Minimum (FactValueNumericLow)

Source: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/concentrations-of-fine-particulate-matter-(pm2-5) (WHO)

The data “SDG Indicator 11.6.2 Concentrations of fine particulate matter ($PM_{2.5}$)” indicates the annual average of $PM_{2.5}$ concentration weighted by the exposed population. Data is prepared in three area types; Urban, Rural, Total, in 194 countries from 2010 to 2016. Metadata information is indicated in Table 3-7.

Table 3-7 Metadata of $PM_{2.5}$ data by the WHO

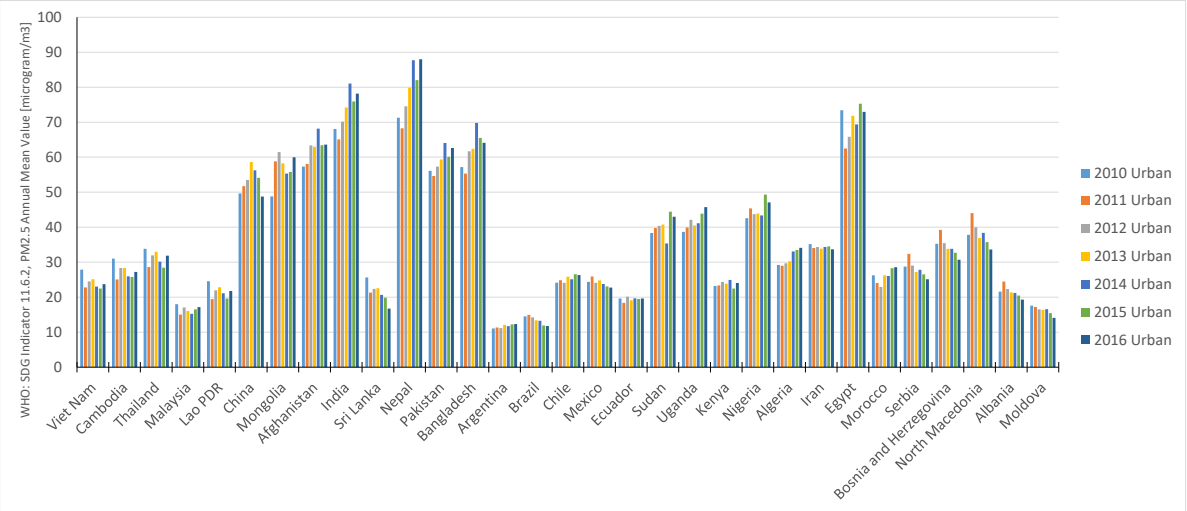
List	Content
Definition	$PM_{2.5}$ concentration weighted by population [microgram/m3]
Note	- Data quality is generally good in high-income countries.

List	Content
	- The definitions of urban and rural areas may vary from country to country.
$PM_{2.5}$ conc. calculation	Estimated by modeling using the results of data integration from satellite remote sensing, population estimates, topography, and ground observations. (WHO, 2016a; Shaddick et al, 2016)
Resolution, cover	Horizontal resolution 0.1°×0.1°, covering 194 countries
$PM_{2.5}$ Estimation	Cagg = SUM (Cnat × Pnat) / SUM (Pnat) Cagg: $PM_{2.5}$ estimation by area type Cnat: national estimation of $PM_{2.5}$ concentration Pnat: national population
QA&QC	Officially published data was used as input data for estimation. The results was carefully cross-checked with the result of monitoring data at ground level.

Source: SDG Indicator Metadata Institutional information, Metadata on SDGs Indicator 11.6.2 Indicator category: Tier I

Figure 3- shows the weighted annual average of $PM_{2.5}$ concentrations by population for the countries surveyed for the period 2010-2016. Overall, the $PM_{2.5}$ annual average concentrations by region tended to be high in Asian, followed by African and Middle Eastern countries.

The annual average concentration of $PM_{2.5}$ can be divided into two groups: countries with an upward trend and countries with a flat or downward trend. In particular, many countries in the Asian region show a relatively high upward trend.



Source: JICA Survey team（SDG Indicator 11.6.2, WHO）

Figure 3-1 $PM_{2.5}$ weighted annual average by population from 2010 to 2016

Category E: Geographical Factors

Among the geographical factors for Category E, the following data were collected E-1: elevation, E-2: annual mean temperature, and E-3: annual mean wind speed. The data was available from the website. Specification of the data is as follows.

E-1: elevation, E-2: annual mean temperature, and E-3: annual mean wind speed
○Source: Historical Unidata Internet Data Distribution (IDD) Global Observational Data ① ○Data Summary

E-1: elevation, E-2: annual mean temperature, and E-3: annual mean wind speed
・Items: Meteorological parameters (Temperature, Wind speed, Wind direction, Air Pressure) ・Monitoring site Attribute (WMOID, Latitude, Longitude, Elevation) ・Monitoring site: 29,500 sites (as of 1st January, 2020 00 [UTC]) ・Frequency: four times a day (every 6 hours, 00, 06, 12, 18 [UTC])
○Source: Average Data all over the World (Japan Meteorological Agency)② ○Data Summary ・Normal value (average value between 1991-2020) of temperature and precipitation all over the world

Source: (1)NCAR/UCAR, https://rda.ucar.edu/datasets/ds336.0/
(2)Japan Meteo, https://www.data.jma.go.jp/gmd/cpd/monitor/normal/

The monitoring data of major cities and airports in target countries were collected from the "Historical Unidata Internet Data Distribution (IDD) Global Observational Data" and "the Average Data all over the World (JMA)". The data was collected for the year 2020. It is assumed that the accuracy and reliability of the data has been validated, as they are published values in meteorological reports issued by the meteorological agencies of each country.

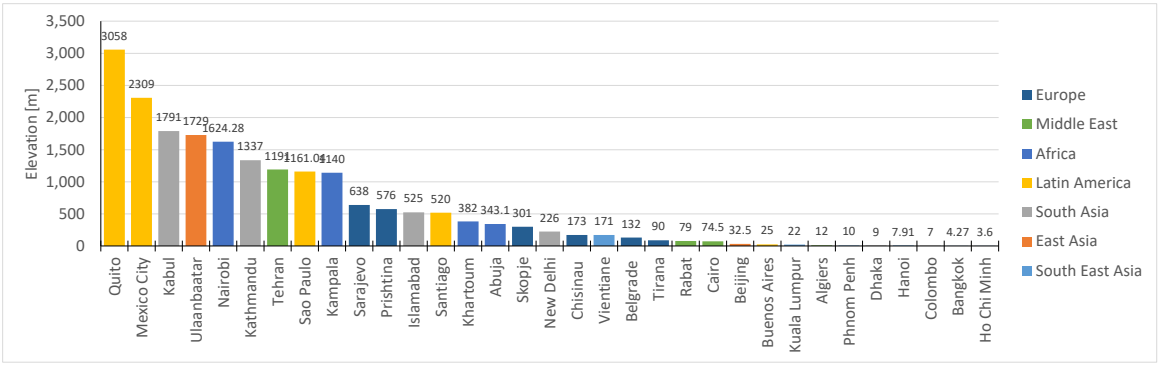
The locations and data collected are shown in Table 3-8. The elevation and average temperature in Sudan were obtained from JMA data, as they were not found in IDD data. The data for Kosovo was also not available, so the data from the VRANJE site in the southern part of neighboring Serbia was used.

Table 3-8 Monitoring sites and collected meteorological data

Area	Country	City	Station	Elevation [m] 1,3	Temperature [deg.C] 2,3	Wind-Speed [m/s] 2	WMOID 1	(lat, lon) 1,3
South East Asia	Vietnam	Hanoi	HA DONG	7.91	25.0	1.9	48825	(20 58 00N, 105 46 00E)
		Ho Chi Minh	NHA BE	3.6	28.2	1.4	48894	(10 39 00N, 106 43 00E)
	Cambodia	Phnom Penh	PHNOM-PENH (KHMOUGH)	10	26.2	1.2	48991	(11 36 00N, 104 52 00E)
	Thailand	Bangkok	BANGKOK METROPOLIS	4.27	29.2	0.6	48455	(13 43 35N, 100 33 36E)
	Malaysia	Kuala Lumpur	KUALA LUMPUR/SUBANG	22	28.1	1.2	48647	(03 07 00N, 101 33 00E)
	LaoPDR	Vientiane	VIENTIANE	171	27.1	1.4	48940	(17 57 00N, 102 34 00E)
East Asia	China	Beijing	BEIJING	32.5	13.8	2.0	54511	(39 56 00N, 116 17 00E)
	Mongolia	Ulaanbaatar	ULAANBAATAR	1729	1.0	1.4	44292	(47 55 00N, 106 52 00E)
South Asia	Afghanistan	Kabul	KABUL AIRPORT	1791	17.1	1.7	40948	(34 33 00N, 69 13 00E)
	India	New Delhi	NEW DELHI/PALAM	226	24.7	2.0	42181	(28 34 00N, 77 07 00E)
	Sri Lanka	Colombo	COLOMBO	7	28.4	0.7	43466	(06 54 00N, 79 52 00E)
	Nepal	Kathmandu	KATHMANDU AIRPORT	1337	15.2	1.4	44454	(27 42 00N, 85 22 00E)
	Pakistan	Islamabad	ISLAMABAD AIRPORT	525	21.9	2.8	41571	(33 37 00N, 73 06 00E)
	Bangladeshi	Dhaka	DHAKA	9	27.1	0.6	41923	(23 46 00N, 90 23 00E)
Latin America	Argentina	Buenos Aires	BUENOS AIRES OBSERVATORIO	25	18.4	2.2	87585	(34 35 00S, 58 29 00W)
	Brazil	Sao Paulo	SAO PAULO (AERO)	1161.04	21.1	3.5	83780	(23 37 00S, 46 39 00W)
	Chile	Santiago	QUINTA NORMAL	520	15.4	0.7	85577	(33 26 42S, 70 40 57W)
	Mexico	Mexico City	MEXICO (CENTRAL), D.F.	2309	20.3	2.2	76680	(19 24 00N, 99 11 00W)
	Ecuador	Quito	IZOBAMBA	3058	12.6	0.5	84088	(00 22 00S, 78 33 00W)
Africa	Sudan	Khartoum	Khartoum	382	30.5	-	-	(15 36 00N, 32 33 00E)
	Uganda	Kampala	ENTEBBE AIRPORT	1140	22.8	3.0	63705	(00 03 00N, 32 27 00E)
	Kenya	Nairobi	JOMO KENYATTA NTERNATIONAL AIRPORT	1624.28	19.7	3.1	63740	(01 19 39S, 36 54 59E)
	Nigeria	Abuja	ABUJA	343.1	26.9	2.2	65125	(09 15 00N, 07 00 00E)
Middle East	Algeria	Algiers	ALGER-PORT	12	20.2	1.3	60369	(36 46 00N, 03 06 00E)
	Iran	Tehran	TEHRAN-MEHRABAD	1191	17.9	3.0	40754	(35 41 00N, 51 19 00E)
	Egypt	Cairo	CAIRO	74.5	22.7	4.1	62366	(30 06 41N, 31 24 50E)
	Morocco	Rabat	RABAT-SALE	79	17.6	2.6	60135	(34 02 46N, 06 45 29W)
Europe	Kosovo	Prishtina	VRANJE	576	11.9	1.6	13489	(42 33 00N, 21 55 00E)
	Serbia	Belgrade	BEOGRAD	132	13.7	1.9	13274	(44 48 00N, 20 28 00E)
	Bosnia and Herzegovina	Sarajevo	SARAJEVO-BJELAVE	638	11.1	1.9	14654	(43 52 00N, 18 26 00E)
	North Macedonia	Skopje	SKOPJE-ZAJCEV RID	301	13.9	2.2	13588	(42 01 00N, 21 24 00E)
	Albania	Tirana	TIRANA	90	16.9	2.1	13615	(41 20 00N, 19 47 00E)
	Moldova	Chisinau	CHISINAU	173	12.1	3.0	33815	(47 01 00N, 28 59 00E)

Source: 1. JMA "WMO International Code" https://www.jma.go.jp/jma/kishou/books/station/station.html
2. NCAR/UCAR「Historical Unidata（ds336.0）」 https://rda.ucar.edu/datasets/ds336.0/
3.JMA "The Average Data all over the World" https://www.data.jma.go.jp/gmd/cpd/monitor/normal/

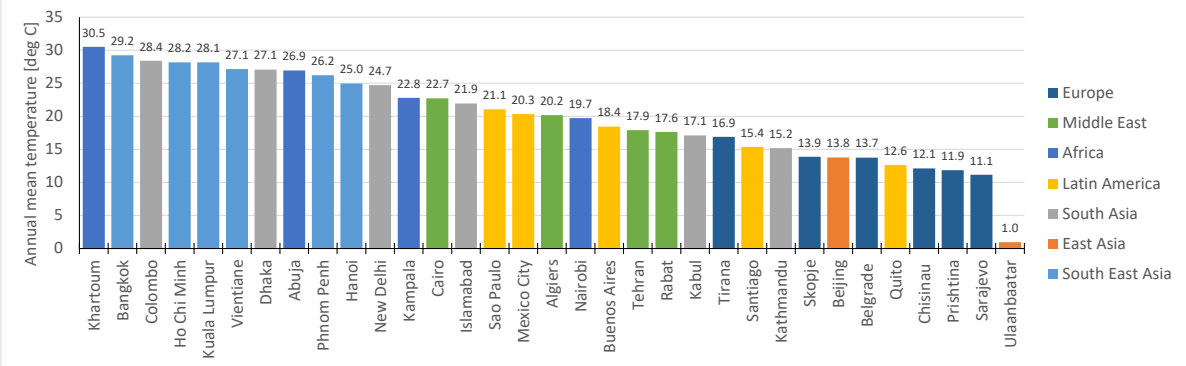
The distribution for E-1: elevation is shown in Figure 3-. The highest elevation among the collected data was 3,058 [m] in Quito, Ecuador. The lowest elevation was 3.6 [m] in Ho Chi Minh City, Vietnam.



Source: JMA "WMO International Code" https://www.jma.go.jp/jma/kishou/books/station/station.html JMA "The Average Data all over the World" https://www.data.jma.go.jp/gmd/cpd/monitor/normal/
(Arranged by JICA Survey team)

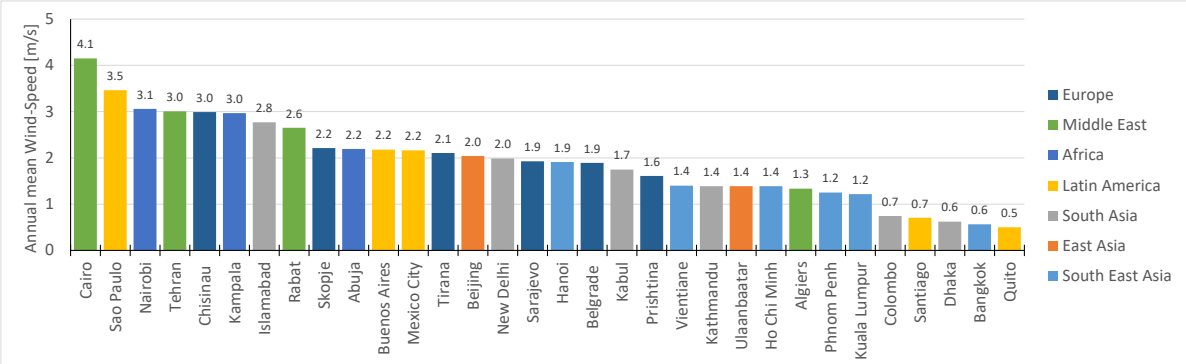
Figure 3-2 Elevation of target cities

The data distribution of E-2: annual mean temperature and E-3: annual mean wind speed is shown in Figure 3-3 and Figure 3-. The highest annual mean temperature was 30.5 [°C] in Khartoum, Sudan, while the lowest was 1.0 [°C] in Ulaanbaatar, Mongolia. Southeast Asian countries tended to have a high average temperature, while East Asian and European countries tended have a low average temperature. The strongest annual mean wind speed was 4.1 [m/s] in Cairo, Egypt, and the weakest was 0.5 [m/s] in Quito, Ecuador.



Source: NCAR/UCAR「Historical Unidata（ds336.0）」https://rda.ucar.edu/datasets/ds336.0/
JMA "The Average Data all over the World" https://www.data.jma.go.jp/gmd/cpd/monitor/normal/
(Arranged by JICA Survey team)

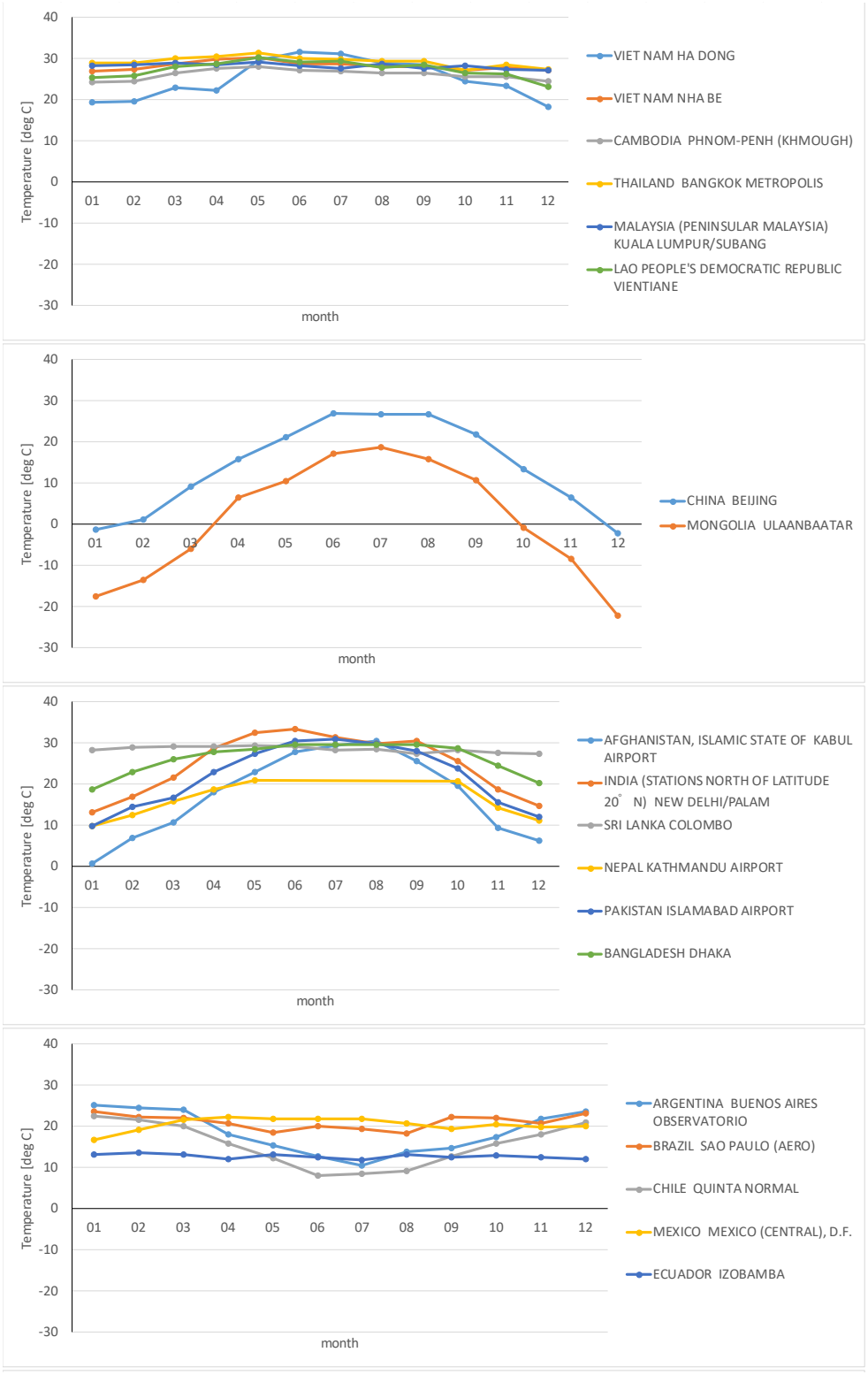
Figure 3-3 Annual Mean Temperature in Target Cities



Source: NCAR/UCAR「Historical Unidata（ds336.0）」https://rda.ucar.edu/datasets/ds336.0/
JMA "The Average Data all over the World" https://www.data.jma.go.jp/gmd/cpd/monitor/normal/
(Arranged by JICA Survey team)

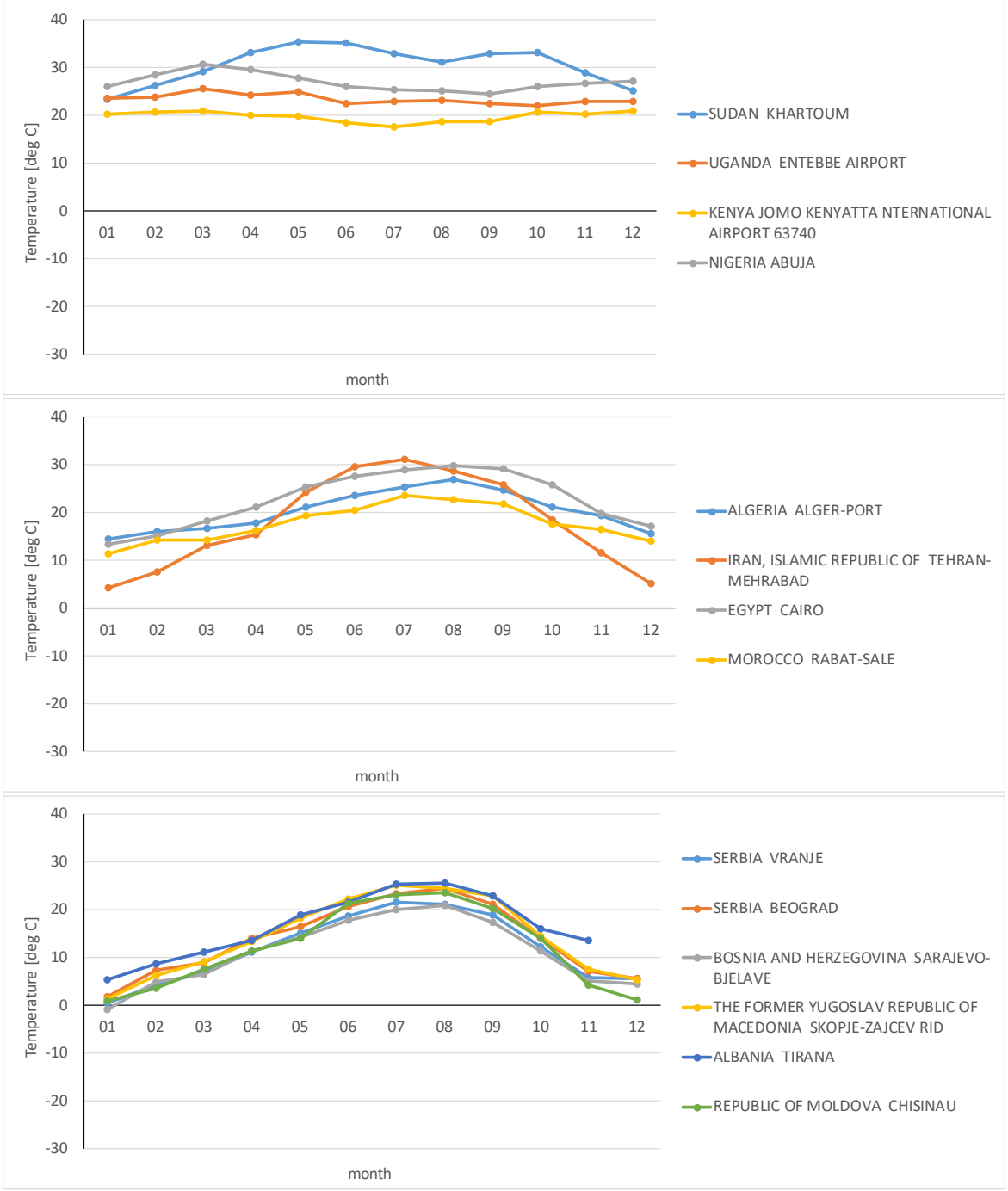
Figure 3-4 Annual Mean Wind Speed in Target Cities

In general, temperature and wind speed tend to be different depending on conditions such as location and season. In addition to the annual mean values, checking the seasonal change trend would be useful in understanding the meteorological conditions in each country. Therefore, the changes in the monthly mean temperature values and wind speed were also examined.



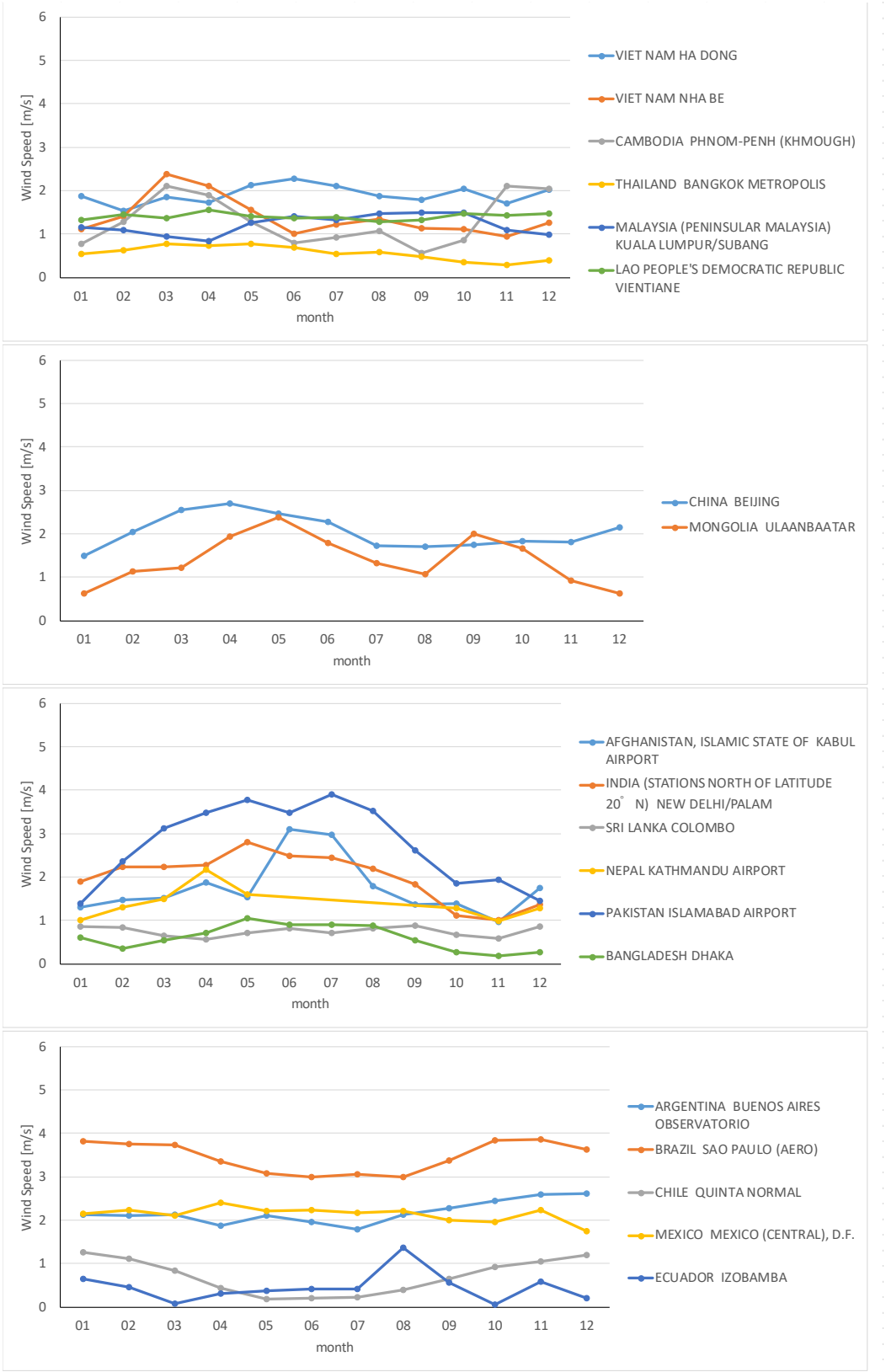
Source: NCAR/UCAR「Historical Unidata（ds336.0）」https://rda.ucar.edu/datasets/ds336.0/
(Arranged by JICA Survey team)

Figure 3-5 Monthly Average Temperature in Southeast Asia, East Asia, South Asia, and Latin America



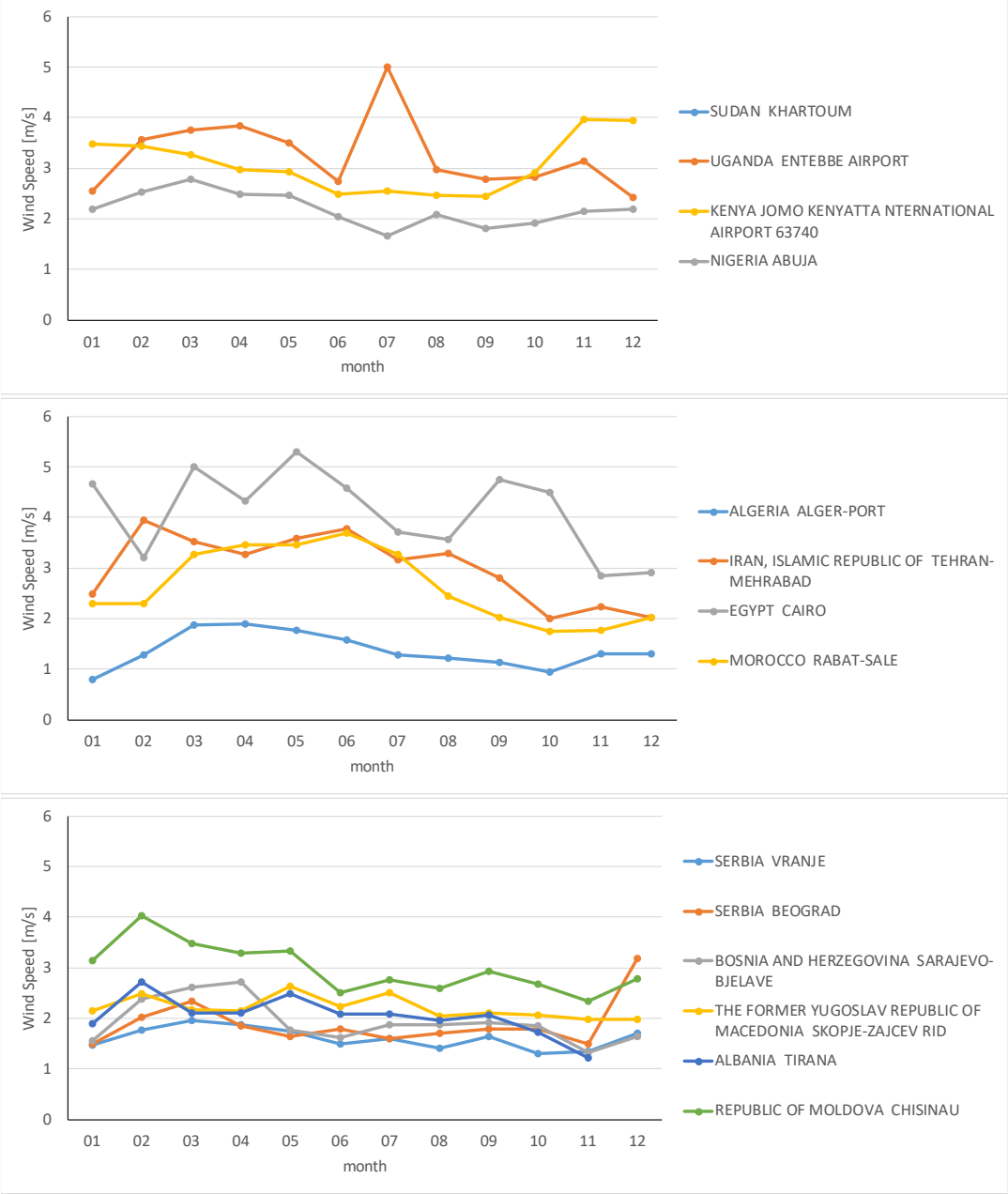
Source: NCAR/UCAR Historical Unidata (ds336.0) https://rda.ucar.edu/datasets/ds336.0/
JMA "The Average Data all over the World" https://www.data.jma.go.jp/gmd/cpd/monitor/normal/
(Arranged by JICA Survey team)

Figure 3-6 Monthly Average Temperature in Africa, Middle East, and Europe



Source: NCAR/UCAR Historical Unidata (ds336.0) https://rda.ucar.edu/datasets/ds336.0/
(Arranged by JICA Survey team)

Figure 3-7 Monthly Average Wind Speed in Southeast Asia, East Asia, South Asia, and Latin America



Source: NCAR/UCAR Historical Unidata (ds336.0) https://rda.ucar.edu/datasets/ds336.0/
(Arranged by JICA Survey team)

Figure 3-8 Monthly Average Wind Speed in Middle East, and Europe

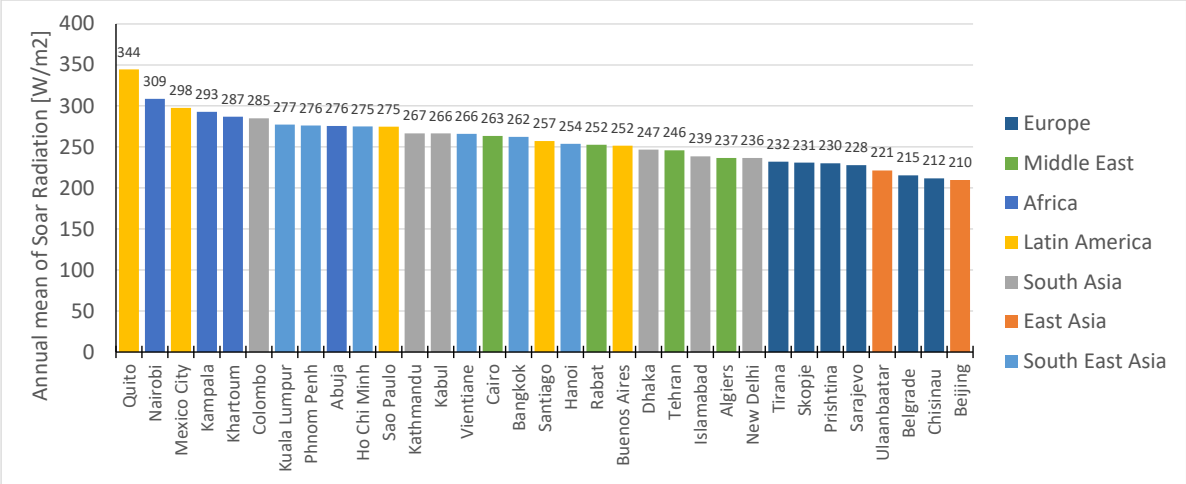
E-4: solar radiation data were collected as follows. The data was available from the website.

E-4Solar Radiation
○Name: CAMS solar radiation time-series ○Data Summary ・Item: Solar radiation (global solar radiation, diffused solar radiation, direct solar radiation) ・Geo Attribute：latitude, longitude, altitude ・Horizontal Resolution: 3-5km ・Frequency: 1 hour

Source: ECMWF, Copernicus Atmosphere Monitoring Service,
https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-solar-radiation-timeseries?tab=form

"CAMS solar radiation time-series" is a dataset of global solar radiation provided by Copernicus Air Quality Monitoring Service through ECMWF. Solar radiation all over the World is provided based on data of air quality, land surface conditions, and satellite observations. The accuracy and reliability of the data are checked by supplementary services [13]. The quality checks conducted on a three-monthly basis are available on the website, and the accuracy and reliability of the data are considered to be sufficient.

The solar radiation data for 2020 was collected. Solar radiation data at the monitoring sites where the data of E-1 to E-3, which were observed, collected and organized as annual averages. The data distribution for E-4 solar radiation is shown in Figure 3-9. The amount of solar radiation was obtained by aggregating the total solar radiation on the ground surface during the clear weather. The highest annual average solar radiation among the collected data was 344 [W/m^2] in Quito, Ecuador, and the lowest was 210 [W/m^2] in Beijing, China.



Source: ECMWF, Copernicus Atmosphere Monitoring Service,
https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-solar-radiation-timeseries?tab=form
(Arranged by JICA Survey team)

Figure 3-9 Solar Radiation Annual Averages at Target Cities
(Global Solar Radiation, at a Clear sky)

Category F: Feasibility of Aid

The information collected on the public safety and stability is shown in Table 3-9.

Although this information is not an indicator directly related to the environmental management of cities, it will be necessary when considering the support in the future. This information was possible to be obtained from a single source for all countries.

[13] https://atmosphere.copernicus.eu/supplementary-services#fa6856b7-a306-4cc4-9137-f3e0cb703093

Table 3-9 Summary of Information in Category F：Public Safety, Stability

No.	Item	Content	Target	Source
F-1	Public Safety	Safety Information from Ministry of Foreign Affairs	Country	Safety Information from Ministry of Foreign Affairs (as of August 2021)
F-2	Political/Social Stability	Political Stability and Absence of Violence/Terrorism 2019 (Percentile in 210 countries. Higher value means better governance).	Country	Worldwide Governance Indicators (WGI) Political Stability and Absence of Violence/Terrorism

Source: JICA Survey team

3.4. Overview Sheet and Basic Checklist

3.4.1. Overview Sheet

Among the information collected in 3.3, items that are easy to compare between countries were organized into the Overview sheet. In order to improve the visibility, information was color-coded.

Table 3- shows an excerpt of the Overview Sheet.

Table 3-10 Overview Sheet (excerpt)

Information organization format																																	
Area classification	Southeast Asia						East Asia		South Asia						Latin America					Africa				Middle East				Europe					
Country	Vietnam		Cambodia	sea bream	Malaysia	Laos	China	Mongolia	Afghanistan	India	Sri Lanka	Nepal	Pakistan	Bangladesh	Argentina	Brazil	Chile	Mexico	Ecuador	Sudan	Uganda	Kenya	Nigeria	Algeria	Iran	Egypt	Morocco	Kosovo	Serbia	Bosnia-Herzegovina	North Macedonia	Albania	Moldova
City	Hanoi	Ho Chi Minh	Phnom Penh	Bangkok	Kuala Lumpur	Vientiane	Beijing	Ulaanbaatar	Kabul	Delhi	Colombo	Kathmandu	Islamabad	Dhaka	Buenos Aires	Sao Paulo	Santiago	Mexico City	Quito	Khartoum	Kampala	Nairobi / Mombasa	Lagos / Abuja	Algiers	Tehran	Cairo	Rabat	Pristina	Belgrade	Sarajevo	Skopje	Tirana	Shishinau
Criteria (evaluation index or unit) ¥ Serial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Country participating in the training	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	-
Air pollution degree (top 3 in PM2.5 area classification)	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No
Has a track record of support and surveys in the field of air quality management	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	Yes
References to the priority areas of the Ministry of Foreign Affairs' national development cooperation policy	Yes	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	Yes	Yes
JCM partner country	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Overview of the urban environment																																	
Population (million people) * Country	97	97	17	70	54	7	1,439	3	39	1,380	21	29	221	165	45	213	19	129	18	44	46	54	206	44	84	102	37	2	9	3	2	3	4
Area (thousand $km)^2$)※Country	331	331	181	513	331	237	9,600	1,564	653	3,287	66	147	796	148	2,796	8,516	756	1,964	257	1,880	242	592	924	2,382	1,629	1,002	447	11	88	51	26	29	34
GDP (GNI) / capita (USD) * Country	2604	2604	1440	6606	11392	2553	9986	4397	542	2014	4323	904	1502	1599	13813	8575	13914	9819	5856	2213	698	1513	2543	4111	4937	3825	3258	4281	6516	5567	5342	4509	2259
Urbanization rate (%) * Country	37.34	37.34	24.23	51.43	77.16	36.29	61.43	68.66	26.03	34.93	18.71	20.58	37.17	38.18	92.11	87.07	87.73	80.73	64.17	35.3	24.95	28	51.96	73.73	75.87	42.78	63.53		56.45	49.02	58.48	62.11	42.85
Economic growth rate (%) * Country	6.0	6.0	5.3	2.1	2.9	3.1	5.7	3.1	1.7	3.2	1.8	5.1	1.3	7.1	-3.1	0.4	-0.1	-1.4	-1.6	-1.1	3.0	3.0	-0.4	-1.1	-7.8	3.5	2.3	5.3	4.6	3.4	3.5	2.3	3.7
Add value by major industry (ISIC) / industry AB: Agriculture, hunting, forestry, fishing CE: Mining, Manufacturing, Utilities F: Construction GH: Wholesale, retail trade, restaurants and hotels I: Transport, storage and communication	C-E	C-E	A-B	C-E	C-E	C-E	C-E	C-E	A-B	C-E	C-E	A-B	A-B	C-E	C-E	G-H	C-E	C-E	C-E	A-B	A-B	A-B	A-B	C-E	C-E	C-E	C-E	C-E	C-E	C-E	C-E	A-B	C-E
Energy consumption (million toe)	60.3	60.3	7.1	100.2	62.5	3.1	2066.6	3.9	-	606.6	10.0	14.0	95.6	32.3	57.2	226.8	28.1	124.6	12.6	12.9	-	17.2	140.9	42.4	200.3	61.4	16.3	1.5	9.1	4.3	1.9	2.1	3.2
Energy consumption / population (toe / capita)	0.6	0.6	0.4	1.4	1.1	0.4	1.4	1.2	-	0.4	0.5	0.5	0.4	0.2	1.3	1.1	1.5	1.0	0.7	0.3	-	0.3	0.7	1.0	2.4	0.6	0.4	0.8	1.0	1.3	0.9	0.7	0.8
Number of air pollution diseases (persons / 10,000 people) * Country	65.1	65.1	87.3	84.6	35.2	109.9	139.8	97.1	95.1	140.8	105.0	133.1	113.0	103.4	37.0	31.0	34.8	33.0	22.4	89.5	73.9	39.9	158.6	40.3	35.0	73.3	40.3		121.5	159.3	124.9	104.7	106.6
Night light (total score in the metropolitan area / 1,000)※City	31.1	119.5	18.1	258.3	342.3	29.8	525.0	35.7	30.6	407.0	59.7	8.8	65.6	64.1	471.8	173.8	175.8	378.3	80.3	85.9	21.2	50.4	53.7	201.0	414.4	1418.5	43.9	16.4	93.6	18.3	26.4	23.2	26.9
Literacy rate (%) * Country	95	95	81	94	95	85	97	98	43	74	92	68	59	75	99	93	96	95	93	61	77	82	35	81	86	71	74		99	97	98	98	99
Social maturity (mortality rate of children under 5 years old (per 1,000 live births)) * Country	21	21	28	9	8	47	9	16	62	37	7	32	69	30	10	14	7	13	14	60	46	41	120	23	14	21	22		6	6	10	9	16
SDG Index (score) * Country	72.8	72.8	64.5	70.9	70.9	63.0	72.1	63.8	53.9	60.1	68.1	66.5	57.7	63.5	72.8	71.3	77.1	69.1	72.5	49.5	53.5	60.6	48.9	70.9	70.0	68.6	70.5		75.6	73.7	72.5	71.0	
Environmental Performance Index * Country	33.4	33.4	33.6	45.4	47.9	34.8	37.3	32.2	25.5	27.6	39.0	32.7	33.1	29.0	52.2	51.2	55.3	52.6	51.0	34.8	35.6	34.7	31.0	44.8	48.0	43.3	42.3	0.0	55.2	45.4	55.4	44.5	44.4
Legal system, basic law, individual law, local level ordinance(Existence of the Basic Environment Law or a law equivalent to it)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Environmental standards(Existence of environmental standards)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes
Air pollutant emission reduction measures and regulatory standards(Existence of emission regulations for industry)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes	No

Source: JICA Survey team

3.4.2. Basic Checklist

The basic checklist was prepared based on the issues categorized in Chapter 3.5 below and the survey items in the Overview Sheet. This is also attached as Annex 3.

The checklist is intended to help JICA's overseas offices to identify information that should be obtained first in order to understand the situation of air quality management in the country/city concerned, and to contribute to the subsequent consideration of the possibility of cooperation and the direction of support needs. Items that are relatively easy to obtain and/or items that are considered to be particularly useful for the analysis of the target country were extracted from the Overview Sheet items. Also, reference and outline of the information to be collected is attached.

Table 3-11 Basic Checklist

	Item	Content	Ref.
Socioeconomic indicators	GDP (GNI)/capita	Real GDP per capita GDP of the whole country is reported in the reference shown in the right column. Check the recent increase. GRDP (Gross regional domestic product) of the target city should also be collected if available.	①
	Urbanization	Ratio of population in the urban area. Data at every 5 years is reported in the reference shown in the right column. Check the recent increase.	②
	Energy Consumption	Energy consumption data by sector and by fuel type (solid/liquid/gaseous) is desirable. The consumption data in the city should also be collected if available.	③
Air quality Management	Legal system, basic laws, individual laws, ordinances of local government	Basic law on environmental pollution (year of enactment) Individual laws on air quality management (year of enactment) Ordinances on air pollution control in the target city (year of enactment)	
	Air quality Standard	Existence of Air Quality Standard In many cases, the standard in the developing countries are based on other existing standard such as US standards, EU standards, the WHO guideline values, etc. It is desirable to understand the standards on which they are based and the differences between them.	
	Policy for air quality management	Basic policies on environmental protection (national/city level) Basic policies on air quality management (national /city level) Other policies and plans related to air quality (e.g. urban planning, traffic planning)	
	Administrations related to air quality management	Identify the central authority/target city department in charge of air quality management	
	Air quality monitoring	List of AQMSs and monitoring items Laboratory for sample analysis Annual report on air quality	
Air Quality Monitoring	Monitoring data of PM, O_3, NOx, SO_2, CO, harmful substances	It is desirable to have measurement data for NOx, SO_2, PM_{10}, and $PM_{2.5}$ for several years. They may be available from the annual reports on air quality mentioned above. If real-time data is available on a web site, past measurement data may be downloadable from the site.	
	Average $PM_{2.5}$ exposure at urban area mainly based on ground level monitoring	The data between 2010 and 2016 is reported in the reference in the right column. Check its recent increase.	④
	Average $PM_{2.5}$ exposure at	The data between 2010 and 2016 is reported in the reference in the right	⑤

	urban area mainly based on satellite monitoring	column. Check its recent increase.	

Source: JICA Survey team

Reference

①	UN Stats National Accounts - Analysis of Main Aggregates	https://unstats.un.org/unsd/snaama/
②	UN- 2018 Revision of World Urbanization Prospects	https://population.un.org/wup/
③	IEA Data and Statistics	https://population.un.org/wup/
④	WHO: SDG Indicator 11.6.2 Concentrations of fine particulate matter ($PM_{2.5}$)	https://www.who.int/data/gho/data/indicators/indicator-details/GHO/concentrations-of-fine-particulate-matter-(pm2-5)
⑤	SEDAC(NASA)	https://sedac.ciesin.columbia.edu/data/set/sdei-annual-pm2-5-concentrations-countries-urban-areas-v1-1998-2016

3.5. Grouping of Issues by Statistical Analysis

Based on the collected information for the 32 countries, a grouping and issue analysis of the target countries was carried out. Table 3- shows the numerical data used in these analysis. As for the air pollution status, the national and urban average exposure data of $PM_{2.5}$ published by the WHO was used as an indicator to evaluate the target countries side by side. The data for 2016, the most recent year available, as well as the data for 2011 were collected and used for the analysis. For socioeconomic data, data for 2011 and 2016 were used if available, or in case when they were not available, data for close years were collected and analyzed. The country of Kosovo was excluded from this analysis because it was not available from the $PM_{2.5}$ data published by the WHO.

Table 3-12 Data used for Analysis

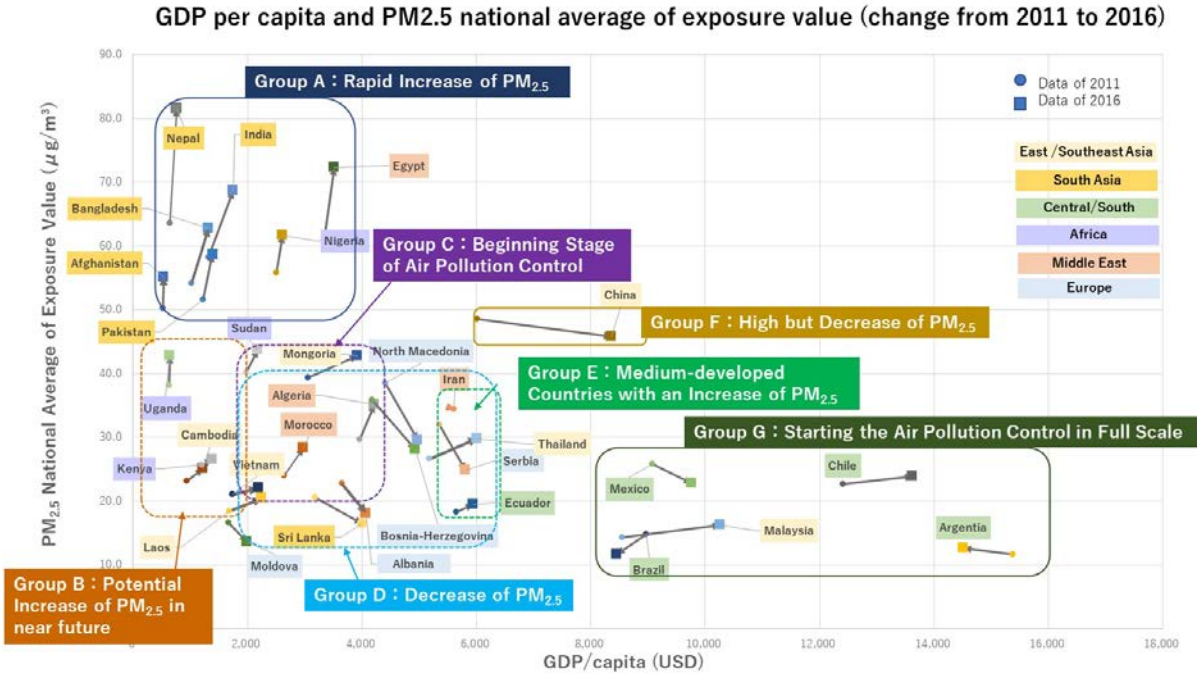
Item	Content	Reference
$PM_{2.5}$	Annual average Exposure by country/urban area (2011 and2016) (weighted by population, 2016 data is the latest) *No data for Kosovo	WHO Global Health Observatory indicator ①
	Annual data at country level and/or at major cities (2017-2020), and monthly data at major cities (only 2020) are available. This data was referred to consider seasonal change in $PM_{2.5}$ exposures.	IQ-AIRwebsite ②
Real GDP per capita	Real GDP (2015 chained price, USD) (2011 and 2016 was used)	UN Stats National Accounts - Analysis of Main Aggregates ③
Urbanization	Population in urban area (2010 and 2015) (The data is reported every 5 years. Data for 2010 and 2015 was adopted.)	UN- 2018 Revision of World Urbanization Prospects④
Energy Consumption	Energy Consumption by fuel type (2010 and 2015) Energy consumption of fossil fuel (2010 and 2015) *No data for Uganda	IEA Data and Statistics website⑤

Source: JICA Survey team

① https://www.who.int/data/gho/data/indicators/indicator-details/GHO/concentrations-of-fine-particulate-matter-(pm2-5)
② https://www.iqair.com/
③ https://unstats.un.org/unsd/snaama/

④ https://population.un.org/wup/
⑤ https://www.iea.org/data-and-statistics

2011 and 2016 data for real GDP per capita and $PM_{2.5}$ country-average exposure are plotted in the Figure 3-10, to see the relationship between the economic growth and air pollution in the target countries. Based on the plot position, 31 countries were classified into 7 groups (Group A to Group G).



Source: JICA Survey team

Figure 3-10 GDP per capita and $PM_{2.5}$ National Average Exposure Value (2011, 2016)

The characteristics of each group (A toG) was analyzed from the aspect of the socioeconomic situation, air quality, and the development of air pollution controls. The status of air pollution control was classified into the following three phases: (1) "System Formation Phase," (2) "Full-scale Operation Phase," and (3) "Autonomous Phase," as developmental processes of environmental administrative systems as shown in Table 3-.

Table 3-13 Development Process of Administrative System on Environment

Phase	**System Formation Phase** Period building fundamentals of administration on Environmental issues		**Full-scale Operation Phase** Full-scale implementation of pollution reduction	**Autonomous Phase** Comprehensive environmental management is carried out by the industry, government, and private sector.
Expected activities	- Development of the environmental legal system - Establishment of the administrative body - Establishment of environmental standards and the monitoring system - Establishment of the emission inventory	- Strengthening the effectiveness of laws and regulations - Formulation of medium/long-term plans - Continuous environmental monitoring to understand the status of air pollution - Continuous update of the emission inventory and its use for pollution control planning.	- Continued implementation of measures and regulations based on scientific evidence - Achieve environmental standard values through autonomous operation of the plan - Voluntary efforts by companies	

Source: edited based on JICA (2003),"Environmental Center Approach"

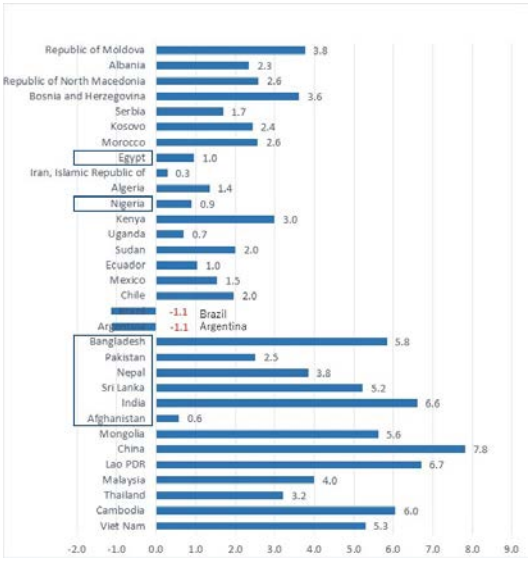
Group A <Countries with Rapid Increase of $PM_{2.5}$>

Nepal, Pakistan, India, Bangladesh, Afghanistan, Nigeria, and Egypt

Group A consists of countries with low GDP per capita but with a rapid increase of $PM_{2.5}$. The economic scale is small while the air pollution is worsening. The group is considered to have an environmental administration in early to middle stage of system formation, and that they are in need of urgent and further development of the infrastructure for air environment administration.

Socioeconomic condition

Group A consists of countries with GDP/capita below USD 3,500 (2015 chain prices), which are classified by the UN as LDCs (Afghanistan, Nepal, Bangladesh,), low-income countries (India, Nigeria, Pakistan), and middle-income country (India). The change in GDP/capita of the target countries (Figure 3-11) shows relatively high growth rates of 2.5-6.6%, except for Afghanistan that was in a state of conflict, and Egypt and Nigeria, where production activities were slow due to the political turmoil caused by the Arab Spring (2011).

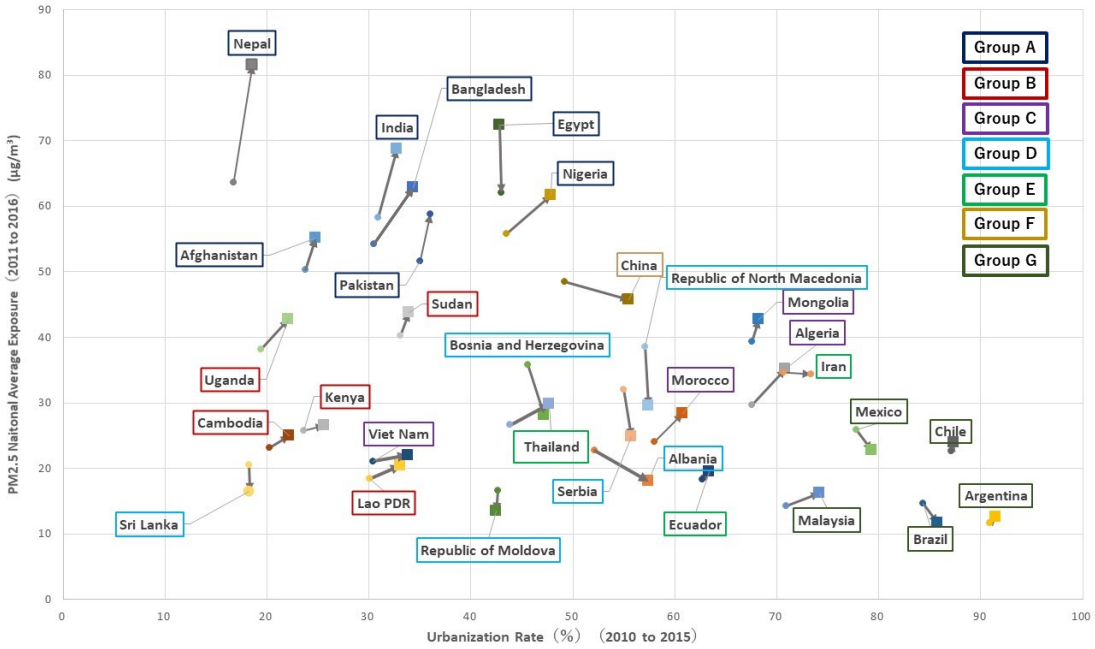


Source: JICA Survey Team

Figure 3-11 Annual average growth rate of GEP per capita (%) (2011-2016)

On the other hand, the urbanization rate in all seven countries is below 50% (see Figure 3-12). It has been confirmed that there is a strong correlation between GDP/capita and the urbanization rate (correlation coefficient of 0.8). Of these countries, Nigeria and Bangladesh have relatively high rates of urbanization, which has increased for about 4% in five years, while

urbanization of Egypt decreased shoing -0.23% and other countries increased for about 1% in five years. In addition, as shown in Figure 3-12, it can be observed especially in Group A that the slope of change in each country is large, that is, the increase in $PM_{2.5}$ value is large with respect to the increase in urbanization rate. On the other hand, except for Group A, the slope is not large, or declining to the right in most of the countries. Especially in Group A, where it is highly likely that air pollution is not properly managed and the increase in the urbanization rate has greatly affected the deterioration of air pollution.



Source: JICA Survey team

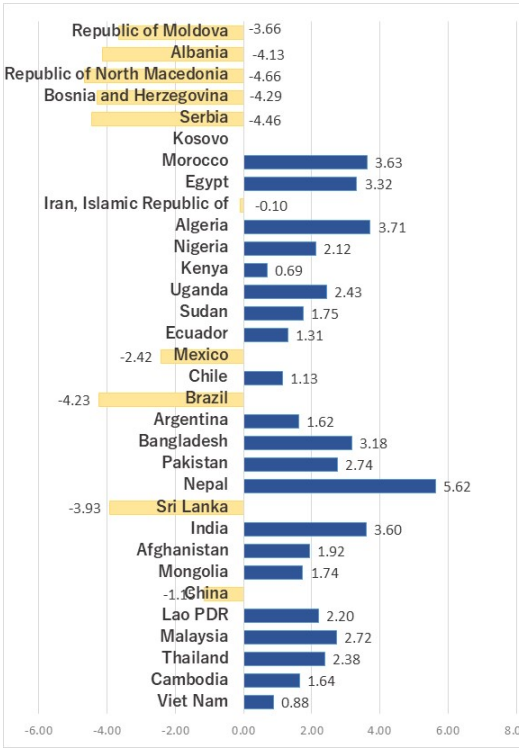
Figure 3-12 Changes in Urbanization Rate (2010 to 2015) and $PM_{2.5}$ National Average Exposure (2011 to 2016)

Air Pollution Condition

Group A and Group B have almost the same level of development (GDP/capita at constant price), but the Group A has very high $PM_{2.5}$ exposure values and also high rates of increase. As shown in Figure 3-, $PM_{2.5}$ exposure values in Group A countries have increased for about 2.0-5.7% in annual average since 2011. In the target countries, problems such as the open burning of waste and automobile emissions, as well as unglazed bricks production in Nepal, have been raised, but the causes of the large increase in $PM_{2.5}$ exposure values have not been identified from this analysis.

In Afghanistan, Nepal, India, Bangladesh, and Pakistan, where monthly data for the metropolitan area can be obtained from IQ-AIR, $PM_{2.5}$ exposure tends to be higher during the dry season from October to February, suggesting that the wet deposition of $PM_{2.5}$ by precipitation in rainy season may cause a decrease in $PM_{2.5}$ exposure.

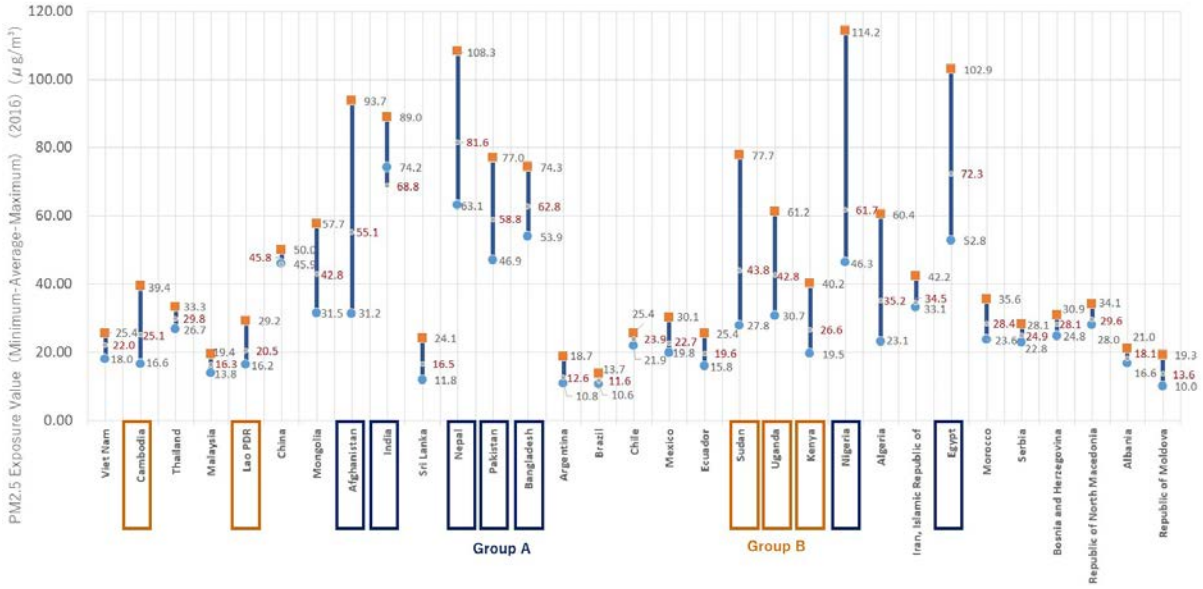
Figure 3- shows the minimum, average, and maximum $PM_{2.5}$ exposure values of each country in 2016: The maximum values are particularly high in Group A and B and the difference between them is relatively large in these countries. This suggests that it is highly possible that the identification of the causes of $PM_{2.5}$ have not been identified so that the effective countermeasures for them have not properly been implemented to control them.



Source: JICA Survey Team

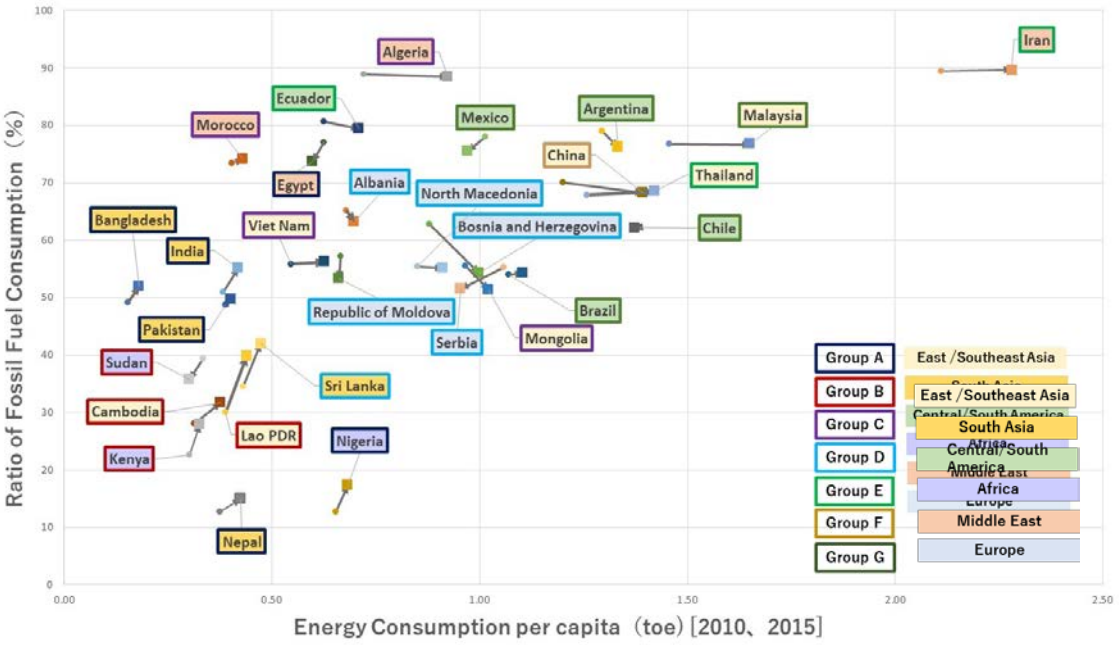
Figure 3-13 Annual Average Change rate of $PM_{2.5}$ National Average of the exposure Value (%) (2011 ~ 2016)

The changes in final energy consumption per capita and the percentage of fossil fuels are shown in Figure 3-15. Group A has an energy consumption per capita of less than 0.7toe, but the situation of the fossil fuel consumption percentage varies from country to country. Only Egypt shows a decreasing trend in the energy consumption along with the urbanization rate.



Source: JICA Survey team

Figure 3-14 Change of the energy consumption per capita and ratio of fossil fuel consumption (2010~2015)



Source: JICA Survey team

Figure 3-15 Change of the energy consumption per capita and ratio of fossil fuel consumption (2010~2015)

Air Pollution Control

All countries in this group have comprehensive laws and regulations equivalent to environmental protection laws. India, Egypt, and Afghanistan have enacted individual laws specific to air pollution control, while Nepal, Bangladesh, Pakistan, and Nigeria have not.

Environmental standards have been set in all countries. Air quality monitoring systems have been established in all countries except for Nigeria and Afghanistan, but up to varying degrees. On the other hand, measures for stationary emission sources such as factories have not been confirmed in Nepal, Afghanistan, and Nigeria. In India, where decentralization is in progress, the status of setting regulations differs from state to state. In Egypt, measures to reduce the environmental impacts of lead smelters and brick factories are being implemented.

In terms of vehicle emission regulations, Egypt, Afghanistan, India, and Nepal have set regulations above the EURO 3 level.

Although organizations involved in air quality management have been established in all countries, issues such as inadequate monitoring systems at the source and lack of human resources have been raised.

Group B <Countries where the increase of $PM_{2.5}$ is expected in the near future (though currently its concentration is not so high)>

Cambodia, Laos, Kenya, Sudan, and Uganda

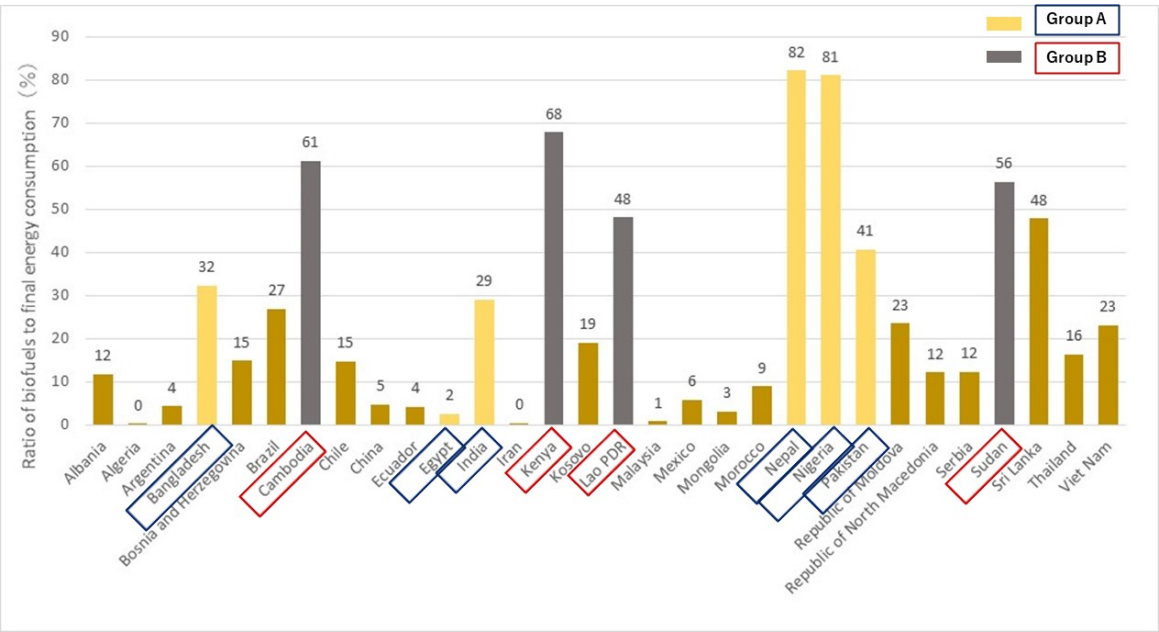
Countries in Group B are still small in economic scale, and are at the beginning stage of air pollution caused by $PM_{2.5}$, or are likely to become polluted in the future. They are considered to be in the early stage of system formation in environmental administration.

Socioeconomic condition

Cambodia, Laos, Sudan, and Uganda belong to LDC, and Kenya to poor countries with a GDP per capita below USD 2,300 (2015 chained prices). The urbanization rate is low, ranging from 22% to 33%, and the rate of increase is highest in Laos at 3.0%, with others being 2.7% in Uganda, 2.1% in Kenya, 1.9% in Cambodia, and 0.8% in Sudan, indicating that rapid urbanization is not underway. Main industries in Laos are manufacturing and services, whereas the main industry in the rest of the countries in this group is the primary industry.

Air Pollution Condition

Compared to Group A, which has a similar GDP/capita as group B, the $PM_{2.5}$ exposure value and its rate of increase are still not so high. In addition, Figure 3-15 shows that the share of fossil fuels in energy consumption and final energy consumption are both small. On the other hand, as in Group A, the share of biofuels is relatively high (see Figure 3-16), which may be due to the tendency to use more firewood and charcoal in households. In all countries, air pollution due to open burning and burning of wastes has been reported.



Source: JICA Survey team

Figure 3-16 Share of Biofuels in Final Energy Consumption (%, 2015)

Air Pollution Control

In this survey, information on the status of air pollution measures in the target countries were not found as much. It was not possible to find individual laws related to air quality except for Cambodia, although the Basic Environment Law, which is a higher level law, has been found [14]. Cambodia has enacted an ordinance on air pollution, but it has been pointed out that it is unclear and incomplete.

In addition, each country has established air quality standards, but the air quality monitoring system is limited or could not be confirmed. Regulations for stationary and mobile sources could not be confirmed except for Cambodia. In Cambodia, an ordinance on air pollution has been enacted, but it has been pointed out that it is unclear and incomplete [15].

Group C < Group at the Beginning stage of Air Pollution Control >

Vietnam, Mongolia, Morocco, Algeria

Group C seems to be in the middle stage of the system formation phase. The framework of the air quality legal system has been introduced, but $PM_{2.5}$ exposure values are on an upward trend. It is highly likely that there are some issues with the inadequate development of emission inventories, etc., the introduction of stricter control measures, and/or the strengthening of the viability of various laws and regulations.

Socioeconomic conditions

Group C consists of low-income countries (Vietnam and Mongolia), middle-income countries (Morocco), and semi-developed countries (Algeria). Low-income countries, Vietnam and Mongolia, are growing at an average of 5.3% and 5.6% GDP/capita/year (Morocco and Algeria are growing at a slower rate of 2.6% and 1.4%, respectively). The urbanization rate is relatively high (60-70%) in Algeria, Morocco, and Mongolia. Vietnam's urbanization rate is lower (34%), but the rate of increase in urbanization is relatively high (3.4%). The main industry is manufacturing.

Air Pollution Condition

National average of $PM_{2.5}$ exposure values are on the rise. The $PM_{2.5}$ exposures are increasing at rates of 3.6% and 3.7% in Morocco and Algeria respectively, which have relatively high GDP per capita. On the other hand, Mongolia and Vietnam, with relatively large increases in GDP per capita, have increases of only 1.7 and 0.9%, respectively.

The share of fossil fuel in the final energy consumption ranged from 50 to 74%, with biofuels accounting for a much smaller share than in Groups A and B: 0% in Algeria, 9% in Morocco, and 3% in Mongolia.

[14] In Uganda, The National Environment (Air Quality) Regulations (Draft) (2020) is planned to be finalized in November 2021. The regulations also set environmental standards.
[15] "Environmental Research (Quarterly)" 2016, No.180

Air Pollution Control

All four countries have introduced air quality legal frameworks, with individual laws, air quality standards, emission standards, and nationwide monitoring systems in place. (Only in Algeria, the status of air quality standards, industrial emission standards, and monitoring could not be found).

All countries are taking measures against mobile sources (e.g., fuel regulation, emission regulations, used vehicle regulations, etc.). Vietnam has set EURO 4 emission standards, Mongolia is in the process of considering the introduction of EURO 5, and Algeria is conducting inspections on compliance with EURO 3 emission standards.

Vietnam has been developing emission standards for each industry, medical waste incinerators, and power plants and regulations for monitoring systems have also been formulated in order to control stationary emission sources. In addition, open burning of municipal and agricultural wastes is prohibited.

In Morocco, various guidelines (e.g., procedures for controlling emissions from stationary sources) have been established and factory inspections by the Ministry of Environment have been stipulated, but it is reported that there are issues with the implementation of laws and regulations due to lack of capacity of law enforcement agencies and lack of practical sanctions.

Both in Morocco and Mongolia, emission inventories have been established partially.

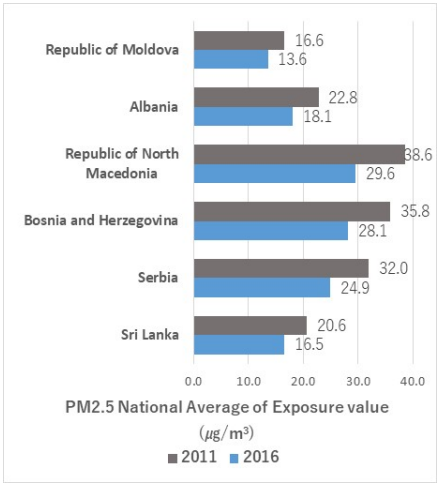
Group D <Countries with a Decrease of $PM_{2.5}$>

Sri Lanka, Moldova, Albania, Bosnia and Herzegovina, Serbia, North Macedonia

In Group D, $PM_{2.5}$ exposure values are relatively low and have already started to decline. In general, this group is considered to be in the transition stage to the full-scale operation phase as the air pollution control is developing gradually.

Socioeconomic condition

The countries in this group are a low-income country (Moldova), a middle-income country (Sri Lanka), and semi-developing countries (Albania, Bosnia and Herzegovina, Serbia, and North Macedonia). The GDP/capita and urbanization rate are generally increasing, but the urbanization rate in Sri Lanka has remained flat, while the one in Moldova has decreased. Albania is being rapidly urbanized (5.3%), but on the other hand, its main industry is the primary sector, and the share of manufacturing is not so high. In other countries, manufacturing is the main industry.

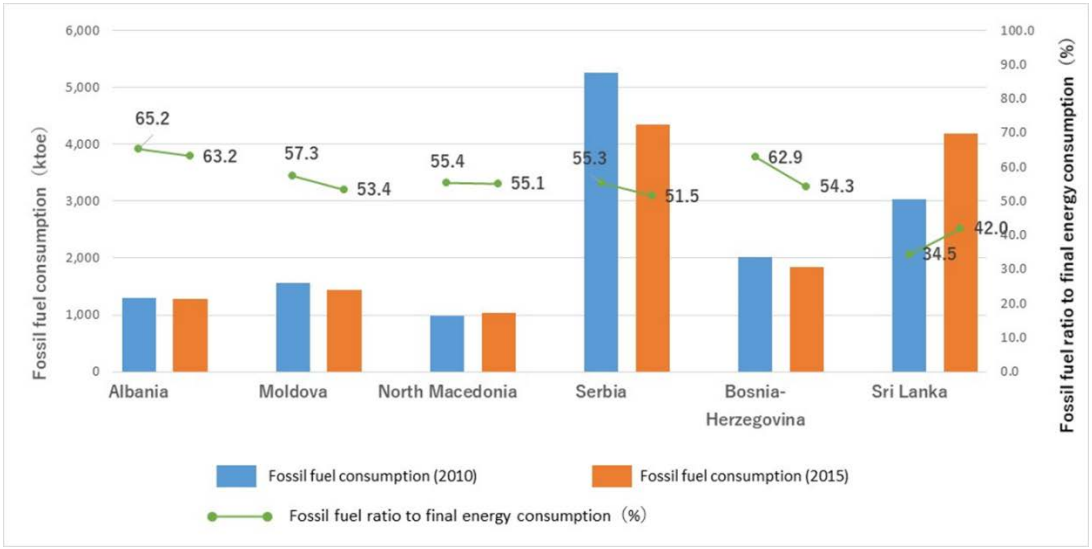


Source: JICA Survey Team

Figure 3-17 National Average of $PM_{2.5}$ Exposure Value (2011, 2016)

Air Pollution Condition

In this group, both national and city averages of $PM_{2.5}$ exposure are relatively low and on a downward trend. Figure 3- shows that the PM exposure in European countries within the group has been decreasing since 2011. Fossil fuels account for 40-60% of the final energy consumption. As shown in Figure 3-, the share of fossil fuels in the consumption of fossil fuels and final energy consumption has decreased in all European countries between 2010 and 2015, which could be one of the reasons for the downward trend in air pollution. One of the factors cited as contributing to air pollution in the target countries is the aging of vehicles, and it has been confirmed that regulations for them are being strengthened gradually.



Source: JICA Survey team

Figure 3-18 Change in Fossil Fuel Consumption in Group D (2010, 2015)

The situation in Sri Lanka is different from that of European countries, but the highest $PM_{2.5}$ exposure in urban areas as well as the national average has decreased for about 20% (from 29.7

to 23.4 μg/m3). On the other hand, the consumption of fossil fuels is increasing, and since wild fires, dust from unpaved roads, and the use of biofuels (48% of the final energy consumption) have been cited as problems related to air pollution, more detailed information needs to be collected for analysis.

Air Pollution Control

The countries in Group D have developed general laws for environmental management as higher-level laws, individual laws pertaining to air pollution control, and environmental standards. With regard to automobile emission regulations, although there was a lot of use of old vehicles in each country, these countries are trying step by step to adopt regulations that apply EU emission standards (EURO3-5).

Since North Macedonia and Albania are recognized by the Council of the European Union as candidate countries for membership, they are actively adopting EU directives and regulations. In Albania, measures have been introduced to reduce the use of fossil fuels in energy production and industrial processes, and to impose carbon taxes on many fossil fuels used in the market, such as diesel, gasoline, coal, coal coke, and kerosene. In North Macedonia, emission standards for stationary sources (mainly in accordance with EU directives) have been introduced, and self-monitoring and reporting are required by factories.

Although the situation in Sri Lanka is different from that of European countries, regulations for stationary sources are in place, as well as regulations for mobile sources and its fuel. Air quality monitoring data are available on the government website.

Group E <Medium-developed Countries with an Increase of $PM_{2.5}$>

Ecuador, Thailand, Iran

Group E consists of medium-income, medium-developed countries, where economic growth, industrialization, and urbanization is ongoing. These countries have already established individual laws, environmental standards, and emission standards related to air quality. Although the formation of air quality administration system is close to completion, $PM_{2.5}$ is still on an upward trend. This group is, therefore, considered to have issues that need to be addressed, such as strengthening the implementation of laws and regulations, enhancing the monitoring system, and establishing medium- and long-term plans and emission inventories.

Socioeconomic condition

Group E consists of medium-income country (Ecuador and Thailand) and medium-developed country (Iran). GDP per capita (2015 chained prices) is between USD 5,500 to USD 6,000, with medium-income countries Thailand and Ecuador growing at 3.2% and 1.0% respectively. Iran, on the other hand, is considered to be slow in growth with an increase of 0.3%.

The main industry is manufacturing, and the urbanization rates are 73% in Iran, 63% in Ecuador, and 48% in Thailand, with increases of 2.7% in Iran, 0.7% in Ecuador, and 3.8% in Thailand.

Air Pollution Condition

$PM_{2.5}$ exposure range from 20 to 35 $\mu g/m^3$, with Thailand and Ecuador increasing at 2.4% and 1.3%, respectively, while exposure range in Iran remains almost unchanged.

Among the countries surveyed the energy consumption/capita is the highest in Iran (2.28toe/person) and the third highest in Thailand (1.42toe/person). The share of fossil fuels in the final energy consumption is also relatively high (90% in Iran, 79% in Ecuador, and 69% in Thailand).

Traffic congestion is a major social problem in the metropolitan areas of these countries, whereas wild fires are problem in the rural areas.

Air Pollution Control

In Group E, laws and regulations related to environmental management equivalent to higher-level laws, individual laws related to air pollution control, and environmental standards and emission regulations have been developed to some extent, although the amount of information collected and the status differs from country to country. On the other hand, monitoring and source monitoring systems are not sufficiently in place.

In Thailand, there is no specific law on air pollution, but it is stipulated in the Factory Act and other laws. As for fixed sources, separate regulations have been introduced for general business activities and specific business activities (power generation, iron and steel production, waste incineration), but the emission monitoring system and its operation have not been found. Open burning is also regulated. Euro 4 is applied to vehicle emissions and fuel quality, and used car import regulations have also been introduced.

In Iran, various regulations have been established, and permissible emission limits have been set for factories, and if the limits are exceeded, the installation of emission reduction equipment becomes mandatory. The country has also introduced EURO 5 regulations and restrictions on the import of used vehicles as measures against mobile sources. However, it has been pointed out that although laws and regulations are in place, implementation, monitoring, and enforcement are still not effective.

In Ecuador, although the amount of information is not sufficient, in addition to the basic legal system, fuel regulations, used vehicle import regulations, and exhaust gas standards have been developed for mobile sources, but only Euro 1 exhaust gas standards (Euro 2 for diesel heavy-duty vehicles) have been applied. Thus, the emission standards are limited to Euro 1 (Euro 2 for diesel heavy-duty vehicles). No regulations for stationary sources have been confirmed. In 2010, a six-year national plan for air quality was formulated.

Group F <Country with a high but Decrease of $PM_{2.5}$>

China

Group F consists of only China, where $PM_{2.5}$ is relatively high, but it is turning into a decreasing trend. The air quality administration is in the process of establishing various legal systems, regulations, environmental and emission standards, and monitoring systems, and is in the process of shifting from the system formation phase to the full-scale operation phase, requiring effective measures to be taken by industry, government, and the private sector.

Socioeconomic condition

Both GDP/capita and urbanization rate have high growth rates, at 7.8% and 6.3% respectively. Energy consumption per capita has also increased by 3.2%.

Air Pollution Condition

$PM_{2.5}$ emissions have started to improve after peaking in 2013, while the economic growth and urbanization are rapidly growing, but the national annual average of $PM_{2.5}$ is still as high as 45μg/m³.

In rural areas, wild fires have remained a problem.

Air Pollution Control

China enacted the Air Pollution Control Law in 1987, and then set various regulations and emission standards. Furthermore, since the outbreak of serious and widespread air pollution in 2013, the Chinese government has introduced thorough measures, such as strengthening the air quality monitoring system, tightening exhaust gas regulations for mobile sources (introducing regulations step by step, aiming equivalent to EURO 6), strengthening emission standards for key industries, and formulating an air pollution prevention action plan.

Group G <Countries starting the Air pollution Control in Full Scale >

Mexico, Chile, Argentina, Brazil, and Malaysia

The countries in Group G have a high GDP/capita and urbanization rate, where industrialization and urbanization have reached a certain stage (slowing rate of increase). $PM_{2.5}$ is relatively low, and there is a slight upward or downward trend. The air environment administration is in the full-scale operation phase, where the establishment of the legal system, implementation system, and other infrastructure as well as the implementation of continuous measures are in progress. Furthermore, it can be said that the group is in the transition to the self-sustaining phase, where companies are undertaking voluntary efforts.

Socioeconomic condition

Group G consists of Latin American countries and Malaysia, which have high urbanization rates of 75% or more as shown in Figure 3-12, and among the target countries are the top five

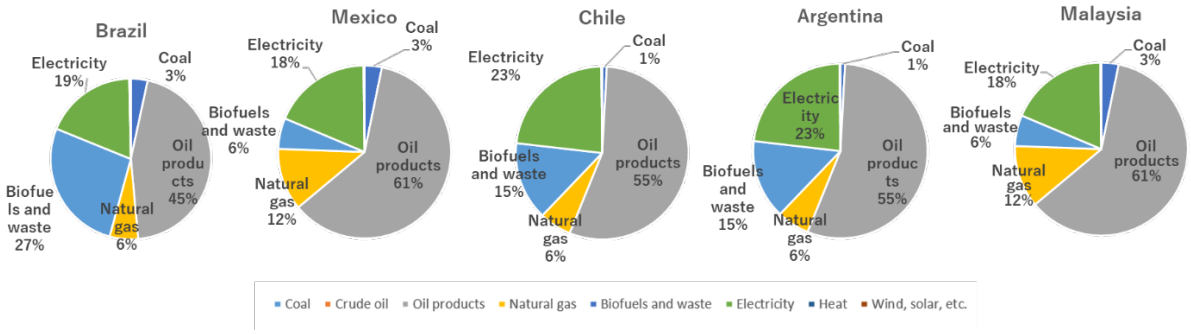
countries in terms of both the urbanization rates and GDP/capita. On the other hand, in terms of the changes in GDP/capita growth rate and urbanization rate, Malaysia has high rates at 4% and 3.3%, respectively. But GDP/capita is on a downward trend or rising at a rate of 1.5 to 2.0%, and the urbanization rate is only rising at 0.3 to 1.5% in Latin America.

Energy consumption per capita is declining in Mexico and Chile.

Air Pollution Condition

$PM_{2.5}$ exposure is relatively low in both national averages and urban areas, with a moderate upward trend, or a downward trend in Brazil and Mexico after 2011.

In terms of final energy consumption, fossil fuel-derived energy accounts for about 55-77% in all five countries, with petroleum fuels accounting for 45-61%, which is quite high. Characteristically, biofuels in Brazil account for a larger share than in other countries, 27%, of which 66% is solid biofuels in factories and 13% is the use of coal and firewood in households. Wild burning of sugarcane fields is also a problem in Brazil, and this is likely to be one of the $PM_{2.5}$ emissions sources.



Source: JICA Survey team

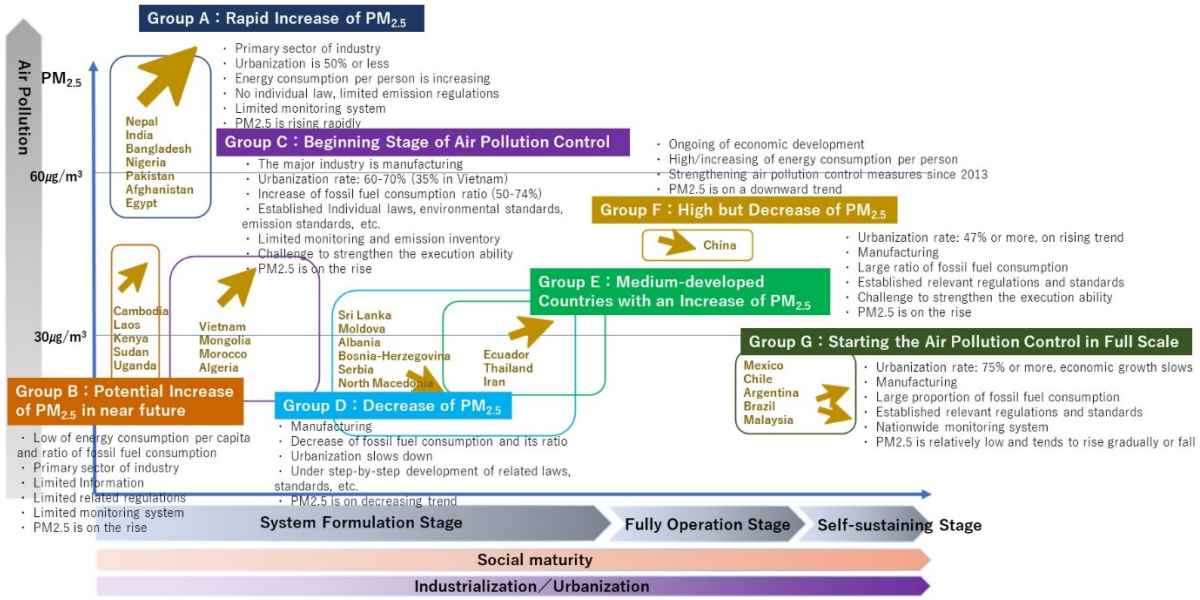
Figure 3-19 Final energy consumption of each country by fuel type (2015)

Air Pollution Control

Laws and regulations related to environmental management have been in place since the 1970s, and individual laws, environmental standards, and a nationwide monitoring system are already in place. In addition, some measures have been taken for both stationary and mobile sources. Although the information is limited, each country is taking a different approach in introducing control systems and regulations, and it can be said that they are in the transition period from the full-scale operation phase to the autonomous phase. For example, Chile is actively promoting the introduction of environmental technologies for businesses.

As for wild fire prevention, Malaysia has established regulations and a monitoring network, while Mexico and Argentina have banned it by law. In Brazil, fires in forested areas are banned to prevent wildfires.

The results of the above discussion are shown in Figure 3-, which is a chart showing the typology of the groups. In addition, Table 3- summarizes the status of each group.



Source: JICA Survey team

Figure 3-20 Categorization of Surveyed Countries into 7 groups

Table 3-14 Categorization of Surveyed Countries into 7 Groups

	Country	Socioeconomic Situation	Air Pollution Situation	Air Pollution Control
A	**< Countries with a Rapid Increase of $PM_{2.5}$ >** Nepal, Pakistan, India, Bangladesh, Afghanistan, Nigeria, Egypt	LDC – medium income country Urbanization < 50% Relatively high growth rate of urbanization (Bangladesh and Nigeria, 4% in 5 years) Relatively high growth rate Major Industry: Primary Industry (2^{nd} in India) Social maturity and SDGs Index are low (48-68)	High $PM_{2.5}$, and still increasing High $PM_{2.5}$ (> 40) in Urban area High in dry season Energy Consumption/capita < 0.7toe The rate of increase of $PM_{2.5}$ is high with respect to the increase rate in urbanization Open burning of waste, agricultural waste, field burning	Beginning/Medium stage of System Formation Comprehensive laws and regulations have been established, but no law for air quality (though India, Egypt, and Afghanistan have it). Air quality standard established, Limited emission regulation (EURO 3 or more, in Egypt, Afghanistan, India, Nepal) Limited monitoring system No open burning control
B	**< Countries where the increase of $PM_{2.5}$ is expected in the near future >** Cambodia, Laos, Kenya, Sudan, Uganda	LDC～Poor Country GDP/capita < 2,300USD Urbanization: 22%～33% No rapid urbanization Major Industry: Primary Industry (Manufacture in Laos) Social Maturity and SDGs Index are low (49~70)	$PM_{2.5}$ is not so high but is in increase Low Energy Consumption/capita, share of fossil fuel High share of Biofuel consumption/wood and coal are used in household Open burning of waste, agricultural waste, field burning	Beginning stage of System Formation Phase Limited information No country has all individual laws, environmental standards, and emission standards and regulations in place. Air quality standard exists (draft in Uganda) Limited or No monitoring system
C	**< Group at the Beginning stage of Air Pollution Control >** Vietnam, Mongolia, Morocco, Algeria	Low to Semi-developed Country Social Maturity and SDGs Index are medium (63~73) Major Industry: Manufacture	Increasing $PM_{2.5}$ Share of fossil fuel is high (50-74%) but biofuel is low (<9%).	Medium stage of System Formation Phase Basic legal framework and emission standards have been introduced. Vehicle regulations and emission standards have been established Limited monitoring and emission inventories Issues in practicality of laws and regulations
D	**< Countries with a Decrease in $PM_{2.5}$ >** Sri Lanka, Moldova, Albania, Bosnia and Herzegovina, Serbia, North Macedonia	Low to Semi-developed Country Urbanization rate is low except Albania (< 1.6%) Major Industry: Manufacture Social Maturity and SDGs Index are higher than C (68~76)	Relatively low and decrease of $PM_{2.5}$ Decrease in Fossil fuel consumption and its share in final energy consumption (in European countries)	Getting into Full-scale Implementation Phase Ongoing development of individual laws, environmental standards, stationary and mobile source emission standards (mainly in compliance with the EU directives), monitoring systems, etc.

	Country	Socioeconomic Situation	Air Pollution Situation	Air Pollution Control
E	**< Medium-developed Countries with an Increase of $PM_{2.5}$ >** Ecuador, Thailand, Iran	Medium income ~ Semi-developed Country Urbanization is relatively high, and in increase (> 47%) Major Industry: Manufacture Social Maturity and SDGs Index are same as for D (70-73)	Increase of $PM_{2.5}$ High Energy Consumption/ capita High share of fossil fuel in final energy consumption (70－90%) Traffic congestion, open burning are social problems	Late stage of System Formation Phase Established individual laws, environmental standard, emission standard for industries Issues in practicality of laws and regulations, monitoring to deal with economic growth, urbanization, and industrialization.
F	**< Country with a high but decrease of $PM_{2.5}$ >** China	High increase rate of GDP/capita, Urbanization, Energy Consumption/capita (7.8%, 6.3%, 3.2%)	Relatively high but decrease of $PM_{2.5}$ Increase of fossil fuel consumption by 3% Open burning of agricultural residue	Getting into Full-scale Implementation Phase Established individual laws, environmental standard, emission standard for vehicles and industries, nationwide monitoring network EURO 6 regulation for Vehicles Air pollution control tightened after 2013.
G	**< Countries starting the Air pollution Control in Full Scale >** Mexico, Chile, Argentina, Brazil, Malaysia	High GDP/capita, High Urbanization (> 75%) Major Industry: Manufacture Increase in rate of GDP/capita and Urbanization is becoming slow in Latin America (<2%) Both increasing in Malaysia (4%, 3.3%) SDGs Index > 69	Low $PM_{2.5}$ in both country average/urban average, low rate of increase or decrease Oil consumption in final energy consumption is high (45-61%). High percentage of biofuels only in Brazil.	Full-scale Implementation Phase ~ Autonomous Phase Air quality management is in Full-scale Implementation Phase Regulation for both stationary and mobile sources Monitoring network in operation Regulation for Open burning (Malaysia, Mexico, Argentine, Brazil)

4. Air Quality Management in Countries Selected for 2nd Stage of the survey

Based on the results of categorization above in the 1st stage of the survey, countries for further survey were narrowed down.

4.1. Selecting Countries/Cities to be surveyed

The criteria for selecting the target countries for detailed survey were set as shown in Table 4- after consultation with JICA, taking into consideration the history and future potential of JICA's support and the degree of air pollution in each country/city. The cities that met each of these criteria were selected by region, and then the representative cities that met the criteria the most were selected for further investigation.

Table 4-1 Criteria and Countries/Cities by Region for selection for the 2nd Stage of the Survey

Criteria	South-East Asia	East Asia	South Asia	Latin America	Africa	Middle East	Europe
Potential Targets of ODA/JICA cooperation	Vietnam (Hanoi), Thailand (Bangkok), Laos (Vientiane)	Mongolia (Ulaanbaatar)	Bangladesh (Dhaka), Nepal (Kathmandu)	Chile (Santiago), Ecuador (Quito)	Sudan (Khartoum), Uganda (Kampala), Kenya (Nairobi), Nigeria (Lagos)	Morocco (Rabat), Egypt (Cairo), Iran (Tehran)	Serbia (Belgrade), Bosnia and Herzegovina (Sarajevo), North Macedonia (Skopje), Albania (Tirana), Moldova (Chisinau), Kosovo (Prishtina)
Contribution to ongoing JICA projects	Bangkok	Ulaanbaatar	Dhaka		Kampala	Tehran	Chisinau, Prishtina
Experience of ODA/JICA cooperation or survey for air environment	Vietnam (Hanoi), Thailand (Bangkok), Malaysia (Kuala Lumpur)	China (Beijing, Xiangtan, etc.), Mongolia (Ulaanbaatar)	Bangladesh (Dhaka)	Power Plants in Argentina and Brazil, Mexico (local cities)		Iran (Tehran, Esfahan)	Kosovo (Pristina), North Macedonia (Skopje)
Cities with Serious Air pollution (top three in each region)	Hanoi, Bangkok, Vientiane	Beijing, Ulaanbaatar	Delhi, Kathmandu, Dhaka	Santiago, Mexico City, Quito	Khartoum, Kampala, Lagos	Arja, Tehran, Cairo	Belgrade, Sarajevo, Skopje
Representative Cities	Hanoi, Bangkok	Beijing, Ulaanbaatar	Kathmandu, Dhaka	Santiago, Mexico City	Kampala, Lagos, Nairobi	Rabat, Cairo	Belgrade, Skopje

Source: JICA Survey team

The representative cities by region selected in Table 4- are shown in Table 4- according to the groups categorized in the 1st Stage of the Survey. As a result, five cities were selected for the

survey: **Hanoi (Vietnam), Nairobi (Kenya), Cairo (Egypt), Belgrade (Serbia), and Mexico City (Mexico)**.

Table 4-2 Cities to be surveyed in the 2nd stage of the survey by Region and Group

	South-East Asia	East Asia	South Asia	Latin America	Africa	Middle East	Europe
A			Kathmandu, Dhaka		Lagos	**Cairo**	
B					Kampala, **Nairobi**		
C	**Hanoi**	Ulaanbaatar				Rabat	
D							**Belgrade**, Skopje
E	Bangkok						
F		Beijing					
G				Santiago, **Mexico City**			

4.2. Complementary Survey of the 1st stage of the Survey

The survey items for the second stage were classified into four categories: (1) collection of additional information on the 1st stage of the survey, (2) collection of information related to air quality management, (3) collection of historical data on air quality and socioeconomic indicators, and (4) support needs. In each country local consultants were hired to conduct these survey. In order to make appropriate comparisons between the five countries, it is necessary to align the content and information quality in all countries, as much as possible. For this reason, the survey team prepared a report format specifying the detailed information to be obtained as shown in Table 4-, and the surveys by local consultants were requested based on this format. The local consultants attempted to collect as much information as possible by interviewing local officials and surveying materials in the local language. The reports of the survey results for each country are attached as Annex 4.

Table 4-3 Survey Content of the 2nd stage of the Survey

(1) Collection of additional information on the 1st stage survey - Validation of the result of the 1st stage Survey - Update for the latest information - Additional information at City level
(2) Collection of information related to air quality management - The following items will be investigated by interviewing government officials involved in air quality administration and collecting information from materials in the local language. ➢ Roles and Responsibilities of relevant administrations for air quality management ➢ History of changes in administrative structure ➢ Donor support and assistance to other countries ➢ Environment-related events (major pollution, accidents, etc.) ➢ Basic law, individual laws, city-level ordinances ➢ Air quality standards (substance-specific standard values, average time) ➢ Overview of air quality monitoring system ➢ Monitoring and reporting system for emission sources ➢ Emission controls for industries and their history ➢ Emission regulations for automobiles and their history ➢ Availability of forecasting and alert systems for air pollution and emergency response systems ➢ International framework for air pollution control
(3) Collection of historical data on air quality and socioeconomic indicators - The following data will be collected from local resources over the past 30 years. ➢ Air quality monitoring data (Hourly data of NOx, SO_2, PM_{10}, $PM_{2.5}$, O_3, CO) ➢ Socio-economic indicators of the target city (population, population density, energy consumption by sector, percentage of the secondary industry, distribution of industries and agricultural land around the city, number of cars owned, GHG emissions of the city) ➢ Wind direction and speed ➢ Land use data for the city and surrounding areas ➢ Emission inventory ➢ Simulation modeling ➢ Number of staff and budget involved in air quality administration

Details of the survey results for each country are attached as Annex 4, Summary of the information and the status of availability is shown as below.

4.2.1. Egypt

(a) Laws on Environment

The major laws, regulations and ministerial decisions related to air quality management are listed below. In Egypt, Law No. 4/1994 reaffirmed the EEAA as the supreme authority in the field of environment, correcting and complementing the inconsistencies in the existing laws in 1994. The establishment of the current environmental management system can be considered to have started here.

- Law No. 4 for the year 1994 Issuance of a law in the matter of the environment, as amended by Law No 9 for the year 2009
- Executive Regulations (modified in 2005)
- Prime Minister's decision 1095 for the year 2011 amending some provisions of the regulation in Arabic.

- Prime Minister's decision 964 for the year 2015 amending some provisions of the regulation in Arabic .Prime Minister's decision 544 for the year 2016.

(b) Administrative Organization on Environment

The Egyptian Environmental Affairs Authority (EEAA) was established in 1982, and then restructured by Law No. 4/1994 Environmental Protection Law (1994), which reaffirmed the EEAA as the highest authority in the environmental field. The first permanent Minister of Environmental Protection was appointed in 1997. The EEAA has been under the Ministry of Environment since then, but still, the EEAA is the highest authority in Egypt responsible for promoting and protecting the environment and coordinating responses to these issues. Based on the interviews, the responsibilities of the EEAA were summarized, and the organizational structure of the EEAA and the Ministry of Environment were also summarized. The following are some example of cooperation between the EEAA and other ministries in the environmental field.

Ministry of Health	EEAA is responsible for air quality in the country. The Ministry of Health will report all monitoring results to EEAA, and EEAA will make a public announcement. The Ministry of Health does not publish any statement.
Industrial Development Authority	There is a full cooperation between Industrial Development Authority and EEAA through the memo of understanding
Ministry of Transport	There is a full inspection for Transportation cars in Egypt with the help of Interior Ministry of Egypt through the General Department for Vehicle Exhaust Plan

(c) Air Quality Standard, Emission Standard

Air Quality Standards

Air quality standards were first stipulated in the Environmental Protection Law of 1994 based on the WHO guidelines, but Egypt did not have sufficient accumulated data on air quality monitoring to set appropriate standards at that time. Therefore, the law was revised in September 2009, including the addition of $PM_{2.5}$ as a new target pollutant and changes of the average time for some pollutants.

Pollutant	Area	Maximum focus (microgram/cubic meter)			
		1hour	8 hours	24 hours	year
Sulfur dioxide	urban / industrial	300 /350	-	125/150	60/50
Carbon Monoxide	urban / industrial	30 mg/cubic meter	10 mg/cubic meter	-	-
Nitrogen dioxide	urban / industrial	300	-	150	60/80
Ozone	urban / industrial	180	120	-	-
Total suspended particles	urban / industrial	-	-	230	125
Particles less than 10 micrometers	urban / industrial	-	-	150	70

Particles less than 2.5 micrometers	urban / industrial	-	-	80	50
Particles measured as smoke	urban / industrial	-	-	150	60
Lead	urban / industrial	-	-	-	1 / 0.5
Ammonia	urban / industrial	-	-	120	-

Emission Standards

The emission standards for air pollutants from industry and for vehicle emissions are both set by the revised Environmental Protection Law (Law 9/2009) and the 2011 Ministerial Decree. The regulatory values by industry and by substance were obtained.

Although information on automobile regulations was not clearly available, it is assumed that they are currently equivalent to a maximum of EURO 4, since there are documents that state EURO 2 and 3 as of 2015 [16] and a policy note recommending the introduction of EURO 5 as of 2021.

(d) Air Quality Monitoring

Air quality monitoring in Egypt started in 1996 with the support of DANIDA's "Environmental Information and Monitoring Programme (EIMP)", which supported the installation of AQMSs. At the same time, USAID's "Cairo Air Improvement Project (CAIP)" was carried out, which consisted of the preparation and implementation of an emission reduction plan for smelters and the conversion of public buses to CNG. The project also conducted air quality monitoring in Cairo to track the results of the project.

The number of AQMSs has increased from 40 in 2000 to 114 as of 2021, which indicates that the air quality monitoring system has continued to expand steadily. On the other hand, it was confirmed that the air quality data from 2006 to 2012 has not been officially released. Although the reason was not disclosed, it seems that monitoring had continued during this period. According to interviews with the authorities, QA&QC of environmental monitoring and data analysis have been pointed out to be current issues.

(e) Emission Inventory

Emission inventory in Egypt was not available for this survey. In our interview with the EEAA, they answered that they do not currently have any emission inventory. On the other hand, the EEAA is working on an air pollution forecast model system [17], which requires some kind of emission inventory. Although it was not possible to find the emission inventory during this short survey, it is an indicator of industrial activity, and, it is possible that some kind of emission information is kept as closed data.

(f) Emission Control and Regulation

Industrial Emissions

[16] https://www.unep.org/resources/policy-and-strategy/air-quality-policies-egypt
[17] https://www.eeaa.gov.eg/en-us/topics/air/airquality/airqualityforecast.aspx

The monitoring of stationary sources started with emission monitoring for cement factories in 1998. Subsequently, the Ministry of Environment established a system for monitoring industrial emissions by requiring companies to establish a continuous self-monitoring network and provide the data to the Environment Agency through the Environment Law No. 4 of 1994 and Law No. 9 of 2009 in order to monitor emissions from industrial facilities. As of January 2022, the number of industrial facilities linked to the national network for emission monitoring is 87 facilities and 434 measuring points.

Vehicle Inspection

Street campaigns for vehicle inspection (fixed/mobile ambushes) are conducted in average 10 times/week with the Directorate General of Environmental Police, and 14,435 vehicles were inspected in 2021, of which 9,305 passed and 5,130 failed. In the noncompliant vehicle re-inspection program at the Technical Center Headquarters, 2,581 vehicles were inspected, of which 1,870 passed and 711 failed.

An annual program to inspect all buses belonging to the Cairo Public Transport Authority is also underway.

(g) Planning and implementation of Air Pollution Control Measures

The following table shows the history of main measures taken by the EEAA based on the interviews with the EEAA and the Ministry of the Environment and review of documents.

Steps for improvement	What has been done for improvement
1996－early 2000	The Cairo Air Improvement Project (CAIP), which was implemented with the support of USAID, included the conversion of public buses to CNG and the construction of a maintenance facility for CNG buses, as a program to convert transportation to clean alternative fuels. In addition, emissions measurement equipment was installed at private gasoline stations and emissions measurements on public roads (demonstration) as part of the vehicle emissions inspection program. On the other hand, for stationary sources, CAIP focused on lead, and relocated a secondary lead collector and refiner located in Cairo, and improved their industrial process. At the same time, the Environmental Information Management Program (EIMP), supported by DANIDA, established a nationwide air quality monitoring network, and set up the transfer system of exhaust gas monitoring data from six cement factories to the EEAA headquarters as a pilot project for a source monitoring system.
2007-2008	In order to improve the working environment in factories and to analyze technologies, it became necessary to establish a nationwide network for monitoring emissions from factories and to create a database. - Monitoring systems that do not allow companies to interfere with the quality, format, and timing of measurement data - Calculation of environmental impact of emissions - Creation of an alarm system in case of exceeding the allowable emission limits specified by the law
2011-2012	A dispersion model for air pollutants was developed by modeling the effects of the temporal and spatial distribution of pollutants as well as geography and meteorology, for the dispersion of pollutants in the atmosphere. The model takes into account both primary and secondary pollutants, and can be used to study and evaluate the effects of all pollutants on air quality.

2012-2021	A GIS software package was provided that included a data analyzer to perform the necessary analysis and display the results on a map, and a system was developed to convert these results into reports, graphs, and map formats for display.

4.2.2. Kenya

4.2.2.1. Historical Transition in Air Quality Management

1) Enactment of related laws and regulations

In Kenya, since the passing of the Environmental Management and Coordination Act (EMCA-1999) by the national assembly and establishment of the National Environment Management Authority (NEMA) in 2002, NEMA established the policy and guielines for air quality management such as 1st National Air quality regulations "Environment Management and Co-Ordination (Air Quality) Regulations, 2014.

In parallel, the constitution of Kenya 2010 saw establishment of 47 local governments commonly known as country governments. These local governments have departments of environment whose responsibilities include enforcement and implementation of air quality policies and guidelines established by the national governments. Based on this constitutional provision, Nairobi City County Government (NCCG) established its independent Air Quality Action Plan (2019-2023) and through this action plan, Nairobi Air Quality Bill-2021 was established as its own local bill on air quality. The table below highlights the major milestones of air quality legal framework in Kenya and Nairobi.

Table 4-4 Enactment of Related Laws on Air Quality Management in Kenya/ Nairobi

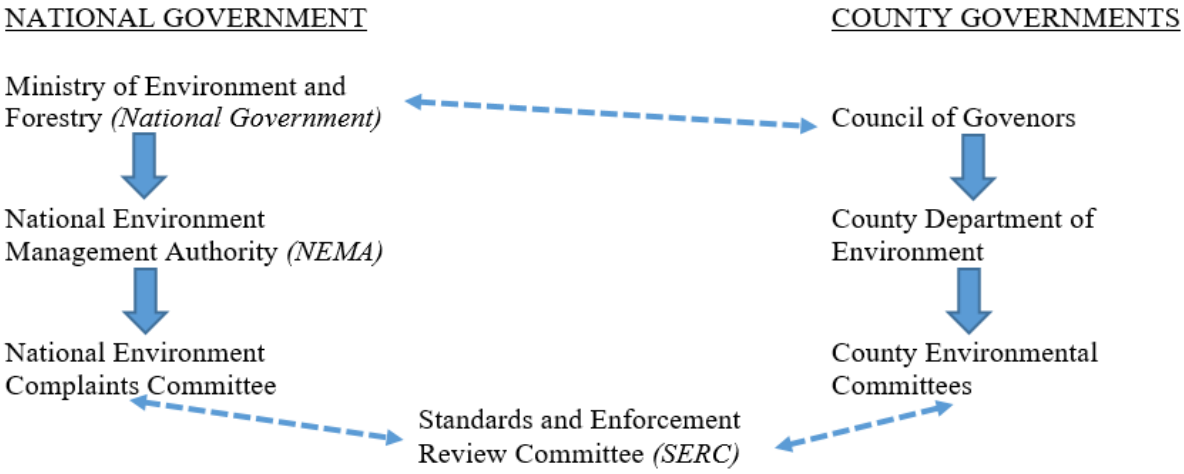
Year	Laws and Regulations	Remarks
1974	National Environmental Secretariat (NES) was established	
1986	Public Health Act, CAP 242	
2002	EMCA-1999 was passed. NEMA was established.	
2010	New Constitution of Kenya 2010 was promulgated.	Through the Fourth Schedule of the Constitution of Kenya, 2010: Part 2, Section 3 – Counties governments (Local governments) were given the following functions and powers: • Control of air pollution, noise pollution, other public nuisances and outdoor advertising
2014	NEMA established the 1st National Air quality regulations "Environment Management and Co-Ordination (Air Quality) Regulations, 2014"	Through its schedules, the regulations provide the following: • Ambient air quality tolerance limits • Priority Air Pollutants, • Emission limits for controlled and non-controlled facilities, • Acceptable emission control technologies • List of methods of test and measurement of air pollutants based on multiple air quality standards set by the Kenya Bureau of Standards (KEBS)
2019-2023	Nairobi City County Air QualityAction Plan (2019 - 2023) was established.	It outlines actions that Nairobi City County Government (NCCG) intends to undertake in order to reduce harmful air pollution in the city.

Year	Laws and Regulations	Remarks
2020	Nairobi City County Air Quality Policy was established.	
2021	Nairobi City County Air Quality Bill-2021 was established.	

Source: JICA Survey team

2) Organization on Air Quality Management

Since NEMA was established in 2002, it is broadly responsible for supervision and enforcement of established air quality laws and regulations. Also, national and county air quality management committees are organized separately with the responsibility of ad-hoc interventions but also for long-term planning of air quality interventions. Below figure shows the management structure of air quality in Kenya.



Source: JICA Survey team

Figure 4-1 Management Structure of Air Quality in Kenya

3) Countermeasures on Air Environment

(i) Ambient Air Quality and Emission Standards

1st National Air quality regulations "Environment Management and Co-Ordination (Air Quality) Regulations, 2014" stipulates the ambient air quality standard in Kenya. This standard value is set separately for three areas; (i) Industrial Area, (ii) Residential, Rural & Other Area, and (iii) Controlled Area.

Below table shows the ambient air quality standard in Kenya, whose title on Kenya Air Quality Act-2014 is "ambient air quality tolerance limits".

Table 4-5 Ambient Air Quality Tolerance Limits in Kenya

Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
1. Sulphur Oxides (SO_x);	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 hours**	125 µg/m^3	80 µg/m^3	30 µg/m^3
	Annual Average		0.019 ppm/50 µg/m^3	

Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
	Month Average			
	24 hours		0.048ppm /125 µg/m^3	
	1 hour			
	Instant Peak		500 µg/m^3	
	Instant Peak (10 min)		0.191 ppm	
2. Oxides of Nitrogen (NO_x);	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 hours**	150 µg/m^3	80 µg/m^3	30 µg/m^3
	8 hours			
	Annual Average		0.2 ppm	
	Month Average		0.3 ppm	
	24 hours		0.4 ppm	
	1 hour		0.8 ppm	
	Instant Peak		1.4 ppm	
3. Nitrogen Dioxide	Annual Average	150 µg/m^3	0.05 ppm	
	Month Average		0.08 ppm	
	24 hours	100 µg/m^3	0.1 ppm	
	1 hour		0.2 ppm	
	Instant Peak		0.5 ppm	
4. Suspended Particulate matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3
	mg/Kg			
	Annual Average****		100 µg/m^3	
	24 hours***		180 µg/m^3	
5. Respirable Particulate Matter (<10 µm) (RPM)	Annual Average*	70 µg/m^3	50 µg/m^3	50 µg/m^3
	24 hours**	150 µg/Nm^3	100 µg/Nm^3	75 µg/Nm^3
6. $PM_{2.5}$	Annual Average	35 µg/m^3		
	24 hours	75 µg/m^3		
7. Lead (Pb)	Annual Average*	1.0 µg/Nm^3	0.75 µg/Nm^3	0.50 µg/m^3
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3
	Month Average		2.5	
8. Carbon monoxide (CO)/ carbon dioxide (CO_2)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3
	mg/Kg			
	24 hours**			
9. Hydrogen Sulphide	24 hours**	150 µg/m^3		
10. Non-methane hydrocarbons				
	Instant Peak	700ppb		
11. Total VOC	24 hours**	600 µg/m^3		
12. Ozone	1-hour	200 µg/m^3	0.12 ppm	
	8 hours (Instant Peak)	120 µg/m^3	1.25 ppm	

a) µg- microgram
b) m^3 – cubic metre
c) ppm – Parts per million
d) ppb – Parts per billion
e) Values at Standard Temperature and Pressure (STP)
f) Conversion factors from ppm to mg/m^3 and mg/m^3 to ppm are stipulated under the Eleventh Schedule

g) * [Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval].
h) ** [24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days].
i) Whenever and wherever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.
j) *24-hour limit may not be exceeded more than three times in one year;
k) ** 24-hour limit may not be exceeded more than three times in one year is micrograms/m^3
l) *** Not to be exceeded more than once per year average concentration
m) *** In conversion of units from ppm to mg/m3 and vice versa shall use guidelines set out under Part II of the Fifth Schedule
Source: NEMA

(ii) Point Source Management

Point Source of Industries

1st National Air quality regulations "Environment Management and Co-Ordination (Air Quality) Regulations, 2014" also stipulates the emission standard, called "Emission limits for controlled and non-controlled facilities". In addition, the guideline for the petroleum sector has been set.

Emission from Mobile Source

Emission performance standards for new vehicles, import regulation for used vehicles and regulations on the fuel composition were formulated for the management of emission from mobile sources as shown in below table. In addition, Roadmap for Harmonization of Vehicle Emission Standards in East Africa was formulated in East Africa in 2017.

Table 4-6 Regulations for Emission from Mobile sources

Emission performance standards for new vehicles	
KS 1515: 2000 ICS 43.040.60 Kenya Standard Code of practice for inspection of road vehicles	The vehicles will be subject to roadworthiness inspection by a KEBS appointed inspection agent in the country of export.
Import regulations for used vehicles	
Kenya Bureau of Standards requirements of Legal Notice No. 78 of 15th July 2005 *(Verification of Conformity to Kenya Standards Imports Order, 2005)* & KS1515:2000 Kenya Standard Code of Practice for Inspection of Road Vehicles.	In Kenya, age limit for imported used vehicles is 8 years, the regulations require annual inspections for commercial and PSVs, and every 2 years for personal cars four years old and above [18].
Regulations on the fuel composition	
The-Petroleum-Act-2019-LN-100-2019 and • East Africa Vehicular Emission-Draft 2021(KEBS)	There are wide ranges in the respective emission limits for CO, HC, NOx, PM, VOC and Opacity for both gasoline and diesel-powered vehicles, whether heavy duty, passenger or light duty. It is recommended that the East African Community countries find convergence on the applicable emission limits. With current harmonized fuel standards capable of supporting Euro IV emission standards it is recommended that the proposed harmonization should target Euro IV equivalent.

Source: JICA Survey team

[18] PVOC Program, Kenya Bureau of Standards.
https://kebs.org/index.php?option=com_content&view=article&id=87&Itemid=426

Open Burning of Agricultural Residue and Household Fuel Consumption

Below table shows the emission regulations for open burning of agricultural residue and other waste, and household fuel consumption.

Table 4-7 Emission Regulations for Open Burnings and Household Fuel Consumption

Regulation on agricultural field burning	
Kenya Agriculture Act 318	It was established in 1986 and later revised in the year 2012 The Act discouraged the practice of annual burning of wetlands
Regulation on open burning of wastes	
Environmental Management and Co-ordination (Waste Management) Regulations	It was established in the year 2006 The regulation discourages open and discreet burning of waste [19]
Regulations on house heating,	
The Energy (Solar Water Heating) Regulations, 2012	It was established in the year 2012 The regulation requires property developers to install and use solar water heating systems in houses.

Source: JICA Survey team

4) Donor Support for Air Quality Management

Below table shows the list of donor support projects for air quality management targeting Kenya. There are some ongoing projects not only those by World Bank and UNEP but also others such as Clean Air Africa Project by National Institute for Health Research.

Table 4-8 List of Donor Support Projects for Air Quality Management in Kenya

Donor name	World Bank
Project name	African Environmental health and Pollution Management Project
Duration	August 2020- July 2025
Budget	USD $ 8,073,395
Summary Counterpart organization • NEMA • Ministry of Health-Department of Public Health • County Governments- Kisumu, Nakuru, Mombasa Activities • Institutional strengthening, knowledge and capacity building • Support for policy dialogue and regulatory enhancements • Demonstrating application of technological tools and economic approaches in the management of e-waste Output Elimination of Polybrominated Diphenyl Ethers (PBDEs), Polychlorinated Biphenyls (PCBs), Hexabromocyclododecane (HBCD), dioxins, furans, cadmium, beryllium through proper e-waste management.	
Donor name	UN Environment Programme (UNEP)
Project name	Digital Billboards
Duration	2021-to -date
Budget	Undisclosed
Summary Counterpart organization	

[19] Waste management regulations (2006).
https://www.nema.go.ke/images/Docs/Regulations/Waste%20Management%20Regulations-1.pdf

- IQAir, a Swiss air quality technology company,
- Safaricom, a telecommunications provider in Kenya,
- Alpha and Jam Ltd and
- Metropolitan Star Lite Ltd,
- Out Of Home (OOH) media

Activities

- Provides real-time air quality information for some of the most harmful type of air pollution, fine airborne particles, known as $PM_{2.5}$

Output

- Increase air quality awareness among the city's 4.7 million inhabitants.

Donor name	World Bank
Project name	Financing Locally–Led Climate Action (FLLoCA) Program
Duration	2021-to -date
Budget	US$171.4 Million

Summary

Counterpart organization

- Social Sustainability Initiative for All Umbrella Multi-Donor Trust Fund(Governments of Denmark and Sweden)
- Ministry of Environment and Natural Resources-Kenya
- County Governments of Kenya

Activities

- The program's development objective is to deliver locally led climate resilience actions and strengthen county and national governments' capacity to manage climate risks.
- Output
- The program will strengthen the national government's capacity to support county government actions, enhance the collaboration between national entities on climate change, and facilitate national oversight of the program.

Donor name	JICA
Project name	Africa Adaptation Program
Duration	2011-2013
Budget	£4.2 Million

Summary

Long-term planning, capacity development and risk management

Counterpart organization

- African Development Bank
- Global Center On Adaptation
- Ministry of Environment and Natural Resources-Kenya

Activities

Output

Donor name	Special Climate Change Fund (SCCF), World Bank, UNDP
Project name	Adaptation to Climate Change in Arid Lands (KACCAL)
Duration	2011-2015
Budget	USD 6.5 Million

Summary

The objective of the "Kenya-Adaptation to Climate Change in Arid Lands" (KACCAL) project was to increase the capacity of communities in Mwingi District to adapt to climate variability and change. Thus, project developed and piloted a range of coping mechanisms for reducing the vulnerability of smallholder farmers in Mwingi to climate change. The project took cognizance of existing indigenous activities/measures used by local communities to cope with the adverse effects of climate change.

Counterpart organization

- Ministry of Arid and Semi-arid lands,
- GEF- Global Environment Facility.
- Activities
- Output
- Enhanced awareness of national and regional stakeholders to plan, manage and implement CC adaptation

measures in arid and semi-arid lands. - Enhanced capacity of district and local level stakeholders to plan, manage and implement climate change adaptation measures - Enhanced communities' ability to plan, manage and implement climate-related activities. KACCAL is a $1 million, three year project, supported by the Special Climate Change Fund (UNFCCC) that has recently begun implementation	
Donor name	National Institute for Health Research | NIHR-UK
Project name	Clean Air Africa
Duration	2018-to -date
Budget	Undisclosed
Summary Counterpart organization - Kenya Medical Research Institute - Ministry of Health (Directorate of Public Health) - Ministry of Energy - Moi University - Amref International University Activities - Inform national policies to scale access to and adoption of clean household energy - Demonstrate the positive impacts on health and climate from populations switching to clean household fuels and - Strengthen health systems to empower community led prevention to fight against household air pollution. Output - Transition to clean cooking among households - Reduced morbidity associated with indoor air pollution - Counties/Community Health Workers reporting on air quality indicators	

Source: JICA Survey team

5) Environemntal Incidents

Rapid urbanization, the corresponding increase in vehicle ownership, and the continued use of solid fuels as an energy source have resulted in the deterioration of air quality in Kenya. In particular, fire accidents in urban areas and idling of vehicles are considered to have a big impact on air quality.

On the other hand, there is no officially available air quality monitoring data so that it is difficult to grasp the current air quality status.

4.2.2.2. Relevant Data Collection

1) Air Quality Monitoring at Air Quality Monitoring Stations

In addition to the continuous ambient air quality monitoring by NEMA which was started from 2014, some monitoring activities are carried out in Nairobi as shown below table. On the other hand, these monitoring activities have some difficulties (e.g. the monitoring parameter is only $PM_{2.5}$, the accuracy of measurement equipment is not guaranteed, etc.).

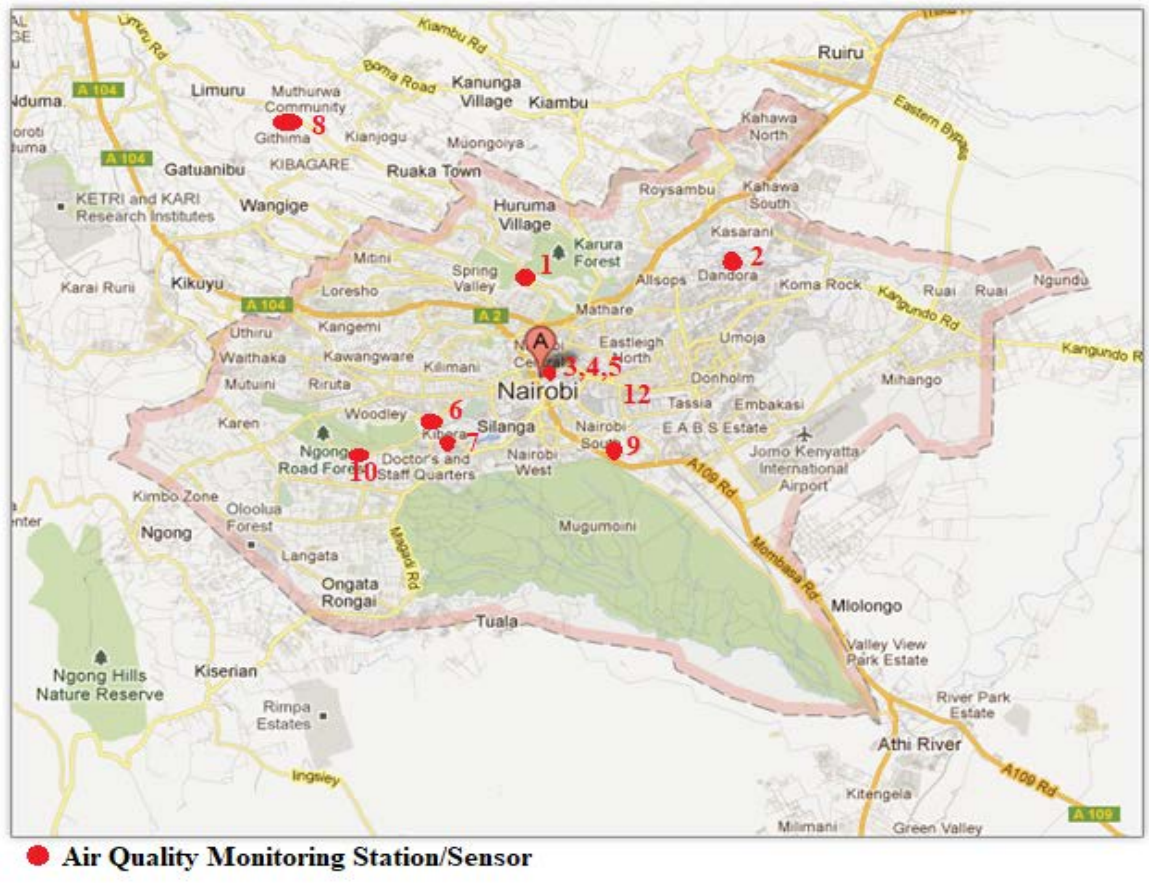
Due to this situation, it was not possible to obtain continuous monitoring results which can show annual trend of ambient air quality in Nairobi.

On the other hand, NEMA also has the mobile air quality monitoring laboratory which is used for monitoring in Nairobi and other cities.

Table 4-9 Air Quality Monitoring Stations in Nairobi (including Mobile Laboratory)

AQMS name/Owner	SO_2	NOx	NO_2	PM_{10}	$PM_{2.5}$	Ox	CO	Other emissions	Website
NEMA mobile air quality monitoring lab	✓	✓	✓	✓	✓	✓	✓	✓	
NEMA designated laboratories	✓	✓	✓	✓	✓	✓	✓	✓	*https://www.nema.go.ke/images/Docs/Gazetted_labs_1.2.22.pdf*
Braeburn Garden Estate School, Nairobi-(NCG))					✓				*https://www.iqair.com/kenya/nairobi/braeburn-garden-estate-school*
Bins Nairobi - Industrial Area, Nairobi-(NCG)					✓				*https://www.iqair.com/kenya/nairobi/bins-nairobi-industrial-area*
Mbaghati Hospital, MBAGATHI RD, Nairobi-(UNEP)					✓				*https://www.iqair.com/kenya/nairobi/mbaghati-hospital-mbagathi-rd*
Kibera Drive, Nairobi-(NCG)					✓				*https://www.iqair.com/kenya/nairobi/kibera-drive*
Safaricom JCC, Mombasa Road, Nairobi(Safaricom)					✓				*https://www.iqair.com/kenya/nairobi/kibera-drive*
Nairobi Air Quality Monitor - US EPA (ke.usembassy.gov)					✓				*https://aqicn.org/city/kenya/nairobi/us-embassy/*
Clean Air Nairobi (Kibera, St.Scholastika, United Nation (UNEP), All Saints, Alliance Girls)				✓	✓			✓	*http://senseable.mit.edu/cleanair-nairobi/*

Source: JICA Survey team



1. Gigiri	2. Dandora	3. Luthuli	4. Landhis
5. Tom Mboya	6. Mbagathi	7. Kibera drive	8. Alliance Girls
9. Safaricom JCC	10. Kenya Meterological Department	11. Jogoo road	12. Bins Industrial Area

Source: JICA Survey team

Figure 4-2 Air Quality Monitoring Stations in Nairobi

Figure 4-3 Mobile Air Quality Monitoring Laboratory owned by NEMA

2) Socio-Economic Data

Below table shows the major socio-economic data collected in this survey. In this survey, indicators were mainly collected that could be explanatory variables for the air environment administration and the air environment situation.

Table 4-10 Collected Major Socio-Economic Data (Kenya)

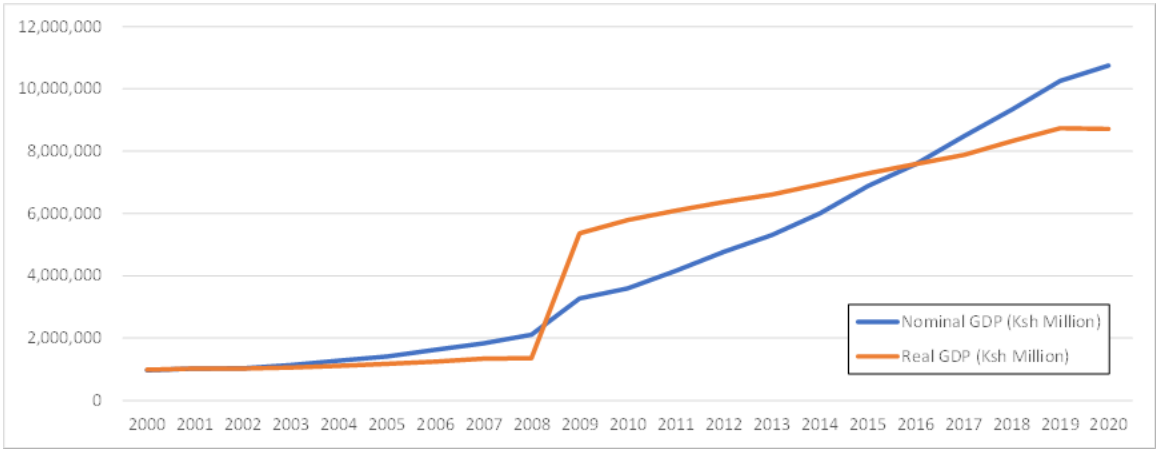
No	Data to be collected	Data Description	Unit	Period	Data Source
1	Population and population density	Total population	Person	1990 - 2020	The World Bank https://data.worldbank.org/indicator/AG.LND.TOTL.K2?locations=KE
		Land area	km^2	1990 - 2020	
		Population density	Persons / km^2	1990 - 2020	
2	Real GDP (Gross Regional Product) of the City/town (If not available, real GDP)	GDP	Real GDP and Nominal GDP for the Country	2000 - 2020	Central Bank of Kenya https://www.centralbank.go.ke/annual-gdp/
		GCP	Gross County Product	2013 - 2017	Kenya Bureau of Statistics https://www.knbs.or.ke/download/gross-county-product-2019/
3	Land use	Land use	Thousand hectares	1990 - 2016	Kenya Bureau of Statistics https://kenya.opendataforafrica.org/imzpszb/resource-statistics-land
4	Energy Consumption by sector	Petroleum and electricity consumption	Petroleum (Thousand tonnes) Electricity (Million KWH)	1985 -2019	Kenya Bureau of Statistics https://www.knbs.or.ke/publications/ (Economic Survey Publications 1974 - 2020)
5	Number of registered vehicles	Total number of registered vehicles (imported & locally assembled)	Units per month	2005 - 2020	Kenya Bureau of Statistics https://www.knbs.or.ke/data-releases/?tax%5Bwpdmcategory%5D=leading-economic-indicators-2021
6	Direct investment amount (Country level)	Foreign direct investment, net inflows (BoP, current US$)	USD	1980 - 2019	The World Bank https://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD?end=2019&locations=KE&start=1980
7	Literacy rate	Literacy rate, adult total (% of people ages 15 and above)	Percentage of adults	2000, 2007, 2014, 2018	The World Bank https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=KE
8	Mortality rate of children under 5 years old	Average for every 5 years between 1950 to 2020	Number /1000 live births	1950 - 2020	United Nations: Department of Economic and Social Affairs (Population Projections 2019) https://population.un.org/wpp/Download/Standard/Mortality/
9	Life expectancy (country level)	Number of years	Years	1990 - 2019	The World Bank https://data.worldbank.org/indicator/SP.DYN.LE00.IN?

No	Data to be collected	Data Description	Unit	Period	Data Source
					locations=KE

Source: JICA Survey team

Below figure shows the Nominal GDP and Real GDP of Kenya from 2000 to 2020.Between 2001 and 2020, Kenya's GDP growth averaged 4.3 percent annually, with the exception of 2020, when it experienced negative growth of -0.3 percent.

The kink in the real GDP graph in 2008 can be attributed to the change in base prices; in 2008 and prior years, prices were based on 2001 prices, while in 2009 and subsequent years, prices were based on 2009 base prices.



Source: Prepared by JICA Survey team based on Published Data

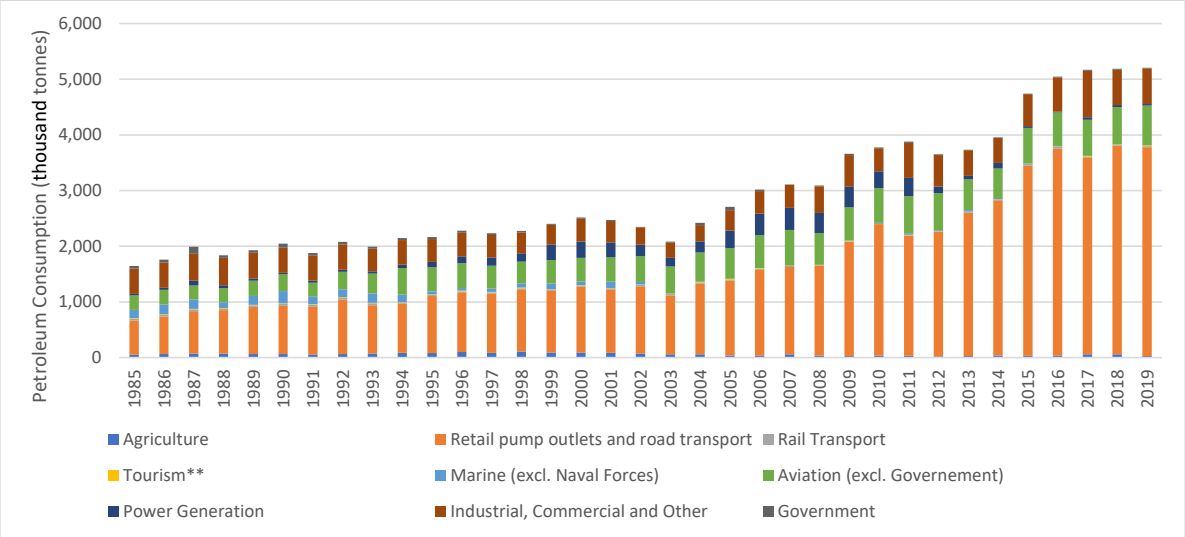
Figure 4-4 Trend of Nominal GDP and Real GDP in Kenya (2000 – 2020)

The figures below show energy consumption by sector in Kenya. The upper figure depicts petroleum consumption, which nearly tripled between 1985 and 2019, as well as the remarkable growth of 'Retail pump outlets and road transport'.

The lower figure depicts electricity consumption, which more than quadrupled between 1985 and 2019. Both 'Domestic and Small Commercial' and 'Large Commercial and Industrial' experienced remarkable growth.

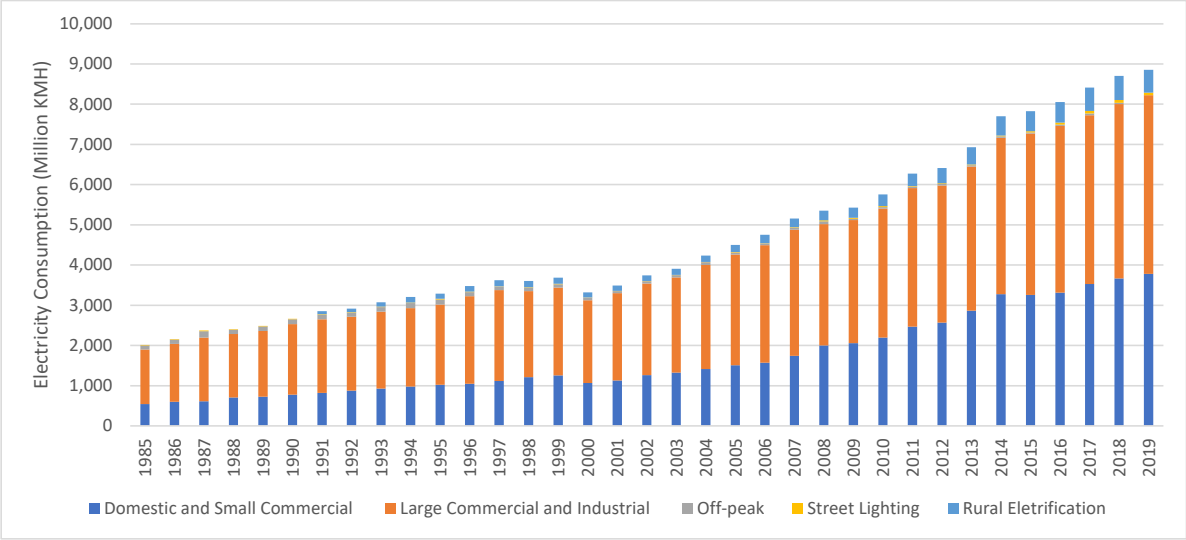
Additionally, we can see a steady increase in rural electrification since 2012. Rural electrification has resulted in the connection of more rural households that previously relied on alternative energy

sources.



Source: Prepared by JICA Survey team based on Published Data

Figure 4-5 Petroleum Consumption of Kenya (1985 – 2019)

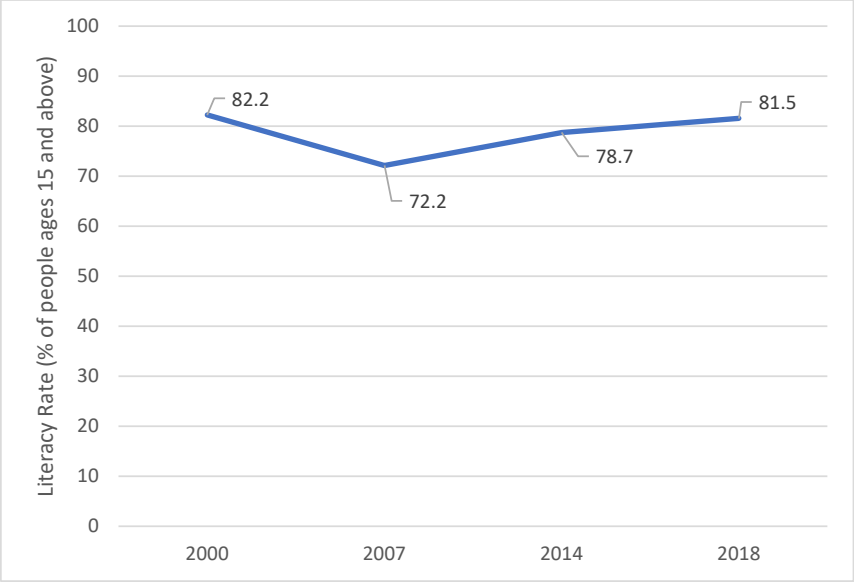


Source: Prepared by JICA Survey team based on Published Data

Figure 4-6 Electricity Consumption of Kenya (1985 – 2019)

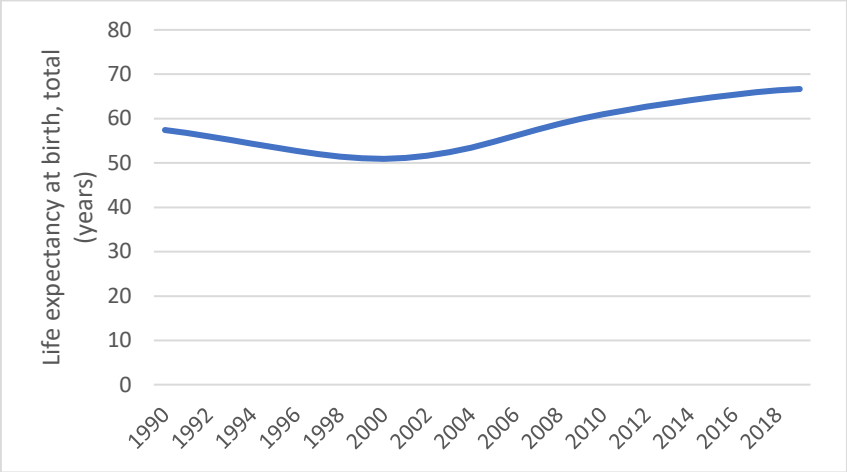
Trend of literacy rate and life expectancy are also collected to grasp the maturity of society as shown below. Literacy Literacy rate reached 81.5% in 2018, while this is higher than the average for Sub-Saharan Africa of 65%, it is lower than the global average of 86% in 2018, according to the World Bank. Between 1990 and 2000, life expectancy decreased from an average of 57 to around 50 years, before increasing to an average of 66 years in 2019.

Note: Due to the lack of annual data for Kenya, the following data may not accurately reflect how rates have changed over time.



Source: Prepared by JICA Survey team based on Published Data

Figure 4-7 Literacy Rate



Source: Prepared by JICA Survey team based on Published Data

Figure 4-8 Life Expectancy

4.2.3. Vietnam

4.2.3.1. Historical Transition in Air Quality Management

1) Enactment of related laws and regulations

In Vietnam, the provision on air pollution was established for the first time when the Law on Environmental Protection, which is the Basic Environmental Law enacted in 1994, was revised in 2005. In addition, the revision in 2014 summarized the provisions on comprehensive air pollution control. Although individual laws such as the Air Pollution Control Law have not been developed, various regulations, environmental standards, and emission standards have been established as

Decree and Circular. In addition, the national plan on the prevention of environmental pollution and the national environmental monitoring plan, etc. have been formulated as the prime minister's decision.

Table 4- shows the historical transition of the laws and regulations related to air quality management in the national government and Hanoi City. The targets of the countermeasures have been expanded from dust to exhaust gas (NO_2, NO_x, CO) from industrial activities and transportation, and further, PM_{10}, $PM_{2.5}$ countermeasures and GHG emission control. On the other hand, in Hanoi City, air pollution caused by the burning of agricultural residues and the use of honeycomb briquettes has become a big problem on air quality, and measures such as calling for residents; it is required to appeal to the residents regarding the prohibition of these action and establish penal regulations.

Table 4-11 Enactment of Related Laws on Air Quality Management in Vietnam/Hanoi City

Year	State/ Hanoi	Related laws and regulations related to air quality management
1993	State	First Law on Environmental Protection issued (No provisions concerning the air environment)
2002	State	Establishment of the Ministry of Natural Resources and Environment (MONRE)
2005	State	LEP amended (addition of provisions on air pollution (emission gas regulations from industries and automobiles, monitoring program, current status grasp at local level, etc.)
2005	State	Establishment of ambient air quality standards (TCVN5937:2005, 2009 and 2015 revised) Maximum Allowable Concentrations of Hazardous Substances in ambient air (TCVN5938:2005, revised in 2009), Industrial emission standards (inorganic substances and dusts) (TCVN5939:2005, revised in 2009), Exhaust Gas Standards (organic substances) (TCVN5940:2005, revised in 2009)
2005	Hanoi	Regulation on the implementation of measures to reduce dust in the construction sector in the area of Hanoi (Decision 02/2005/QD-UBND)
2009	State	Redefined the following standards: National Technical Regulations on Hazardous Substances in ambient air (QCVN06:2009BTNMT), National Technical Regulation on Industrial Emission of Inorganic Substances and Dusts (QCVN19:2009), National Technical Regulation on Industrial Emission of Organic Substances (QCVN20:2009)
2009～	State	Establishment of exhaust gas standards in each industrial sector (cement production, chemical fertilizer production, thermal power plant, industrial waste (2012), combustion of solid medical waste (2012), steel (2013))
2010	State	Law on Economical and Efficient use of energy (50/2010/QH12, revised in 2018)
2010	State	Approval of scheme for controlling emission from motorbikes, motorcycles in cities, provinces (Decision 909/QD-TTg)
2014	State	LEP amended (the new section on comprehensive air pollution control and air quality management, and the chapter on collection and management of environmental data were added.)
2015	State	The installation of continuous emission monitoring systems and reporting to MONRE were made mandatory for factories of more than a certain size in industries (steel, thermal power plants, cements, chemicals, petrochemicals) with high exhaust emissions. (Decree 38/2015-ND-CP: Waste and Scrap Management)
2016	State	Approval of national action plan for air quality management up to 2020, vision towards 2025 (Decision 985a/QD-TTg) Setting the targets of emission gas of SO_2, NOx, and CO from certain industrial activities, Implementing mitigation measures for PM_{10}, $PM_{2.5}$ focused on industrial source, energy source, transportation and construction source
2017	State	Regulations on Environmental Monitoring Techniques (Circular No. 24/2017 TT-BTNMT)

Year	State/ Hanoi	Related laws and regulations related to air quality management
2018	Hanoi	Prohibision of illegal burning of straw, crop by-products and other waste to mitigate the environmental impact of Hanoi City.
2019	Hanoi	Prohibition of Usage of Honeycomb Briquette in Hanoi City (Directive 15/CT-UBND)
2019	State	Revision of industrial emission monitoring: objects, items to be monitored, frequency (Revising Decree 38/2015),
2020	Hanoi	Strengthening management measures the State of improper burning of straw, crop by-products and other wastes to minimize negative environmental impacts (Directive 15/CT-UBND)
2020	Hanoi	Action No. 149/KH-UBND on "Green growth action of Hanoi city to 2025, orientation to 2030" was formulated which includes targets for reduction of GHG emissions.
2020	State	LEP amended. More detailed regulations on air quality conservation were added, such as formulation of air quality conservation plans at the national and local levels, responsibilities of private sectors on air quality environment (obligion of automatic continuous observation and reporting for large-volume exhaust gas emission contractors, etc), prohibition of combustion of agricultural residues, etc. Inaddition, efforts to tackle climate change were embodied.
2021	State	Application of EURO 4 regulations to newly manufactured and imported vehicles
2021	State	The directive (Directive 03/CT-TTg) was enacted to request Hanoi, Hochiminh city and other cities/provinces posing highly potential air pollution to implement air pollution control such as emission inventory, PM_{10} and $PM_{2.5}$ monitoring and assessment.
2021	State	Approval of national air quality management plan from 2021 to 2025 (Decision 1973/QD-TTg)
2021	Hanoi	Strengthening environmental control at Kraft Village (307/KH-UBND)
2022	State	Application of EURO 5
2022	State	Enacted the Implementation Regulations for air quality management stipulated in the LEP (Decree 08/2022/ND-CP)
2022	State	Regulations and solutions for low emission of GHG and protecting Ozone layer: (Decree No. 06/2022 per ND-CP)

Source: JICA Study Team

2) Governmental Organization on Air Quality Management

< Central Government >

The Ministry of the Natural Resources and Environment (MONRE) was established in 2002, and transferred from the Ministry of the Scientific and Technological Environment which was previously responsible for the administration of the air environment. MONRE is currently in charge of air quality control (environmental standards and monitoring), exhaust emissions regulations and permit-related regulations from the industrial sector and transportation sector, and emission control from the informal sector. Under MONRE at the national level, the air quality and pollution management are administrated by VEA (Vientamn Environment Administration) and the Center for Environmental monitoring under VEA.

In this survey, the budget, number of staff, details of implementation, issues, etc. are investigated for the relevant organizations in order to grasp the amount of input to the air environment administration and the execution capability of the plan/law and regulation. The key relevant information of VEA collected through interview survey is as follows.

- ✓ Approximately 20 staff members. The budget for air quality management is unknown. There are issues on human resource development and shortage of budget.

- ✓ The enactment of individual laws and regulations at the national level is insufficient, and pollution control has not been implemented effectively. Another problem is on insufficient budget for air environment monitoring.
- ✓ For the future plan, the VEA is considering support for the formulation of the air quality management plan in each province, preparation of the emission inventory, management by allocating the emission allowance, expansion of the air quality monitoring system, management of the waste generation source, preparation of the air quality prediction and warning system and so on.

Table 4- shows the major central government agencies and their responsibilities on air quality management.

Table 4-12 Major Government Agencies and Responsibilities on Air Quality Management in Vietnam

Ministries/ Agencies	Key responsibilities/roles
MONRE	- Management of ambient air quality; - National action plan on air quality management; National/provincial plan on air quality management (newly enacted in LEP 2020); - Establishment of ambient air quality standards; - Monitoring of ambient air quality; - Assessment of ambient air assimilative capacity; - Management of emission gas: quantity/quality; - Technical guidance/requirements on emission gas management: treatment and monitoring; - Establishment of emission gas standards from manufacturing facilities, incinerators; - Cooperate with MOT to develop roadmap for application of quality standards on emission from motor vehicles; - Pollution sources inventory and registration; - Monitoring of emission gas: quantity/quality; - Issuance of emission discharge permit (integrated in the certificate of completion of environmental protection works, the certificate of eligibility for environmental protection in import of scrap for use as raw production materials, or the license for hazardous waste treatment); - Pollution control of emission gas from craft villages (overlapped with MARD, MOIT)
Ministry of Science and Technology (MOST)	- Conduct appraisal of standards (QCVNs) prepared by MONRE and MOT; - Establishment of quality standards for fuel used in vehicles
Ministry of Agriculture and Rural Development (MARD)	- Control of emission gas from agriculture activities (cultivation, animal husbandry) and rural area; - Control of emission gas from craft villages (overlapped with MONRE, MOIT)
Ministry of Industry and Trade (MOIT)	- Management of environmental protection in industrial sectors, including industrial emission gas; - Implementation of cleaner production strategy; - Implementation of energy conservation programs, energy audit; - Planning of renewable energy development, instead of coal power; - Handling of severe polluted industrial entities; - Management of industrial clusters of handicrafts (overlapped with MONRE, MARD)
Ministry of	- Establishment of emission gas quality standards from vehicles (moved to

Ministries/ Agencies	Key responsibilities/roles
Transportation (MOT)	MONRE after LEP 2020); - Control of emission from vehicles; - Policy on encouragement of environmental-friendly vehicles

Source: JICA Survey team

<Local level (Hanoi City)>

The Local People's Commission is required to formulate a provintial air quality management plan in addition to the local environmental protection plan in accordance with the provisions of LEP (2020). The provintial air quality management plan should include assessment of air quality, monitoring, identification of causes of air pollution, scope and solutions of air quality management and implementation system.

In Hanoi City, as support for air quality control conducted by the Region People's Committees, the Hanoi DONRE (Department of Natural Resources and Environment) has been conducting air quality monitoring, control on air quality violations, air pollution countermeasures, and evaluation of environmental impact assessment reports. In addition, DONRE is obliged to report to the Region People's Commission and MONRE in accordance with the provisions of legislations. The Hanoi DONRE organizes HEPA (Hanoi Environmental Protection Agency) and it practically carries out pollution control and air monitoring activities. Below are key facts findings from interviews with HEPA.

- ✓ The Hanoi DONRE is in the process of formulating the Hanoi Air Quality Management Plan for five years and will be finalized in 2022.
- ✓ The use of honeycomb briquettes related to measures against indoor air pollution was prohibited in 2019. Since some people still use the honeycomb briquettes in the city, penal provisions will be established in 2022.
- ✓ In 2020, Hanoi DONRE has been allocated 100 million VNDs to air quality management.
- ✓ Plans are being made to relocate concentrated manufacturing plants to rural areas, but mechanisms to support enterprises' relocation to rural areas have not been developed and are not in progress.
- ✓ There is a plan of relocation of industrial production facilities that cause serious environmental pollution, but it doesn’t work smoothly. Mechanisms and policies to support businesses to relocate are currently in the process of being developed, not yet issued.
- ✓ Some of the issues are limitation of human resources for air quality management in the localities and limitation of professional capacities. The management of air quality requires inter-regional and inter-provincial coordination, However, the coordination between relevant units/ agencies have not been synchronized and effective.

3) Countermeasures on air environment

(iii) Ambient air quality and emission standards

In Vietnam, ambient air quality and various emission gas standards are stipulated in the National Technical Regulations (QCVN). (See Figure 4-). Ambient air quality standards are shown inFigure 4-14; $PM_{2.5}$ was newly added when QCVN was revised in 2009.

Table 4-13 Major Standards for Air Quality Management in Vietnam (National Technical Regulations)

Category	Criteria	Overview
Air quality standards	QCVN 05:2013/BTNMT	Air quality standards
	QCVN 06:2009/BTNM	Maximum permissible concentration standards for hazardous substances in the air environment
Industrial exhaust gas standards	QCVN 19:2009/BTNMT	Industrial exhaust gas standards (dust and inorganic substances)
	QCVN 20:2009/BTNMT	Standards for Industrial Exhaust Gas (Organic Substances)
	QCVN 21:2009/BTNMT	Industrial exhaust gas standards (chemical fertilizer manufacturing industry)
	QCVN 22:2009/BTNMT	Industrial Exhaust Gas Standards (Thermal Power Plants)
	QCVN 34:2010/BTNMT	Industrial exhaust gas standards (inorganic substances and dust in the refining and petrochemical industries)
	QCVN 41:2011/BTNMT	Emission standards from the cement manufacturing industry
	QCVN 51:2017/BTNMT	Emission standards from the steel industry
Exhaust Gas Standards for Waste Disposal	QCVN 61-MT:2016/BTNMT	Standard for exhaust gas from municipal waste incinerators
	QCVN 30:2012/BTNMT	Exhaust gas standards from industrial waste incinerators
	QCVN 02:2012/BTNMT	Standards for exhaust gas from solid medical waste
Exhaust gas standards for vehicles	QCVN 01:2009/BKHCN	Quality standards for gasoline, diesel, and biofuels
	QCVN 86:2015/BGTVT	Regulation of gaseous pollutant emissions from vehicles manufactured and imported

Source: JICA Survey team

Table 4-14 Ambient Air Quality Standard in Vietnam

No.	Factor	Average value per hour [µg/m^3]	Average value per 8 hours [µg/m^3]	Average value per 24 hours [µg/m^3]	Average value per year [µg/m^3]
1	SO_2	350	-	125	50
2	CO	30,000	10,000	-	-
3	NO_2	200	-	100	40
4	O_3	200	120	-	-
5	TSP	300	-	200	100
6	PM_{10}	-	-	150	50
7	$PM_{2.5}$	-	-	50	25
8	Lead	-	-	1.5	0.5
Notes: "-" means Not Regulated					

Source : QCVN 05:2013/BTNMT

(iv) Point Source Management

Point source of Industries

As described above, for the industrial source, the exhaust gas standard from the chimney of the plant is regulated by QCVN. In 2019, the installation of automated exhaust gas monitoring equipment was mandated for facilities that generate a large amount of exhaust gas (11 industrial sectors including glass, steel, cement, and thermal power plants) regulated in No.40/2019/ND-CP,

and these facilities should submit the monitoring data to the DONRE. Penalties for failure to comply with environmental impact assessments and environmental conservation plans are stipulated in 2016 (No.155/2016/ND-CP, Decree 55/2021/ND-CP).

On the other hand, factories engaged in recycling activities in the informal sector called Kraft Village are scattered in suburban and rural areas, and they tend to discharge exhaust gas to the outside without appropriate treatment by using old-style technology, which generate air pollution surrounding environment.

Emission from Mobile Source

For emission from automobiles, Vietnamese government has issued the Decision No. 249/2005/QD-TTg in 2005 stipulating the roadmap for application of emission standards to road motor vehicles, and then updated it in 2011 and 2016, in which emission standards were set as follows.

- Newly manufactured, assembled and imported: Euro 4 (from 2017 to 2021) and Euro 5 (from 1st Jan 2022)
- [motorcycles] Newly manufactured, assembled and imported: Euro 3
- Import used automobiles: Euro 4
- Emission standards for cars participating in traffic: Euro 1 (for car manufactured before 1999), Euro 2 (for car manufactured since 1999 up to present)

For inspection of automobiles, MOT (Ministry of Transport) has issued the Circular No. 16/2021 on regulations on technical safety inspection and environmental protection for automobiles. Based on vehicle type and year of manufacture, each type of car will have a different inspection cycle (from 6 months to 18 months). In addition, one of the inspection steps is the measurement of emissions (CO, HC).

Open burning of agricultural residue

In Hanoi City, air pollution caused by open buring of agricultural residue (straw) is one of the issues particularly in June and August. The revised LEPs (2020) contain provisions concerning the prohibition of the burning of agriculture residue. In addition, Directive No.15/CT-UBND was enacted by Hanoi city People's committee on strengthening state management measures for illegal burning of straw, crop by-products and other waste in order to minimize negative impacts on the city's environment. However, open buring has still been reported to be seen especially in rural areas in the suburbs of Hanoi City. [20]

Household fuel consumption

Because air pollution (indoor air pollution) caused by honeycomb briquettes, which were widely used as fuels in ordinary households, and increased respiratory diseases caused by such pollution

[20] https://en.vietnamplus.vn/hanoi-suffers-alarming-air-pollution-because-of-straw-burning/215524.vnp

became social problems, Hanoi City established a provision Directive No.15/CT-UBND on replacement and eradication of the use of honeycomb coal as fuel in daily life and business services in order to minimize negative impacts on the city's environment in 2019.

Until the end of 2020, the government had been supporting the transition to alternative fuels that are considered safe and environmentally friendly for households and supporting honeycomb briquette manufacturers. However since 2021, the government has established penalties for manufacturing and use of honeycomb briquettes.

4) Donor Support for Air Quality Management

Table 4- shows donor supports for air quality control administration targeting Vietnam and Hanoi City so far. Currently, with MONRE as the counterpart, USAID has conducted a project for improving the air environment through a diversified stakeholder network. At the same time, USAID signed MOUs on climate change with MONRE in February 2022 to provide support through the resolution of both issues.

Table 4-15 Donor Supports for Air Quality Management in Hanoi/Vietnam

Year	Donor	Budget	Project name	Overview
2006-2008	the Swiss Agency for Development and Co-operation (SDC - Switzerland)	2,734,000 USD	Swiss-Vietnamese Clean Air Programme (SVCAP)	Support for the policy reform and building a database for MONRE/DONRE, etc.
2013-2015	JICA	997,140 USD	The Project for Institutional Development of Air Quality Management in Vietnam	Strengthening Air Environment Administration (VEA/MONRE), Support for revision of LEPs, Preparatoin of a roadmap for air quality management, human resource development, etc.
2017-2020	German Federal Ministry for the Environment	2,920,687 Euro	Integrated Air Quality Management and Climate Change Mitigation within the framework of the World Bank's Pollution Management and Environmental Health (PMEH) Programme	Including expanding the air quality monitoring network in Hanoi, establishing emissions inventories, and updating the online information platform, Support for revision of LEPs in MONRE Support the expansion of urban monitoring networks in Hanoi, establishment of emission inventories, update of online information platforms, Support of MONRE to revise the LEP
2019-2022	USAID	1,400,000 USD	Collective Action for Clean Air	Support for building networks among diverse stakeholders to improve air pollution measures and related health issues, with MONRE as a counterpart

Source: JICA Survey team

5) Environemntal Incidents

Table 4- summarizes the major environmental incidents happened iin Hanoi City or in Vietnam.

Table 4-16 Environmental Incidents happened in Hanoi/Vietnam

Year	Environmental Incidents	Description
2008	Vedan environmental accident (Thi Vai River Pollution) [1)]	In the southern province of Donnai, it was reported that the Thi Vai river was polluted as the Vedan plant continued to dump hazardous wastes into the river for many years. It has also been reported that fisheries became impossible due to water pollution, and respiratory and intestinal diseases of local residents increased. 47 industrial areas are located in the Tivi River Basin, and many other businesses are illegally dumping waste without proper waste disposal. However, illegal dumping cannot be solved because of the small amount of penalty paid by the businesses rather than the investment for proper waste disposal.
2016	Formosa fish massive death [2)]	In April 2016, a large amount of fish died at 200km along the coast of five provinces; it was reported that 140 tons of fish and 67 tons of shellfish died. Damage to humans such as direct effects on fisheries due to reduced fishing catches, poisoning due to eating caught fish, and skin irritation were also reported. The cause was confirmed to be the discharge of illegal effluent containing chemicals from the neighboring Folmosa Company. In June 2016, Formosa pledged to the Government and Vietnamese people for apologies, compensation of US$500 million (about ¥51 billion), and measures to prevent a recurrence.
2016	Air polluting [3)] from the Vinh Tan 2 thermal power plant	Air pollution became a problem caused by exhaust gas from the Vinh Tan 2 thermal power plant in Binh Thuan Province, located in South Central part of Vietnam. In response, the state People's Commission established a working group, investors established and responded to more precise environmental technologies.
2019 - 2021	Air pollution in Hanoi	Air pollution due to straw burning especially between June and August in the rural area of Hanoi City became a problem. Therefore, in 2020, Hanoi People's Commission issued Directive No. 15, which prohibited the burning of straw and agricultural by-products from January 1, 2021. In addition, the deterioration of air pollution caused by $PM_{2.5}$ in Hanoi City and the health damage to the residences, increase of numbers of respiratory diseases have also become social problems. Responding to that, the government prohibited using honeycomb briquettes and started to support the residents for their fuel change.

Note:
1) http://www.ipsnews.net/2008/12/environment-vietnam-river-pollution-scandal-a-wake-up-call/
2) https://hcmcpv.org.vn/tin-tuc/xu-ly-su-co-formosa-la-bai-hoc-quan-trong-cho-cac-dia-phuong-1491844972
3) http://english.vietnamnet.vn/fms/environment/150834/vinh-tan-power-plant-still-polluting-residential-areas.html
Source: JICA Survey team

4.2.3.2. Relevant Data Collection

1) Air Quality Monitoring at Air Quality Monitoring Stations

Table 4- shows the air quality monitoring stations under the jurisdiction of DONRE and MONRE in Hanoi, and their locations are shown in Figure 4-9. shows. In Hanoi City, Viet Nam Meteorological and Hydrological Administration (VNMHA) under the MONRE has been observing SO_2, NO_2, CO, and $PM_{2.5}$ since 2004 (No. 12 and No. 13 in the table below) for the purpose of observing meteorological and hydrological data. In addition, SO_2, NOx, CO, NO, PM_{10} and $PM_{2.5}$ have been observed at the observation stations of Northern Center for Environmental Monitoring (NCEM) under VEA since 2007 by the Decision No 16/2007 /QĐ -TTg.

In addition, in 2016, Hanoi City established and started to operate 10 continuous automatic air quality monitoring stations, including two fixed stations and eight sensor stations (No. 1 to No. 10 in the table below). The monitoring items of fixed stations are PM_{10}, $PM_{2.5}$, NOx, CO, O_3, SO_2, and

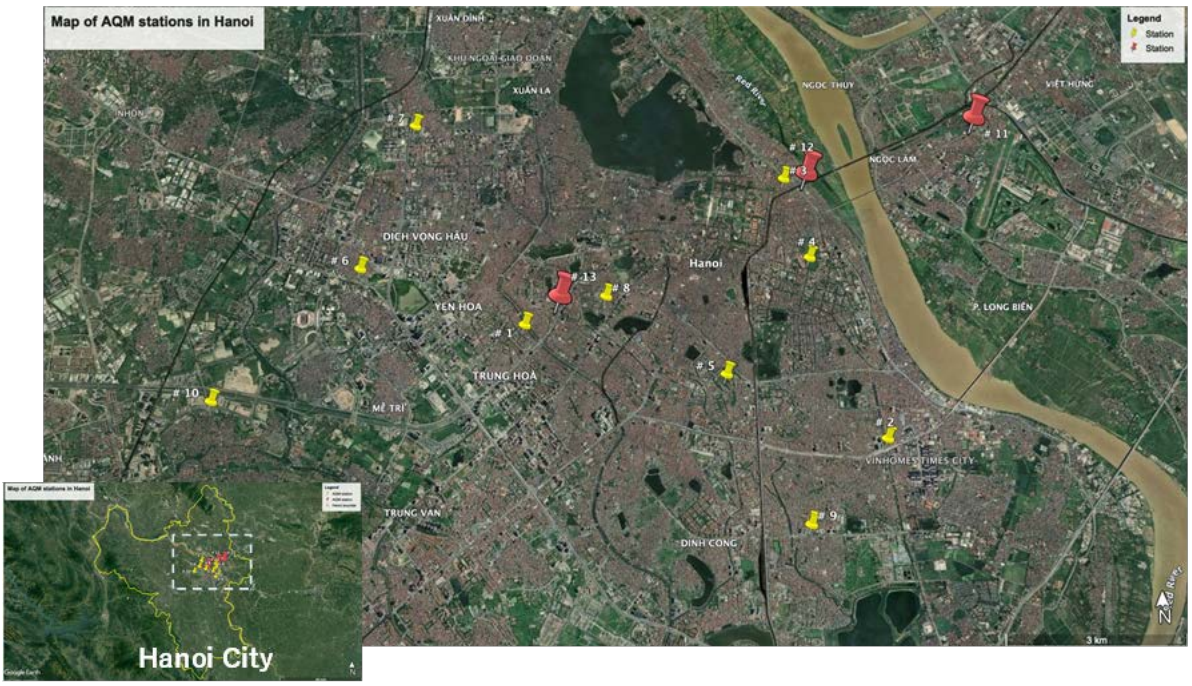
meteorological parameters (barometric pressure, temperature, humidity, and wind direction). On the other hand, the sensor station measures $PM_{10,}$ $PM_{2.5}$, CO, NO_2 and meteorological parameters.

As of May 2020, there were a total of 35 automated air quality monitoring sensor stations in Hanoi City, and since 2018 the Hanoi City DONRE has published hourly PM_{10}, $PM_{2.5}$, NO_2 concentrations and AQI indices, and daily mean temperatures and humidities on its website (https://moitruongthudo.vn/).

Table 4-17 Air Quality Monitoring Stations in Hanoi（Supervised by DONRE, MONRE）

No.	AQMS	SO_2	NOx	NO_2	O_3	CO	NO	CH_4	PM_{10}	$PM_{2.5}$	type	Management /Operation agency	Monitoring period
1	Trung Yen 3 Street	✓	✓	✓	✓	✓	✓		✓	✓	Station	DONRE/ HEPA	2017～
2	Minh Khai Ward	✓	✓	✓	✓	✓	✓		✓	✓	Station	DONRE/ HEPA	2017～
3	Hang Dau					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
4	Hoan Kiem District Police Headquarters - Trụ sở CAQ Hoàn Kiếm					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
5	Kim Lien Preschool - Mầm non Kim Liên					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
6	My Dinh					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
7	Pham Van Dong					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
8	Building near Thanh Cong lake					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
9	Tan Mai					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
10	Tay Mo					✓	✓		✓	✓	Monitoring sensor only	DONRE/ HEPA	2017～
11	Northern Environmental Monitoring Center - Nguyen Van Cu	✓	✓		✓	✓			✓	✓	Station	MONRE/ VEA/NCEM	2007～
12	Hanoi Hydrological and Environmental Station	✓		✓	✓	✓	✓	✓	✓	✓	Meteorological and Envi. Station	MONRE/ VNMHA	2004～
13	Lang - Hanoi Station	✓		✓	✓	✓	✓	✓	✓		Meteorological and Envi. Station	MONRE/ VNMHA	2004～

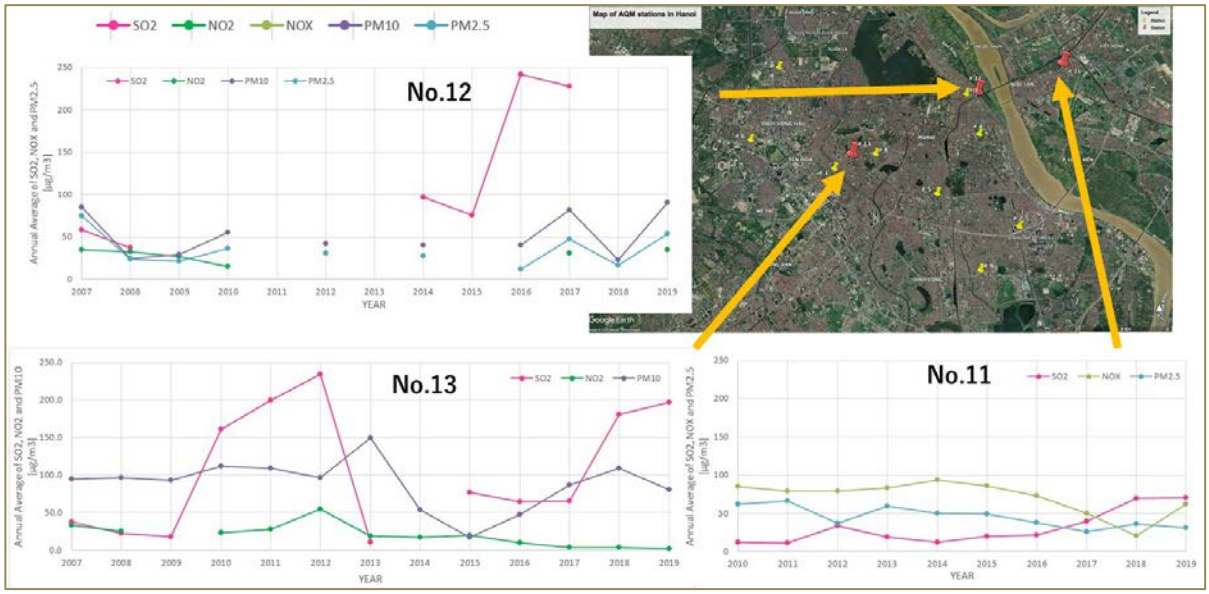
Source: JICA Survey team



Note: Each of Figure in the map correspond to each of the monitoring stations in Table 4-17.
Source: JICA Survey team

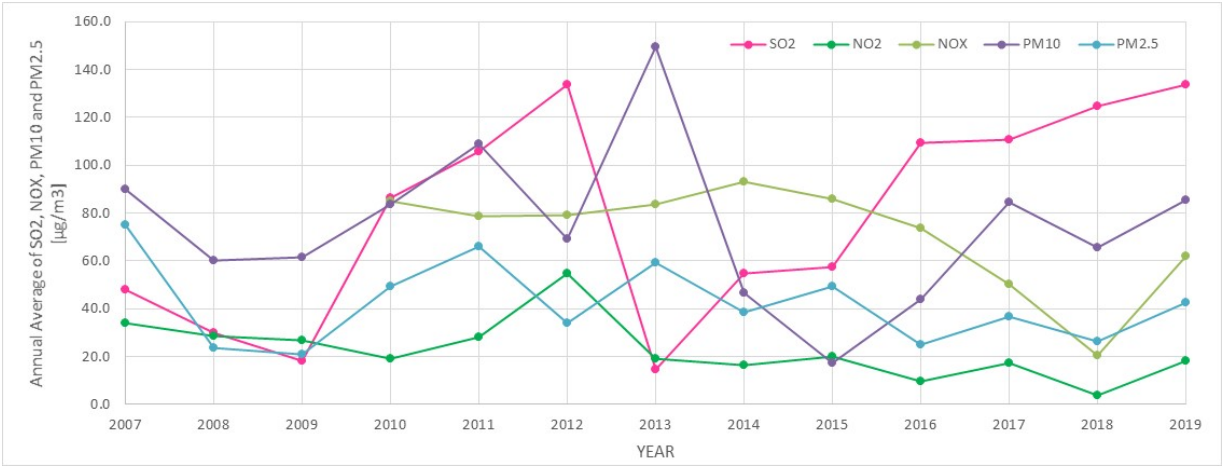
Figure 4-9 Air Quality Monitoring Stations (under the jurisdiction of DONRE, MONRE) in Hanoi City

Figure 4-11 shows the changes in the annual average of air quality monitoring data observed at the air monitoring stations No.11 to 13, which were available for acquiring the relatively long-term data in this survey, while Figure 4-11 shows the changes in the average of the three stations. The air quality values observed at the station No.13 located near the center of Hanoi City are generally high, while the values observed at the station No.11 located slightly away from the center tends to be lower than that of other stations. The values of SO_2 has been on an increasing trend in recent years for all three stations, while the values of NO_x and NO_2 have been on a slight decreasing trend since 2012-2014. On the other hand, there isn't a tendency for improvement of annual average values of $PM_{2.5}$.



Source: JICA Survey team

Figure 4-10 Annual Average Change in Air Quality at Three Monitoring Stations in Hanoi City



Source: JICA Survey team

Figure 4-11 Annual Average of Air Quality in Hanoi City (2007-2019, SO_2, NO_2, NOx, PM_{10}, $PM_{2.5}$)

2) Socio-Economic Data

Table 4- shows the major socio-economic data collected in this survey. In this survey, indicators were mainly collected that could be explanatory variables for the air environment administration and the air environment situation. Some indicators that could not be collected in the city level were collected at the national level.

Table 4-18 Collected Major Socio-Economic Data (Hanoi City, Vietnam)

Data and contents	Year	Area covered by data	Data Source
Population	1990-2020	Hanoi (All 63	General Statistics Office[1)]

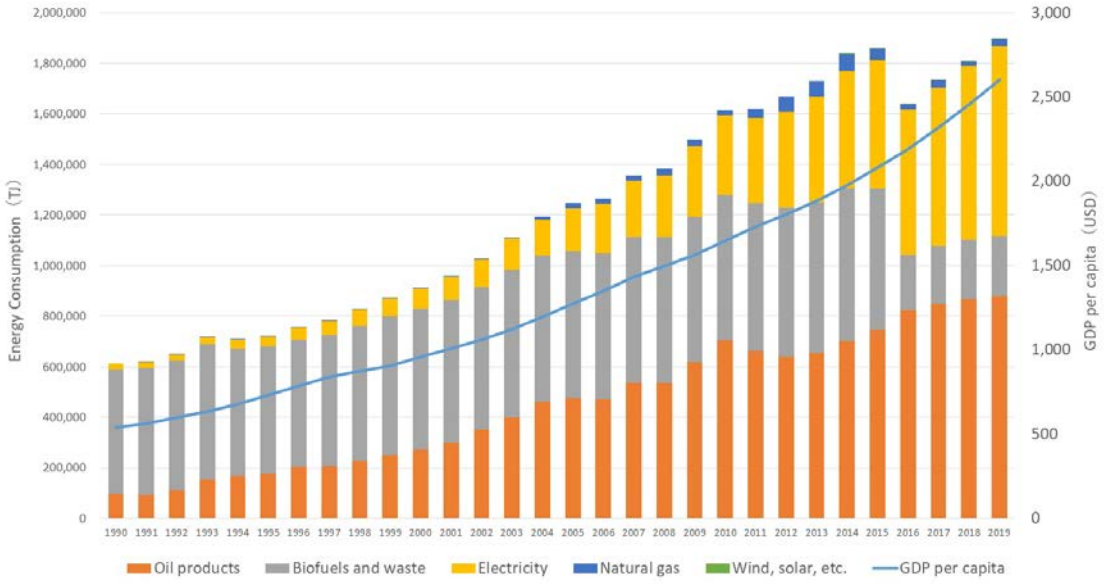
Data and contents	Year	Area covered by data	Data Source
		province)	
Population Density	2004-2020	Hanoi (All 63 province)	
GRDP at constant price	1990-2020	Hanoi	General Statistics Office of Ha Noi[4)]
Land use (Agricultural production land Forestry land, Specially used land, Homestead land)	2000, 2003, 2006-2009, 2011, 2013-2018	Hanoi (All 63 province)	General Statistics Office[1)]
Energy consumption by sectors (Industry, Transsport, Residential, Commercial and public services, Agriculture/forestry, Non-energy use)	1999-2019	National	IEA[6)]
Energy consumption by sources (coal, oil products, biofuels and waste, electricity, natural gas, wind/solar/etc.)	1999-2019	National	IEA[6)]
Industrial structure (Index of industrial production by industrial activity)	2014-2020	Hanoi	General Statistics Office of Ha Noi, Ho Chi Minh, Hai Phong, Da Nang, Can Tho[4)]
Number of registered vehicles (Total number of cars in traffic/ circulation, Total number of newly manufactured and assembled cars, Total number of imported cars inspected, Total number of newly manufactured and assembled motorcycles)	2016-2021 (monthly)	National level	Vietnam Register[3)]
GHG emissions of the country	1994, 2000, 2010, 2014, 2016	National	Reports of Vietnam to the UN framework convention on climate change
Direct Investemt amount (Foregin direct investment projects licensed)	1988-2020 2000-2020	National/Province	General Statistics Office[1)]
Literacy rate	2006, 2010 - 2020	Hanoi (All 63 province)	General Statistics Office[1)]
Mortality rate of children under 5 years old	2010, 2012 - 2020	Hanoi (All 63 province)	General Statistics Office[1)]
Life expectancy	2005, 2009 - 2020	All six provinces	General Statistics Office[1)]

Note: The websites of the sources are as follows;

1) General Statistic Office: https://www.gso.gov.vn/en/statistical-data/
2) Key energy consumption: https://vepg.vn/legal_doc/pm-decision-1577-qd-ttg-on-the-issuance-of-the-list-of-designated-energy-users-2019/
3) Vietnam Register: http://www.vr.org.vn/thong-ke/Pages/tong-hop-so-lieu-phuong-tien-giao-thong-trong-ca-nuoc.aspx
4) General Statistics Office of Ha Noi, Ho Chi Minh, Hai Phong, Da Nang, Can Tho:
http://thongkehanoi.gov.vn/
https://thongkehaiphong.gov.vn/
http://www.thongkecantho.gov.vn/
https://cucthongke.danang.gov.vn/
http://www.pso.hochiminhcity.gov.vn/web/guest/home;jsessionid=E709DB114E14855E31E11185CBEA2B28
5) Key energy consumption 2020: https://vepg.vn/legal_doc/pm-decision-1577-qd-ttg-on-the-issuance-of-the-list-of-designated-energy-users-2019/
6) Data and Statistics, International https://www.iea.org/data-and-statistics/data-browser/?country=WORLD&fuel=Energy%20consumption&indicator=CO2Industry

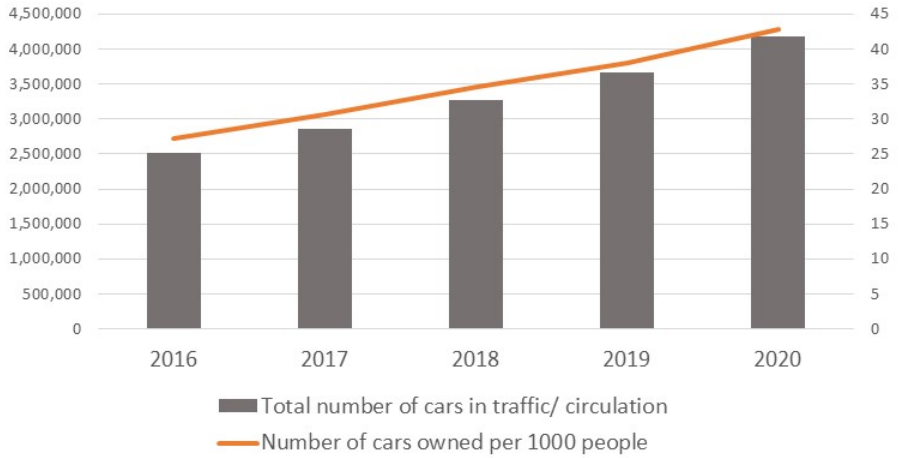
Source: JICA Survey team

Economic activities have been expanding in Vietnam, and the GDP growth rate has been maintained at an annual average of about 6.5% since 2000. In Hanoi City, GRDP has grown at an annual rate of about 11% since 2010. Figure 4-12, Figure 4-13, and Figure 4-14 show changes in GDP per capita and energy consumption by fuel, total number of cars and number of cars per 1000 people, and changes in GHG emissions in Vietnam respectively as indices related to air pollution.



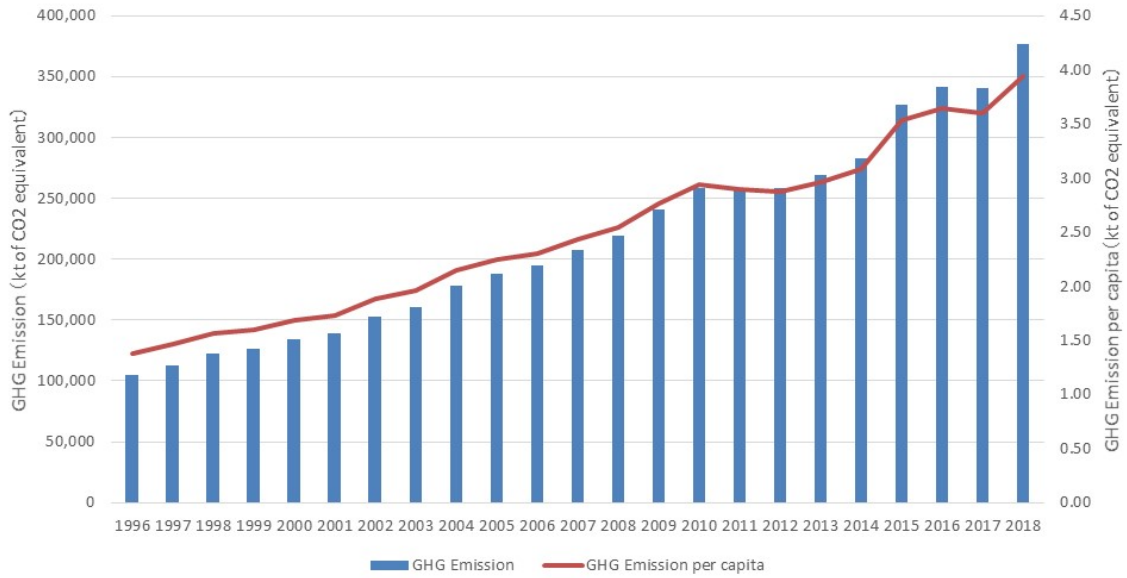
Source: Prepared by the JICA survey team based on published data (General Statistics Office of Vietnam)

Figure 4-12 Energy Consumption by Fuel and GDP per capita in Vietnam (1990-2019)



Source: Prepared by the JICA survey team based on published data (Vietnam Register)

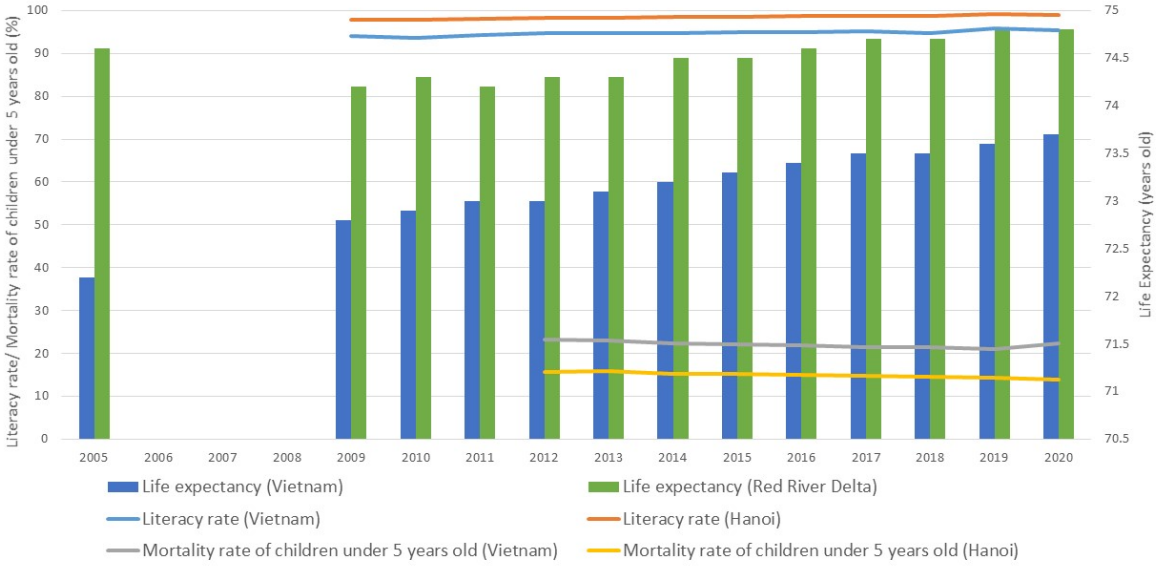
Figure 4-13 Total Number of Cars in traffic and Number of Cars per 1000 people in Vietnam (2016-2020)



Source: JICA Survey team

Figure 4-14 GHG emissions (1996-2018)

Figure 4-15 shows the changes of literacy rate, mortality rate of children under 5 years old, and life expectancy at birth, which were collected to assess the maturity of society. Since 2005, the average life expectancy in Hanoi has increased by 0.2 years and the mortality rate has decreased by 1.6%; there has been no significant change.



Source: JICA Survey team

Figure 4-15 Changes in Literacy Rate, Mortality Rate of Children under 5 years old, and Life Expectancy at Birth (Hanoi, Vietnam)

4.2.4. Serbia

(a) Laws on Environment

The main laws related to air quality management are as follows.

The Law on Environmental Protection, enacted in 1991, was the first law on environmental protection in Serbia. After the upheavals associated with democratization, the formation of Serbia's current environmental protection system began with the approval of a new law on environmental protection in 2004. This law was amended in 2009 to include a law dedicated to individual environmental issues (Law on Air Protection). At the same time, EU directives were transposed into domestic laws in light of the EU Stabilization and Association Process, which was underway with the aim of EU accession in the future.

Law	Link to the Law (Serbian)
Law on Air Protection ("Official Gazette of RS ", No. 36/2009, 10/2013 and 26/2021)	https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/skupstina/zakon/2009/36/8
The Climate Change Act ("Official Gazette of RS ", No. 26/2021)	https://www.propisi.net/zakon-o-klimatskim-promenama/
Law on Confirmation of Protocols on Long-Term Organic Polluting Substances with the Convention on Cross-Border Air Pollution over long distances from 1979. Year ("Official Gazette of RS - International Agreements", No. 1/2012)	http://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/mu/skupstina/zakon/2012/1/16/reg
Law on Confirmation of Heavy Metal Protocols with the Convention on Cross-Border Air Pollution at long distances from 1979. ("Official Gazette of RS - International Agreements", No. 1/2012)	https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/mu/skupstina/zakon/2012/1/17/reg

(b) Administrative Organization on Environment

The major agencies involved in air quality administration include the following.

Ministry of Environmental Protection (MEP)	The Department of Air and Ozone Layer Protection is responsible for air quality monitoring, planning and managing the implementation of the Air Quality Control Programme, and approvement of companies that measure emissions of air pollutants. It supervises the work of the Air Agency, autonomous province, local autonomous regions, and authorized corporations.
Serbian Environmental Protection Agency (SEPA)	SEPA is part of the MEP and is responsible for the following tasks - Development and management of the national information system for environmental protection - Implementation of air quality monitoring, management of national laboratories, and collection and processing of environmental data. - Preparation of reports on the state of the environment and the implementation of environmental protection policies - Cooperation with the European Environment Agency (EEA) and the European Information and Observation Network (EIONET)
Autonomous Province of Vojvodina and local self-government unit	Autonomous province and local self-governing bodies are responsible for air quality monitoring within their jurisdiction as defined in the law of Air Protection. For the purpose of air quality monitoring, autonomous Province of Vojvodina and local self-government units are obliged to establish a local network of supplementary measuring stations and measuring points as necessary, and to provide measured air quality data to SEPA.

City of Belgrade - Secretariat for Environmental Protection	The Secretariat of Environmental Protection of the City of Belgrade provides a plan for air quality monitoring, which will be agreed upon by the Ministry of Environmental Protection. The budget of the implementation of the Air quality management program in Belgrade is provided from the city. In accordance with the legal provisions, the Secretariat coordinates all activities of the local monitoring network. In order to perform this task, the city of Belgrade needs to authorize the competent institutions/legal entities to perform the measurements, which is the responsibility of the Institute of Public Health of Belgrade. Secretariat for Environmental Protection of Belgrade is legally responsible to publish air monitoring data and to submit them to SEPA. One or more pollutants exceed their limit values in Belgrade city for a long period of time. As the air quality in Belgrade is evaluated as "Excessively Polluted", the Secretariat for Environmental Protection of the City of Belgrade is obliged to prepare an air quality plan. The latest plan "the Belgrade Air Quality Plan for 2021-2023" and monthly air quality report are published on the SEPA website (Only in Serbian language).
City of Belgrade - Institute for Public Health	The Institute for Public Health has been conducting air quality management for more than 30 years at 30 sites (including 8 automatic monitoring stations) in cooperation with the Environmental Protection Secretariat of Belgrade and with MEP in other regions. The data from the AQMSs in Belgrade are aggregated and the hourly AQI (CAQI developed by the EU, the European Regional Development Fund, and the Regional Initiatives Project) is calculated and published. The institute prepares and submits monthly reports based on air quality data in Belgrade to the Belgrade City Environmental Protection Secretariat.

In addition, there is no specific agency for monitoring emission sources, but operators are required to monitor emissions and report the data to SEPA. Operators are obliged to establish emission reduction plans from stationary sources in order to take measures to reduce air pollution, install technological solutions, and secure emission reduction costs.

The environmental inspectors of the MEP supervise the inspection for the implementation of the Air Protection Law and its Enforcement Decree.

The autonomous Province of Vojvodina and local self-government units are entrusted with the task of inspecting and supervising the implementation of air pollution control measures in facilities for which their respective competent authorities have issued construction/use permits. MEP website [21] provides information on permits for air quality monitoring and measurement of emissions from stationary sources, the list of legal entities authorized to perform measurement services, and rules on measurement of emissions of air pollutants from stationary sources.

(c) Air Quality Standard, Emission Standard

Limit values for air quality standards are specified in the Law on Air Protection adopted in 2009. The limit values are based on the EU directive, but they are gradually strengthened by setting additional permissible limits for about 10 years after the enactment.

[21] https://www.ekologija.gov.rs/dozvole-obrasci/zastita-vazduha-i-ozonskog-omotaca

Table 4-19 Changes on Air Quality Standards in Serbia

Загађујућа материја, μg/m³	Период усредњавања	ГВ (граничнa вредност)	Не сме да буде прекорачена више од X пута у календарској години	ТВ, Толерантна вредност (ГВ + граница толеранције)	2012.	2013.	2014.	2015.	2016.	2017.	2018.	2019.	Доња граница оцењивања	Горња граница оцењивања
Сумпор диоксид (SO_2)	1 h	350	24 x	500	470	440	410	380	350	350	350	350	-	-
	24 h	125	3 x	125									50	75
	календарска година	50	-	50									-	-
Азот-диоксид (NO_2)	1 h	150	18 x	225	217.5	210	202.5	195	187.5	180	172.5	165	75	105
	24 h	85	-	125	121	117	113	109	105	101	97	93	-	-
	календарска година	40	-	60	58	56	54	52	50	48	46	44	26	32
Суспендоване честице PM_{10}	24 h	50	35 x	75	70	65	60	55	50	50	50	50	25	35
	календарска година	40	-	48	46.4	44.8	43.2	41.6	40	40	40	40	20	28
Суспендоване честице $PM_{2.5}$	календарска година	25	-	30	30	29.3	28.5	27.8	27.1	26.4	25.7	25	12.5	17.5
Озон (O_3)	8 h max	120	25 x у години у току 3 године											
Угљен-моноксид (CO)	8 h max	10000	-	16000	14800	13600	12400	11200	10000	10000	10000	10000	5000	7000
	24 h	5000	-	10000	9000	8000	7000	6000	5000	5000	5000	5000	-	-
	календарска година	3000	-	-										
Олово (Pb)	24 h	1	-	1									-	-
	календарска година	0,5	-	1	0.9	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.25	0.35
Бензен (C_6H_6)	календарска година	5	-	8	7	6.5	6	5.5	5	5	5	5	2	

The results of air quality monitoring measurements are collected and stored at SEPA, in accordance with the Law on Air Protection of the Republic of Serbia and its implementing regulations. SEPA assesses air quality in Zones and Agglomeration according to these results and the criteria described in the Law on Air Protection.

Reference methods have been established to measure the concentrations of Sulfur dioxide, Nitrogen dioxide, Nitrogen oxides, Suspended particles, Lead, Benzene, Carbon monoxide, and ground-level Ozone.

(d) Air Quality Monitoring

SEPA is responsible for the operation of the automatic air quality monitoring system in the Republic of Serbia.

Monitoring results are published in real time on websites of SEPA [22] and of the European Environment Agency (EPA) [23]. SEPA also issues and publishes annual reports on the state of air quality. Air quality monitoring in Belgrade is carried out within a local network managed by the Municipal Institute of Public Health at 35 stations under contract with the Secretariat of Environmental Protection. Data on the state of air quality in Belgrade can be obtained through an application available on the city's website (http://www.beoeko.com/).

(e) Emission Inventory

The Republic of Serbia presents emissions of air pollutants for the period 1990-2019 every five

[22] http://www.amskv.sepa.gov.rs/stanicepodaci.php
[23] https://aqportal.discomap.eea.europa.eu/products/data-viewers/utd-viewer/

years in the Informative Inventory Report to the LRTAP Convention conducted by the Environmental Protection Agency. The methodology used to calculate the emissions in the inventory follows the EMEP/EEA Emissions Inventory Guidebook 2019.

Although the data itself was not available, emissions from crop burning (category 3.F) and open burning (category 5.C.2) are not calculated because they are regulated by law and there is no official information on these activities according to the summary report. Many categories are estimated based on Tier 1 method of the inventory guidebook, which is a relatively rough estimate.

(f) Emission Control and Regulation

Industrial Emission Sources

The Environmental Protection Law stipulates the establishment and maintenance of a National Register of Pollution Source and a Local Register of Pollution Source. The national registration has been implemented by SEPA since 2010, and the subject facilities have reported annually through an online platform.

The Local Register of Pollution Source is under the jurisdiction of the competent authorities of local governments, and not all local governments have established such a registry. The registry in the city of Belgrade is not fully functional yet. According to the information obtained from the Environmental Protection Secretariat of Belgrade, the main problem is non-existence of an adequate enforcing instrument. The secretariat of environmental sector and the secretariat of inspections (including environmental inspection) are separate, and the secretariat operating inspections does not have sufficient skill or knowledge of air pollution control management.. Because of this reason environmental inspectors are not controlling if the operators are fulfilling their duties in respect to reporting to the Local register.

The Industrial Emissions Directive (2010/75 / EU) is an important EU regulation that regulates air emissions for all relevant industrial sectors, including conditions defining the scope of application for companies and permissive concentrations of pollutants per activity.

The Industrial Emissions Directive (2010/75/EU) is a key EU regulation regulating air emissions for all relevant industry sectors, including conditions defining the coverage of companies and permitted concentrations of pollutants by activity. Serbia has partially harmonized its national legislation with the provisions of this directive, but due to limited capacities and still unfinished legislative framework, their implementation in practice is very slow. Chapter 2 of the Industrial Emissions Directive has been transposed into the domestic regulatory framework by the Law on Integrated Pollution Prevention and Control - Law on Integrated Prevention and Control of Environmental Pollution (IPPC law). The Ministry of Environmental Protection has prepared a preliminary list of facilities subject to the issuance of an integrated permit, which includes a total of 227 facilities. The permit conditions including emission limit values (ELVs) must be based on the Best Available Techniques (BAT).

The MEP has a database of references on BAT, but data on the actual extent of its use is still being collected and is not yet available to the public. 46 out of 227 covered factories, are operating without the required operation permits.

Vehicle Emission

The import of used cars is regulated by the "Regulation on the import of used cars". It is estimated that about 120,000 cars are imported into Serbia annually, and these cars meet the regulations above EURO 3. The average age of registered cars is around 15 years, almost double the EU average of just under 8 years.

For automotive fuels, the Sulfur content of liquid fuels is regulated in "the Rulebook on Technical and Other Requirements for Liquid Fuels of Petroleum Origin". The sulfur content of heavy oil is reduced from 3% to a maximum of 1% since 2021, while the Sulfur content of diesel oil is set at 0.1% and that of Euro Diesel at 10 ppm.

As for new vehicle regulations, buses and heavy-duty vehicles produced in Serbia, they will be subject to standards of at least EURO 4 (buses assembled in Serbia will be subject to standards of EURO 5 at least).

Open burning of Agricultural waste, Field Burning

The Law on Fire Protection prohibits burning fires in the forest and at a distance of 200 meters from the forest, as well as burning the remains of small crops, burning garbage in the open and burning plant remains. This law has had several amendments since 2009 ("Official Gazette of RS" No. 111/2009, 20/2015, 87/2018 and 87/2018).

Households

Emission limits for air pollutants are specified for small combustion facilities that produce heat for household heating or water purification and whose heat input is less than 1 MWth when using solid fuels, less than 5 MWth when using liquid fuels, and less than 10 MWth when using gaseous fuels.

In Serbia, the National Statistical Office has stopped monitoring the number of households with stoves and wood-burning stoves, even though they are the most commonly used heating devices, as about 60% of households use solid fuels for heating.

In Belgrade, about 270,000 households are connected to the central heating, but according to the statistics office, the largest sources of heat are coal, fuel oil, gas, and firewood consumption. Many households without central heating (about 210,000) consume the most electricity, firewood, and coal.

(g) Planning and implementation of Air Pollution Control Measures

Procedures for the preparation of policy and action plans for air quality management are defined through Rulebook on the Content of Short-Term Action Plans ("Official Gazette of RS", No.

65/2010 [24]). Agglomerations and cities that have third-category air quality air (excessively polluted air) have a legal obligation to enact an Air Quality Plan. Belgrade Air Quality Plan (2021-2031) was published in 2021 (only in Serbian Language), which includes AERMOD simulation modeling, and estimation of air pollution structure through UNMIX Model by EPA. Based on these analysis, the following measures to reduce air pollution in Belgrade city area in 2021-2031 are recommended: Upgrading of public transportation and other vehicles, Upgrading of emission reduction equipment in power plants, and abolition of heating boilers.

The "District Energy in Cities Initiative" lead by UNEP has launched a three-year project titled "Increasing Investment in Urban District Heating Energy Systems - SEforAll Energy Efficiency Accelerator". Belgrade has been selected as one of the four pilot cities. The project for improving district heating systems mainly aims at providing support to the city of Belgrade and the utility company "Belgrade Power Plant" for modernization and expansion of the district heating.

4.2.5. Mexico

(a) Laws on Environment

Information on laws and regulations related to air quality and individual laws in the Federal District was collected. The following is an excerpt of collected list of laws.

General Laws	
General Law on Ecological Balance and Environmental Protection (LGEEPA)	Prevention and control of air pollution is discussed in Chapter 4, Section 2, which sets forth the government's authority in three levels.
General Law on Health	Regulates the right to health protection that every person has under the terms of article 4 of the CPEUM, establishes the bases and modalities for access to health services and the concurrence of the Federation and the federative entities in matters of general health. The Law establishes the powers of the environmental and health authorities related to the protection of human health against risks and damages dependent on environmental conditions. It also establishes the powers of the Federal Commission for the Protection against Sanitary Risks (COFEPRIS) regarding the effects of the environment on health, occupational health, hazardous waste, basic sanitation, and accidents involving toxic and dangerous substances, or radiation.
Regulation of the LGEEPA on the Registry of Emissions and Transfer of Pollutants (2004)	It regulates the Registry of Emissions and Transfer of Pollutants (RETC) in terms of its integration, operation, dissemination and updating. Also, it establishes the obligated subjects to report.
Local laws	
Environmental Law on the Protection of Land in the Federal District (2000)	It regulates the emission of pollutants from stationary and mobile sources, and open burning. It grants faculties to the SEDEMA, and the local governments in matter of prevention and control of atmospheric contamination.
Regulation of the Environmental Law on Protection of the Land in the Federal District, in the Matter of Vehicle	It contains the provisions regarding vehicle verification in Mexico City, the operation of verification centers, verification programs, as well as the obligations of automobile owners. Likewise, it grants powers to SEDEMA regarding vehicular verification.

[24] https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/ministarstva/pravilnik/2010/65/2/reg

Verification (2012)	

(b) Administrative Organization on Environment

The major agencies involved in air quality administration include the following.

The Secretariat of Environment and Natural Resources (**SEMARNAT**)	The Secretariat of Environment and Natural Resources is the principal responsible body for defining the national environmental policies and regulations. In regards to air quality, it is responsible for defining the policies at the national level and for establishing the national strategy for air quality. It also defines the laws, regulations, and standards that are the reference framework for air pollution control. Through the General Directorate of Air Quality and Pollutant Emissions, and Transfer Registry (DGGCARETC), it is responsible for coordinating the development of Air Quality Improvement Programs for each of the country's state, as well as responsible for the registry of emissions and transfer of pollutants.
The Federal Attorney for Environmental Protection (**PROFEPA**)	PROFEPA, a decentralized body of SEMARNAT, is in charge of compliance and enforcement according to the related environmental laws, as it is the General Law on Ecological Balance and Environmental Protection (LGEEPA, is its acronym in Spanish), in addition to being responsible for verifying compliance with the conditions established in a large number of concessions, licenses, authorizations and permits.
The Security, Energy and Environment Agency (**ASEA**)	ASEA is a decentralized administrative body of SEMARNAT that regulates and oversees industrial safety, operational safety, and environmental protection related to activities in the oil and gas sector.
The National Institute of Ecology and Climate Change (**INECC**)	INECC is a research organization of the Mexican State that generates and integrates technical and scientific research on ecology and climate change, to support decision-making.
The Environmental Commission of the Megalopolis (**CAMe**)	CAMe is a political coordination body constituted on August 23, 2013, through a Coordination Agreement between the Federal Government via the Ministry of Environment and Natural Resources and the Governments of the Federal District, State of Mexico, Hidalgo, Morelos, Puebla and Tlaxcala, in order to carry out the planning and execution of actions in terms of environmental protection, preservation and restoration of the ecological balance in the region that extends to 16 Delegations of the Federal District, and 224 municipalities in total between the State of Mexico, Hidalgo, Morelos, Puebla and Tlaxcala.
The Secretariat of Environment of Mexico City (**SEDEMA**)	SEDEMA works on the agenda focused on five priority areas for the protection of the environment and to promote sustainable development, with clear goals and actions for the sound use of the natural resources and a new environmental governance that allows investment, maintaining and proper management of natural resources. One of the topics in the agenda is air quality and climate change.
Mexico City's Environmental and Land Use Attorney (**PAOT**)	PAOT is a decentralized public body of the Public Administration. Its purpose is to defend the rights of the inhabitants of Mexico City to enjoy an adequate environment for their development, health, and well-being, through the promotion and monitoring of compliance with the legal provisions on environmental matters and land use planning.
Secretariat of Environment of the State of Mexico (**SMA**)	SMA's objective is to plan, coordinate, direct and evaluate matters related to the state policy in terms of environmental protection and preservation of the ecological balance in the State.
The Environmental Protection Attorney of the State of Mexico (**PROPAEM**)	PROPAEM's purpose is to guarantee to people the right to live in an environment suitable for their development, health and well-being, through the procurement, surveillance and dissemination of compliance with the environmental regulations applicable at the state level, as established by the

	Decree of the State Executive by which the Decentralized Body called the Office of the Attorney for the Protection of the Environment of the State of Mexico is transformed into a Decentralized Public Body.
Institute of Energy and Climate Change of the State of Mexico (**IEECC**)	IEECC is a decentralized public body, with its own legal personality and assets, is divided from the Secretariat of the Environment, and its aim is to promote the strengthening of institutional and sectoral capacities to face climate change, through the development of scientific and technological research on climate change, energy efficiency and renewable energies within the scope of the State competence.

According to the General Law on Ecological Balance and Environmental Protection, the federal government through SEMARNAT is responsible for the attention of 11 sectors of industrial sources. The state governments, through their environmental agencies, is responsible for the other industries and service sources.

Local governments and municipalities are responsible for monitoring the compliance of pollution sources under their jurisdiction with emission limits and designating areas for the establishment of fixed sources.

For the Mexico City Metropolitan Area (MCMA), the responsible agencies are SEDEMA and SMA.

(c) Air Quality Standard, Emission Standard

Air Quality Standard

As for the ambient air quality standards, the technical standards were established in 1993, followed by the standard values in 1994. Subsequently, O_3, PM_{10}, and $PM_{2.5}$ were added in 2014. The standards have been revised some time since then, including revision of SO_2 standard in 2019.
Mexico's air quality standards are based on guidelines from the World Health Organization (WHO). These guidelines advice on thresholds and limits for major air pollutants that cause health risks. The table below compares Mexico's current air quality standards with the WHO guidelines.

Pollutant	NOM limit	WHO Guidelines	Period
PM_{10}	75 µg/m^3	15 µg/m^3	Daily
	40 µg/m^3	5 µg/m^3	Annual
$PM_{2.5}$	45 µg/m^3	45 µg/m^3	Daily
	12 µg/m^3	15 µg/m^3	Annual
O_3	0.095 ppm	60 µg/m^3 *	1 hour
	0.070 ppm	100 µg/m^3	8 hours
NO_2	395 µg/m^3	---	1 hour
	---	25 µg/m^3	Daily
	---	10 µg/m^3	Annual
SO_2	524 µg/m^3	---	8 hours
	288 µg/m^3	40 µg/m^3	Daily

	66 µg/m^3	---	Annual
CO	12,595 µg/m^3	4 mg/m^3	8 hours
Pb	1.5 µg/m^3	---	Quarterly

Vehicle Emission Standards

The Norma Oficial Mexicana (NOM) for the period 2003-2018, which defines the maximum permissible limit (MPL) for pollutant emissions of new vehicles, has been collected.

The regulation of imported vehicles were initially published in 2011 and have been revised in 2020. Regulations on environmental protection are set forth in NOM-041-SEMARNAT-2015 [25], which stipulates MPLs for HC, CO, O_2 and NOx in the exhaust gas.

On the other hand, the quality standards for fuels including gasoline and diesel for automobiles are specified in NOM-016-CRE-2016 [26].

(d) Air Quality Monitoring

The Air Quality Monitoring System (SIMAT) is responsible for permanent measurement of the main air pollutants and evaluation of compliance with the Official Mexican Standards (NOM) for environmental health in Mexico City and the metropolitan area. In operational terms, the SIMAT is made up of four subsystems (RAMA, REDMA, REDMET and REDDA), a laboratory for the physicochemical sampling analysis (LAA) and a data processing and dissemination center (CICA).

The Automatic Atmospheric Monitoring Network (RAMA)	***RAMA*** *uses continuous equipment for the measurement of sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, PM_{10} and $PM_{2.5}$. It integrates 34 monitoring stations and has a laboratory for the maintenance and calibration of the monitoring equipment.*
The Atmospheric Monitoring Manual Network (REDMA)	***REDMA*** *is responsible for collecting suspended particulate matter samples for gravimetric analysis and the determination of heavy metals, mainly lead. This network comprises 10 sites and uses manual equipment for sampling that takes place once every six days.*
The Solar Meteorology and Radiation Network (REDMET)	***REDMET*** *works along with 26 sites with continuous equipment for measuring the main surface meteorological variables: temperature, relative humidity, wind direction and speed, solar radiation, and barometric pressure.*
The Atmospheric Deposit Network (REDDA)	***REDDA*** *uses semi-automatic equipment to collect samples of dry deposit (sedimentable dust) and wet deposit (rain, hail, snow, dew) at 16 sampling sites. A physicochemical analysis is carried out on the wet deposit samples to find the physical characteristics of the precipitation, its ionic composition and acidity. Sampling is done once every seven days.*
The Environmental Analysis Laboratory (LAA)	***LAA*** *is responsible for the physicochemical analysis of the samples collected by different monitoring networks. It performs elemental analysis, gas chromatography, gravimetry and the study of aerosols.*
The Air Quality Information Center (CICA)	***CICA*** *is the repository of all the data generated by the Atmospheric Monitoring System, it is responsible for validation, processing and dissemination of the information generated by the monitoring program.*

[25] http://dof.gob.mx/nota_detalle.php?codigo=5396063&fecha=10/06/2015
[26] http://www.dof.gob.mx/nota_detalle.php?codigo=5450011&fecha=29/08/2016

(e) Emission Inventory

SEMARNAT has implemented an Information Subsystem of the National Inventory of Criteria Pollutant Emissions (SIINEM [27]). SIINEM is a continuously updated tool, which is aimed for the public and specialized users for the dissemination and consultation of INEM results. These consultations can be carried out spatially, graphic, or tabular, at the National, State, Metropolitan or Municipal Zone level, by pollutant and emission source of criteria pollutants. The inventory for MCMA was first established in 1996 and has been updated roughly every two years since.

(f) Emission Control and Regulation

Industrial Emission Sources

The General Law on Ecological Balance and Environmental Protection (LGEEPA) establishes the authority of each jurisdiction (federal, state, and local) for air quality management.

- Country: Prevention and control of air pollution generated by stationary and mobile sources that are not under federal jurisdiction and function as industrial facilities.
- Local governments: apply legal provisions for the prevention and control of air pollution generated from fixed and mobile sources that are not under federal jurisdiction and that function as business or service facilities. The state government participates in this process in accordance with the state law.
- Country: Stationary and mobile sources that are not under federal jurisdiction and function as industrial facilities

(g) Planning and implementation of Air Pollution Control Measures

PROAIRE

The programs to improve air quality and reduce emissions of pollutants (PROAIRE [28]) are instruments that establish measures and actions in the short, medium, and long term, to prevent and reverse the trends of deterioration of air quality in a specific region or federal entity. PROAIRE is applied to large cities where air pollution problem is most serious due to population, industrial activity, car ownership, and climatic and geographic conditions. It is means of establishing short-, medium-, and long-term measures and actions to improve air quality in designated areas and federal agencies.

The PROAIRE-ZMVM [29] for the Metropolitan Zone of the Valley of Mexico (ZMVM) has been prepared for the period 2021-2030 and includes 18 measures targeting multiple sectors. The research agenda includes modeling of the formation process of O_3 and $PM_{2.5}$ secondary pollution, updating the representativeness and accuracy of VOC Speciation in emission inventories, and toxicological and epidemiological studies on health effects. The following points are emphasized as measures.

[27] https://gisviewer.semarnat.gob.mx/wmaplicacion/inem/
[28] https://www.gob.mx/semarnat/acciones-y-programas/programas-de-gestion-para-mejorar-la-calidad-del-aire
[29] https://www.gob.mx/cms/uploads/attachment/file/671178/Proaire_CDMX.pdf

- *Reduce pollutants emitted by the industrial sector through the establishment and updating of regulatory measures and the use of emission control technologies.*
- *Reduce emissions associated with the generation, transmission, and distribution of electrical energy. Reduce emissions of particulate matter, NOx, and black carbon pollutants associated with the generation of electrical energy through the creation of regulatory measures and the use of emission control technologies.*
- *Improve solid waste management and reduce emissions from this sector. Reduce the amount of solid waste sent to final disposal sites and reduce pollutant gas emissions through treatment and the use of new technologies.*
- *Improve environmental monitoring. Improve air quality monitoring related to concentrations of regulated pollutants and photochemical smog precursors in the ZMVM.*
- *Reduce emissions from road traffic. Reduce emissions of particles generated by vehicular traffic on paved and unpaved roads.*

4.3. Correlation between socioeconomic development, changes in air quality management system and air pollution status

In order to analyze qualitatively the effects of the measures, the history of the introduction of measures, the establishment of environmental management systems, and trends in air quality conditions were compared using historical data of air pollution levels over time.

4.3.1. Egypt

Efforts in Egypt began with the enactment of the Air Protection Act in 1994 and the reorganization of the EEAA, and AQMSs were introduced with the support of Denmark (DANIDA) in 1996-1999. The network of AQMSs has been steadily expanding since then. On the other hand, there were some difficulties in obtaining data, for example air quality monitoring data was not officially published for the period 2006-2012 and the emission inventory information was not available.

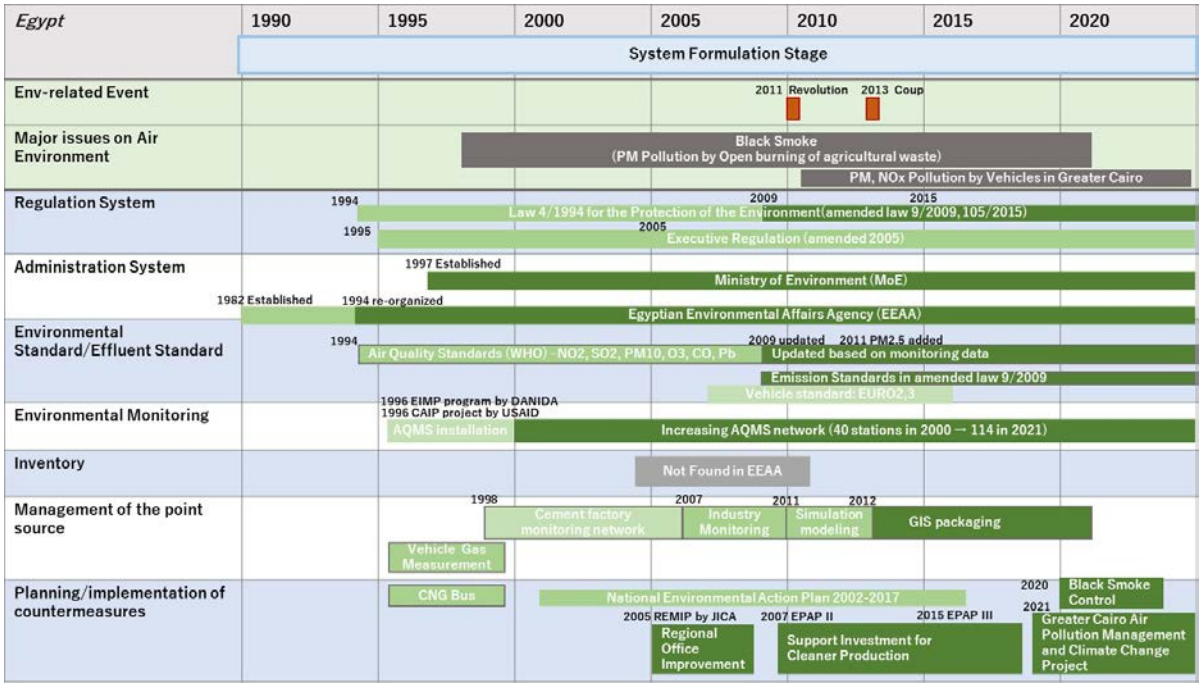
Details of each air pollution control measure was also not available. One of the reasons for this was that we were not able to prepare all the official letters necessary to collect information during this short survey period, as the ministries with jurisdiction were diverse by industry.

Together with the start of industrial source monitoring in 2007, the decline in SO_2 and NOx in ambient air from 2007 to 2013 can be attributed largely to industrial source control measures.

On the other hand, the trend of PM_{10} is remaining high. It has been reported that black smoke from burning of agricultural residues has been a continuing problem rather than the industrial sources, and that the impact of automobiles in the Cairo metropolitan area has been significant. These issues are currently in focus.

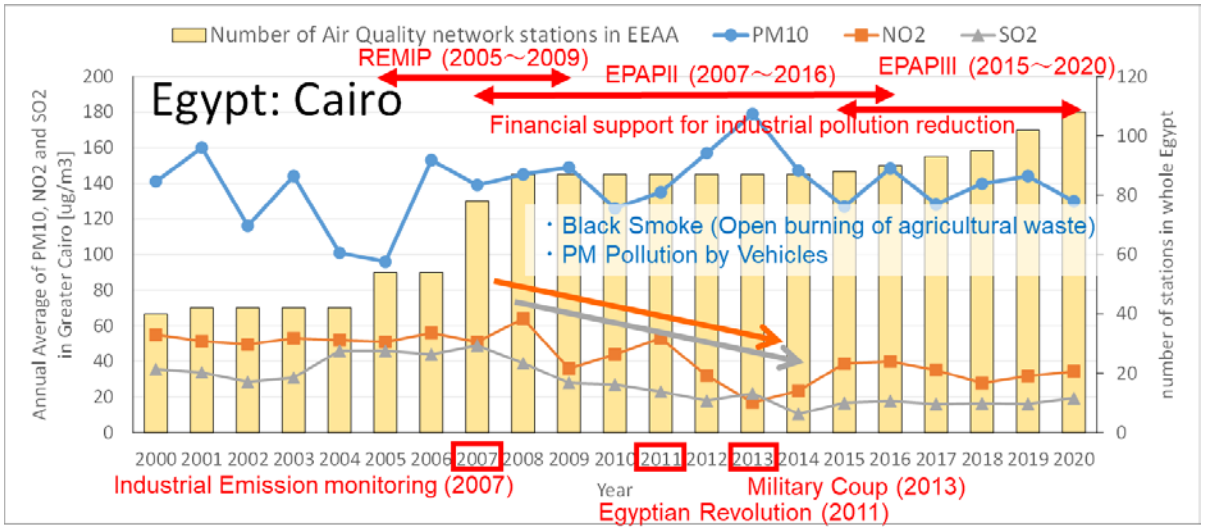
In the 1st stage of the study, Egypt was placed in Group A, which is a group of countries with rapidly rising $PM_{2.5}$ levels and where air pollution is deteriorating. Pollution associated with primary industries, such as burning of agricultural waste, is becoming a problem in Egypt, which is consistent with the characteristics of this group. On the other hand, although the concentration of PM_{10} remains high, there is no clear trend of increase in recent years, including that of NO_2 and SO_2. One reason for this may be that 2011, the year of the Egyptian revolution, was chosen as the base year for comparison in the first stage. Also, the monitoring of $PM_{2.5}$ was still limited and may

have represented a biased situation. One of the characteristics of this group was that they had a limited air quality monitoring system. In order to understand the status of air pollution, it is necessary to understand the long-term trends of multiple pollutants as much as possible, and to verify the reliability of the monitoring system.



Source: JICA Survey team

Figure 4-16 History of Air quality management in Egypt



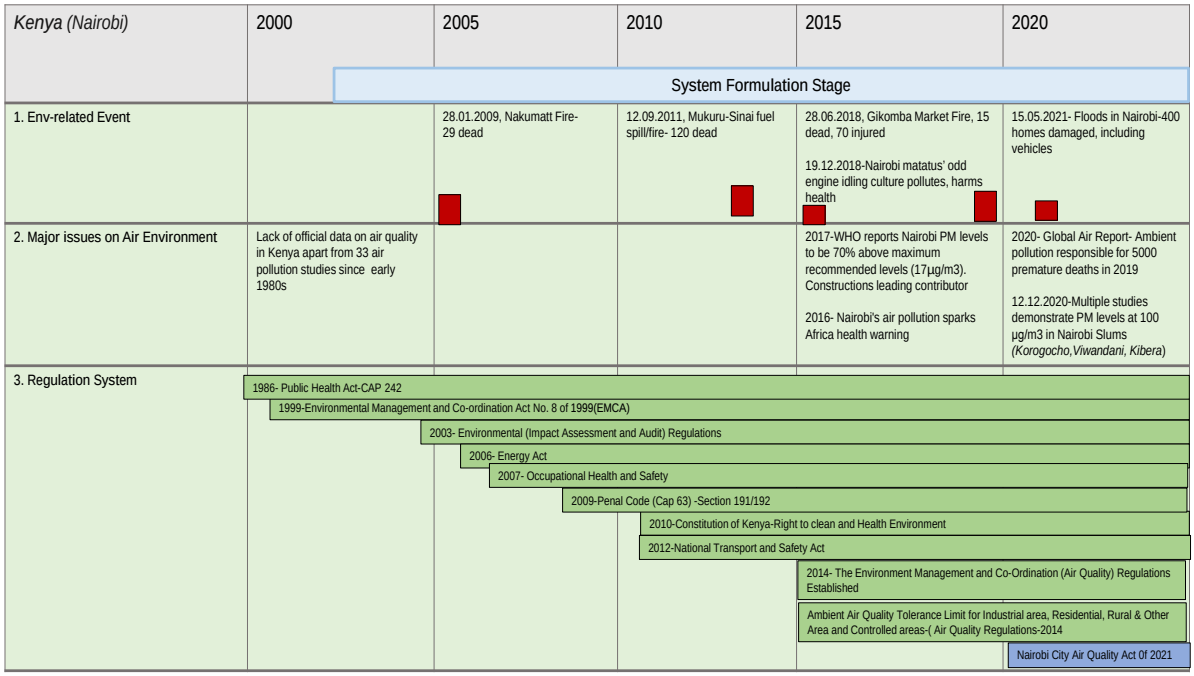
Source: JICA Survey team

Figure 4-17 Changes in air quality and related events in Egypt

4.3.2. Kenya

The figures below compare the transition of the air quality management administration in Kenyaand the changes in the air quality in Nairobi during the same period.

Continuous ambient air quality monitoring started from 2014, however, the quality and quantity of data are not enough. Therefore, it can be said that Kenya is in the process of System Formulation Stage.



Green: Activity of Kenya, Blue: Actibity of Nairobi, and Orange: Activity of Donors, etc.
Source: JICA Survey team

Figure 4-18 Transition of Air Quality Management Administration in in Kenya

4.3.3. Vietnam

Figure 4-19 and Figure 4-20 compare the transition of the air quality management administration in Vietnam and the changes in the air quality in Hanoi during the same period.

In Vietnam, basic contents of regulation on air pollution were stipulated in the Law on Environmental Protection, when it was amended in 2005. The environmental standards and exhaust gas standards were established in 2005 and 2009 respectively and have been successively updated since then. In 2015, companies were obliged to install continuous monitoring systems and report them to MONRE for factories of more than a certain size in industries with high exhaust gas emissions, and penalties were introduced in 2016. On the other hand, MONRE/DONRE just started air environment monitoring in 2018, and the exhaust gas inventory has not been established yet. (In Hanoi City, an exhaust gas inventory is planned to be created in 2022 together with the air quality management plan.)

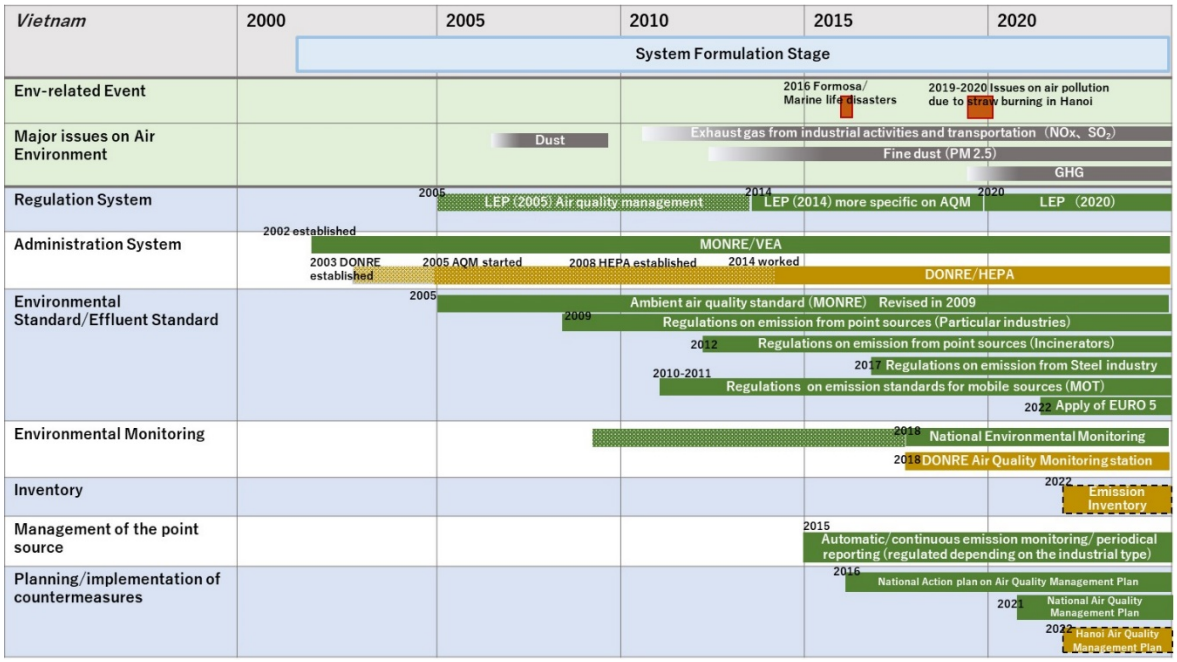
In the first stage survey, Vietnam was positioned as Group C “start taking countermeasures”. As mentioned above, the framework of the basic legal system, the air administration organization, and the air environment and emission standards have already been introduced in Vietnam, while the air quality monitoring system is on the development process since 2018 and the inventory hasn’t been introduced yet. Therefore it can be said that Vietnam is in the process of System Formulation Stage.

Looking at the situation of change in air pollution, although the data collected in this survey is limited, the annual average concentration of NO_2 has been on a slight decrease since 2012-2014, while the annual average concentration of SO_2 has been on an upward trend after it decreased sharply in 2012-2013. Since the annual average concentration of $PM_{2.5}$ does not show any improvement trend, the effect on air pollution improvement was not observed.

One of the reasons can be the expansion of economic activities in Hanoi City (growth rate of GRDP is about 11%) including an increase in the number of automobiles owned (average annual growth rate of 13.5%) and an increase in fossil fuel consumption. In addition, although regulations such as mandatory installion of automatic air quality monitering and reporting of the monitoring data for the factories of more than a certain size in industries have been established, there is a possibility that there are some issues on the performance capability of the governmental agencies for execution of these regulations. Furthermore, despite the prohibition of the use of honeycomb briquettes as household fuel and open burning of straw and agricultural by-product, they are still being done in Hanoi; Raising awareness of residents and strengthening crackdowns are issues in Hanoi City. In order to solve these issues, it is an urgent task to investigate the cause of the air pollution by expanding air quality monitoring system, collecting and analyzing reliable data and building the emission inventory for formulation of concrete measures.

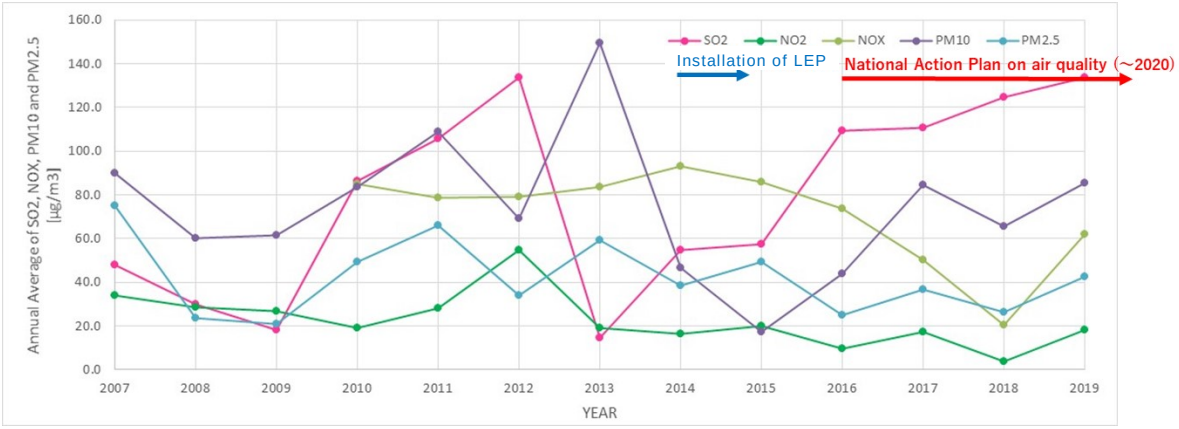
JICA has implemented the Project for Institutional Development of Air Quality Management in the Socialist Republic of Vietnam (2013-2015). The project aimed to support the development of legal system, including amendments to the Law on Environmental Protection, and to propose a roadmap for the formulation of the Air Quality Control Plan. As a result, the Environmental Protection Law was amended in 2015 and a new section on air quality protection was established.

However, it was found that the division of responsibilities of organizations related to air quality management was unclear and that there were issues in implementing the system. Also, the motivation to take action for air quality management was low, since air pollution control was not prioritized compared to waste and wastewater control. In the interviews conducted in this survey, it was also mentioned that the enactment of relevant laws and regulations is insufficient, pollution control measures are not functioning effectively, and the lack of budget and the need to strengthen the capacity of staff, especially for air quality monitoring, as remaining issues, suggesting that air pollution control measures have not been prioritized yet.



Source: JICA Survey team

Figure 4-19 Transition of Air Quality Management Administration in Vietnam



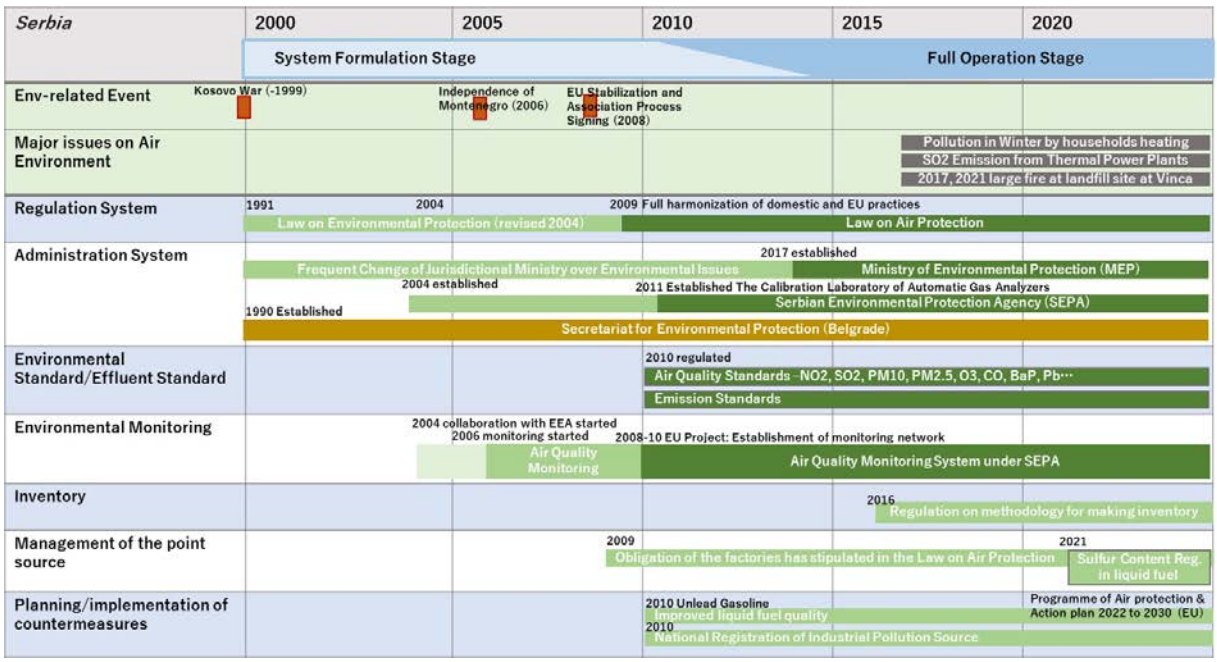
Source: JICA Survey team

Figure 4-20 Change in Air Quality in Hanoi and Relevant Events in Vietnam

4.3.4. Serbia

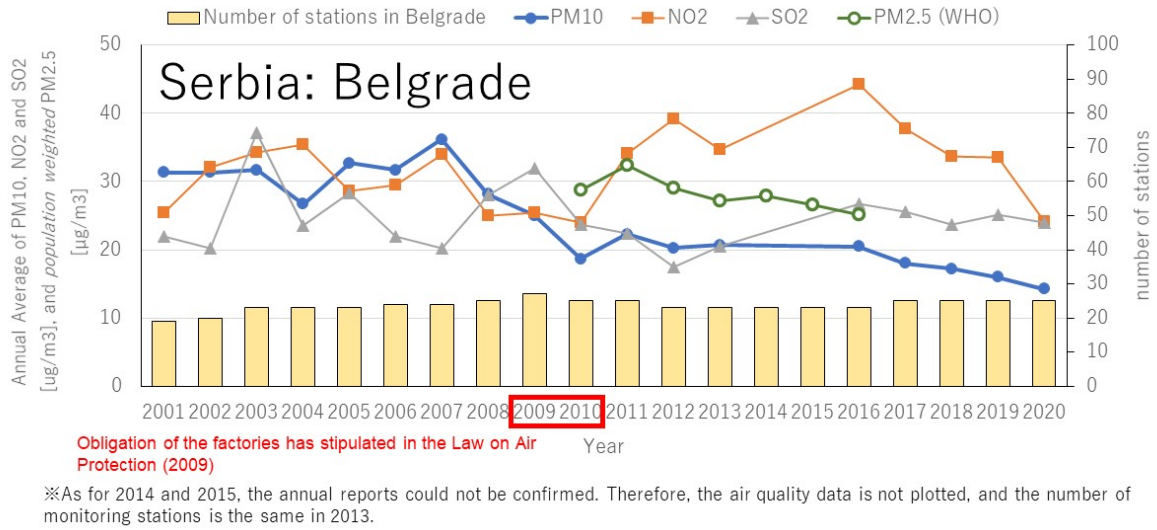
Serbia took the opportunity of becoming a candidate country for EU membership to develop the air quality management system to meet EU standards rapidly from around 2010, rather than necessity to take measures against air pollution. It is assumed that this is a common situation in this region. On the other hand, although there are laws and regulations in place, the accumulation of actual data such as emission inventory is still insufficient, and it is believed that there are issues with practicality of the system.

In the 1st stage of the survey, Serbia was placed in Group D (Countries with a reduction of $PM_{2.5}$). Same as other Balkan countries, the annual average $PM_{2.5}$ exposure levels are relatively low, and the PM_{10} monitoring data supports this too. However, it turned out that pollution by PM was frequently reported and was a problem in the region. The reason for this is thought to be that the air pollution in Belgrade is caused by PM generated through combustion of wood, biomass, coal, etc. for house heating, and the pollution season is limited. It should be noted that this kind of seasonal pollution may be overlooked in the analysis using annual average values only.



Source: JICA Survey team

Figure 4-21 History of Air quality management in Serbia



※As for 2014 and 2015, the annual reports could not be confirmed. Therefore, the air quality data is not plotted, and the number of monitoring stations is the same in 2013.

Source: JICA Survey team

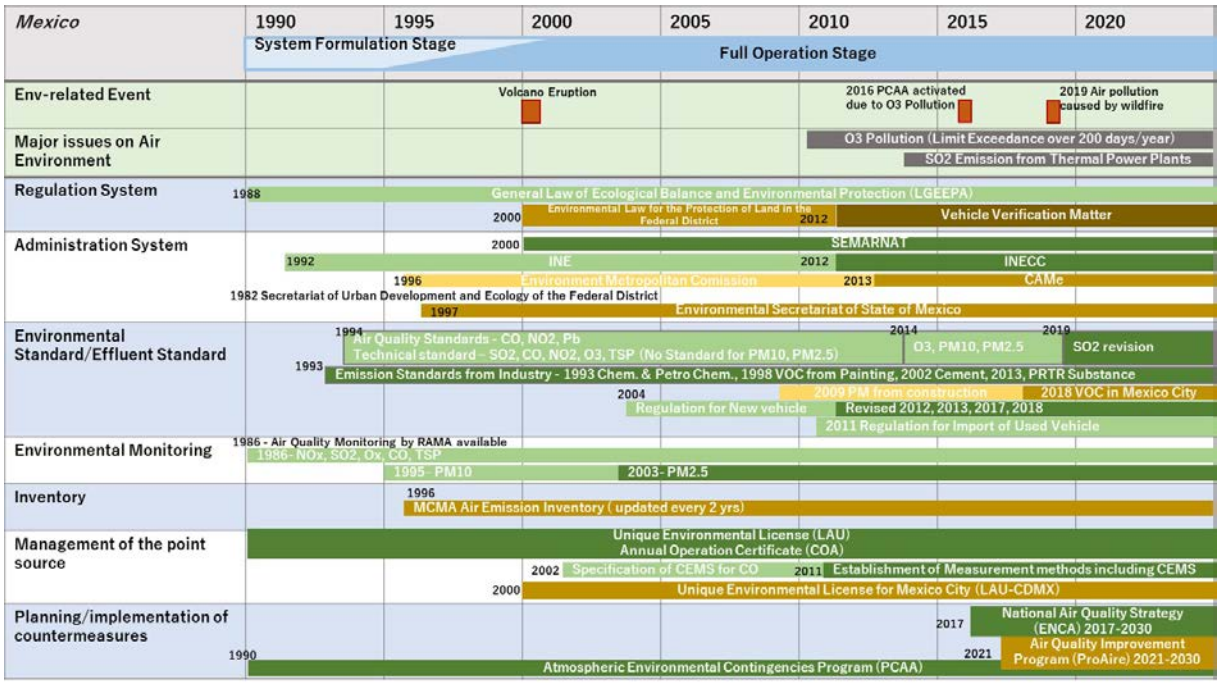
Figure 4-22 Changes in air quality and related events in Serbia

4.3.5. Mexico

In Mexico, the development of air quality management system began in as early as the 80s and 90s, and after the establishment of air quality standards in 1994, SEMARNAT was established in 2000, indicating that a certain level of development has been achieved in almost all sectors. JICA supported the development of the first air pollution control plan in the MCMA through the Study on Air Pollution Control Plan in the Federal District (1986-1988), and subsequently supported the development of emission control from stationary sources (1990-1995), air quality monitoring (2006-2008), as well as joint study on ozone formation mechanisms (2011-2015) (see Table 4-21). All of these projects seem to be carried out at the appropriate time according to the issues at that time, contributing to the full development of Mexico's air quality management in every fields.

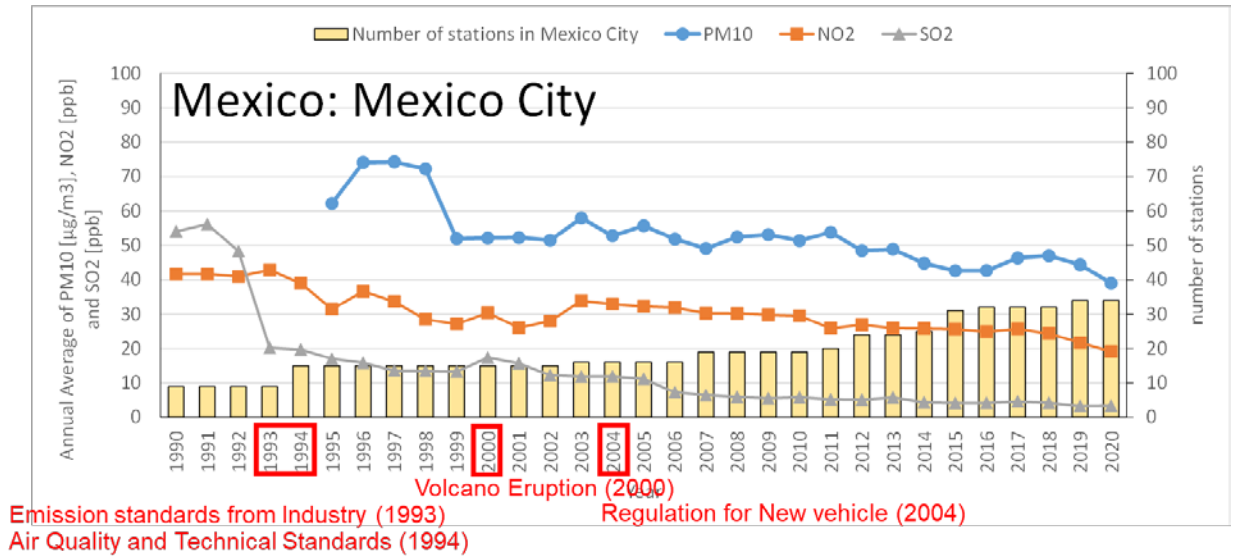
In terms of air pollution, the concentrations of NO_2, SO_2, and PM_{10} have been steadily decreasing, while photochemical oxidants have become the biggest problem, which is a particular characteristic compared to other countries.

In the 1st stage of this survey, Mexico was included in Group G (Countries in full-scale operation phase) and was positioned as a country with relatively advanced air pollution measures. This was supported by the development of laws and related administrative agencies, access to various data, and actual changes in air quality over time. Photochemical oxidants have been cited as an issue in air pollution in recent years, and this is thought to be partly due to the geographical conditions of high elevation and strong solar radiation, as shown in the elevation and solar radiation data (3.3(c) Classification E). It is assumed that the same problem could occur in other cities with similar conditions, regardless of their stage of development.



Source: JICA Survey team

Figure 4-23 History of Air quality management in Mexico



Source: JICA Survey team

Figure 4-24 Changes in air quality and related events in Mexico

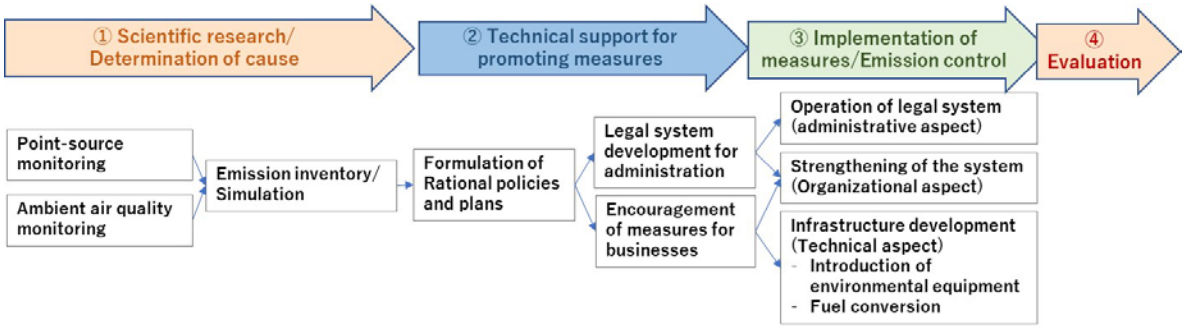
4.4. Observations for 5 Countries/Cities

4.4.1. Qualitative discussion of the status of air quality management and the effects of air quality improvement in each country

Table 4-20 lists the building status of the air quality management and air quality of the five target cities/countries surveyed as shown in Section 4.3.

Initiatives for air quality management are classified according to the four approaches as shown in Source: Policy Note Vol.06 (JICAResearch Institute/ Thailand Office)

Figure 4-25, corresponding to the classifications shown in Table 2-2. The following observations were made based on this categorization.



Source: Policy Note Vol.06 (JICAResearch Institute/ Thailand Office)

Figure 4-25 Four Approaches of development of air quality management

The five cities were selected from Group A (Countries with a rapid increase of $PM_{2.5}$), B (Countries where the increase of $PM_{2.5}$ is expected in the near future), C (Group at the beginning stage of air pollution control), D (Countries with a decrease in $PM_{2.5}$), and G (Countries starting the air pollution control in full scale), respectively, based on the results of the first stage of the survey. The survey results presented in Chapter 4 confirm that Mexico, in Group G, has achieved a certain level of improvement in all sectors related to air quality management, and that the ambient air concentrations of pollutants have also improved accordingly. This indicates that Mexico is making good progress in developing effective air quality management. On the other hand, in the other four cities, it was observed that some part of air quality management was not in place or had issues with the effectiveness of the system.

Based on this, the comparative table of the five cities confirms that all countries have developed their administrative management systems to a certain level, more or less, including the development of environmental legislation, the establishment of environmental administrative agencies, and the introduction of environmental standards and emission standards. On the other hand, the available data in the field of air quality monitoring and emission inventory varied greatly from country to country indicating differences in the level of progress. For example, in Mexico, air monitoring systems have been in place since the 1980s, whereas in Vietnam, monitoring began in 2007 and full-scale implementation started in 2018. In Egypt, although air quality monitoring began in the 1990s, and the number of AQMSs has been steadily increasing, the government stopped publishing

the results of measurements during the period 2006-2012. In source control, Group A (Egypt), C (Vietnam), and D (Serbia) also reported the introduction of emission control, monitoring, and reporting systems, but the operational aspects have not been confirmed, and it was reported in Serbia and other countries that there are issues with the enforceability of regulations due to inadequate auditing organizations and capacity.

Table 4-20 Status of Air Quality Management and Air Quality for the Five Target Cities

First stage		**A: Rapid increase of $PM_{2.5}$**	**B: Potential increase of $PM_{2.5}$ in near future**	**C: Beginning stage of air pollution control**	**D: Decrease of $PM_{2.5}$**	**G: Starting the air pollution control in full scale**
Country/City		**Egypt/Cairo**	**Kenya/Nairobi**	**Vietnam/Hanoi**	**Serbia/Belgrade**	**Mexico/Mexico City**
Social events / environmental accidents		(2011 Revolution, 2013 coup d'etat)		Formosa environmental accidents (2016)	(2006 Declaration of Independence)	
Major air environmental issues		Black smoke/ Open burning PM, NOx	$PM_{2.5}$	NOx, SO_2, $PM_{2.5}$ Open burning/Indoor heating	SO_2 from thermal power generation, Indoor heating/ fire at final disposal site	Mobile source, $PM_{2.5}$
Major donor supports for air environment improvement		Automotive exhaust gas and lead-refining measures (USAID 1996-2003), monitoring and factory measures (DANIDA 1996-2001), and factory pollution measures (WB 1990-)	Capacity building (JICA 2011-13), Clean Air Africa (NIHR-UK, 2018-), Capacity building & system building (WB 2020-), Monitoring & environmental awareness building (UNEP 2021-)	Capacity building (SDC 2006-2008), Institutional building (JICA 2013-2015), MONRE Strengthening (Germany 2017-2020), and Network building (USAID 2019-2022)	Air monitoring facility (EU 2008-2011), Public awareness promotion (GEF 2019-), Air conservation programs (EU 2019-2021)	Air pollution countermeasures planning, SO_2 reduction measures, strengthened monitoring, scientific clarification and covenant countermeasures (JICA 1987-), Air quality control in the automobile/ transport sector (WB 1992-1999)
Transition of air environment situation		NO_2, SO_2: decreasing from 2007, flat since 2014 PM_{10}: flat at high level	Lack of data	NO_2, NOx: decreasing from 2012-2014 SO_2: decreasing sharply during 2012-2013, then largely increasing $PM_{2.5}$: remaining unchanged	PM_{10}: decreasing from 2007 NO_2 increased until 2016 and subsequently trended downward SO_2 slightly increased from 2012	NO_2/SO_2: downward trend since the first half of the 90s PM_{10}: downward trend since 1999
Air Environment Administration						
Approach	**Measure**					
(1) Scientific research/ Determination of cause	Environmental monitoring	Started in 1996, 114 stations in Cairo City (2021)	Started in 2014	Full-scale launch in 2018, 10 locations in Hanoi (2022)	Started in 2006, 35 sites	Air Monitoring System (1988)
	Emission inventory	Not confirmed. Air pollution forecasting model system in operation	Not confirmed. Mentioned in Nairobi Air Quality Action Plan (2019-2023)	(Scheduled to be established in 2022)	2016	1996～

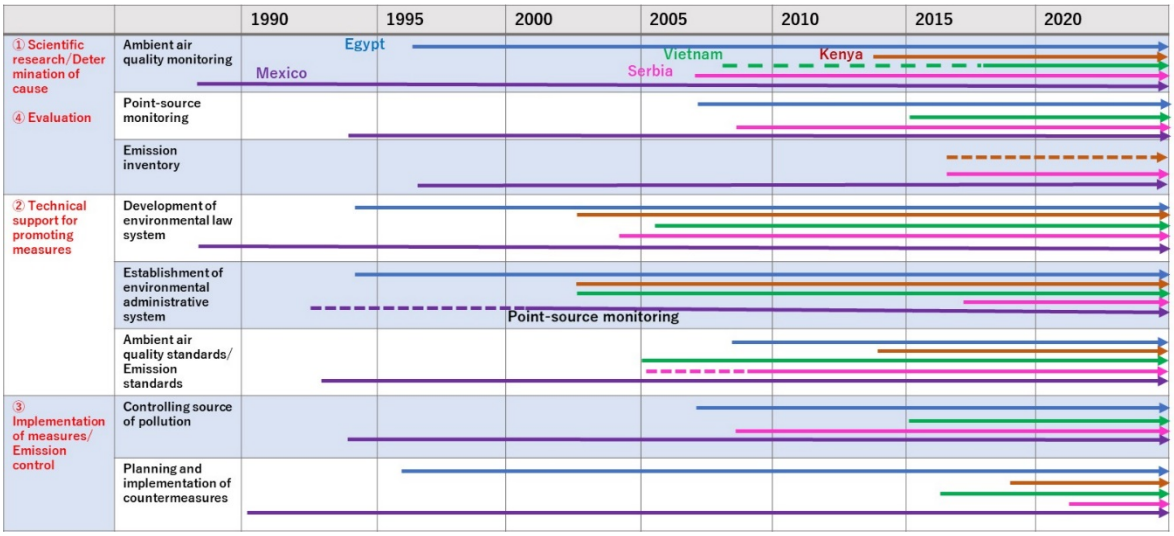
	First stage	A: Rapid increase of $PM_{2.5}$	B: Potential increase of $PM_{2.5}$ in near future	C: Beginning stage of air pollution control	D: Decrease of $PM_{2.5}$	G: Starting the air pollution control in full scale
	Country/City	**Egypt/Cairo**	**Kenya/Nairobi**	**Vietnam/Hanoi**	**Serbia/Belgrade**	**Mexico/Mexico City**
(2) Technical support for promoting measures	Development of environmental law system	Basic Environment Law (1994)	Comprehensive Environmental Management Law (2002)	Law on Environmental Protection (2005, 2020)	Environmental Protection Act (1991, 2004) Air Protection Law (2009)	General Act on Ecosystem Balance and Environmental Protection (1988)
	Establishment of environmental administrative system	Environment Agency (1982, 1994)	National Environmental Management Agency (2002)	Ministry of Natural Resources and Environment (2002)	Ministry of Environmental Conservation (2017)	Environment and Natural Resources Secretariat (2000) National Institute of Ecology and Climate Change (1992)
	Ambient air quality standards/ emission standards	Ambient air quality standards (1994 WHO Guidelines, revised 2009) Exhaust gas standards (2009) Vehicle Exhaust Gas EURO2,3 (2015?)	Ambient air quality standard (2014) Exhaust gas standards (2014)	Ambient air quality standard (2005) Exhaust gas standards (2009-)	Ambient air quality standard (2009) Automobile exhaust gas standards (2005-)	Ambient air quality standards (1994, added PM in 2014) Exhaust gas standards (1993) Vehicle exhaust gas (2004, EUR6 from 2019)
(3) Implementation of measures/ Emission control	Controlling source of pollution	Plant exhaust gas monitoring (2007) and exhaust gas monitoring (2009)	Emissions regulations and monitoring at factories (from 2014) Open burning is also regulated	Emissions regulations and monitoring at factories (from 2015) No burning or indoor honeycomb	Regulation and monitoring of exhaust gas at factories, establishment of emission reduction plans, and submission of annual reports (2009)	Exhaust gas regulations at factories and businesses (1988, 1994) Measures for automobile fuel (lead-free, emission control technology, 1991-)
	Planning and implementation of countermeasures	CAIP (Measures against exhaust gas from buses, etc.) (1996), Monitoring of exhaust gas from cement plants, National monitoring (DANIDA,), etc.	Nairobi Air Quality Action Plan (2019-2023)	National Air Quality Management Program (2016)	National Air Protection Program/Action Plan (2022-2030)	The Mexico City Metropolitan Air Pollution Control Integrated Project PICCA (1990-), PROAIRE (1995-2000, 2002-2010, 2011-2020), BRT development

Source: JICA Survey team

In order to clarify the differences in the progress in each sectors of air quality management as described above, Figure 4-26 shows the history of each country's efforts by each sector. Each field related to air quality management is also classified according to the four approaches shown in Figure 4-25. In order to implement effective and practical environmental management, it is ideal that the progress starts from (1) scientific investigation and determinationof causes, to (2) technical support for promoting measures, (3) implementation of measures/emission control, and (4) evaluation, starting with the top line of the figure.

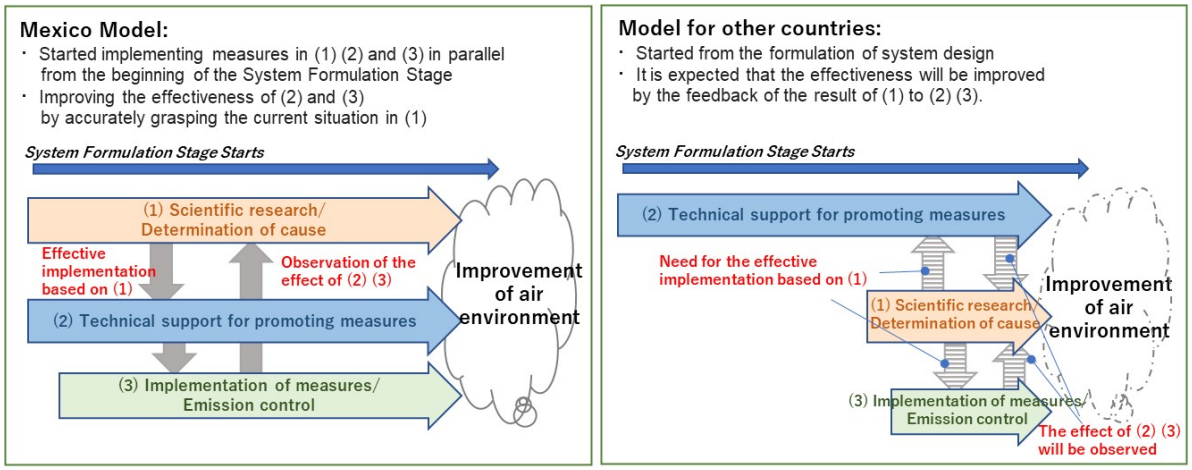
In Mexico (purple line), where air pollution control measures are considered to be making steady progress, it was confirmed that approaches of (1), (2), and (3) were initiated simultaneously, starting with the development of air quality monitoring. And then, developments in all sectors were introduced comprehensively and continuously in the 1990s. It is also considered that the early development of basic information based on (1) enabled the planning and verification of effective measures and regulations in (2) and (3).

On the other hand, in Vietnam (green line) as an example, while (2) institutional development for air quality management started in the early 2000s, air quality monitoring started in 2007, emission source monitoring started in 2015, and emission inventory cannot be found, suggesting that the stage (1) has not progressed sufficiently. In particular, the emission inventory field was confirmed to be insufficiently developed in all countries except Mexico. The emission sources that should be regulated with priority cannot be identified without the information on emission amounts by sources. Also, the most efficient air pollution control measure for achieving air quality standards can be estimated by by simulation modeling using emission inventory, combining with cost analysis. Without these information, setting appropriate emission standard in phase (2), or comparison of effectiveness in phase (3) is impossible. In addition, the fact that certain trends cannot be found from the AQM data in Egypt, Vietnam, and Serbia suggests that the monitoring system in (1) is inadequate or weak, and/or the administrative enforcement capacity and/or financial capacity for (3) may not be sufficient. Including Kenya, highly accurate and long-term monitoring data should be obtained to understand the pollution structure. In order to obtain these basic data, and to progressively develop from (2) to (4), it is important to acquire basic technical skills related to emissions measurement at the source and maintenance of air quality measurement stations, as well as to secure a regular budget for maintenance and management, including the purchase of consumables, and to continuously assign personnel with the necessary skills.A schematic comparison of Mexico's progress with that of other countries is summarized in Figure 4-27.



Source: JICA Survey Team

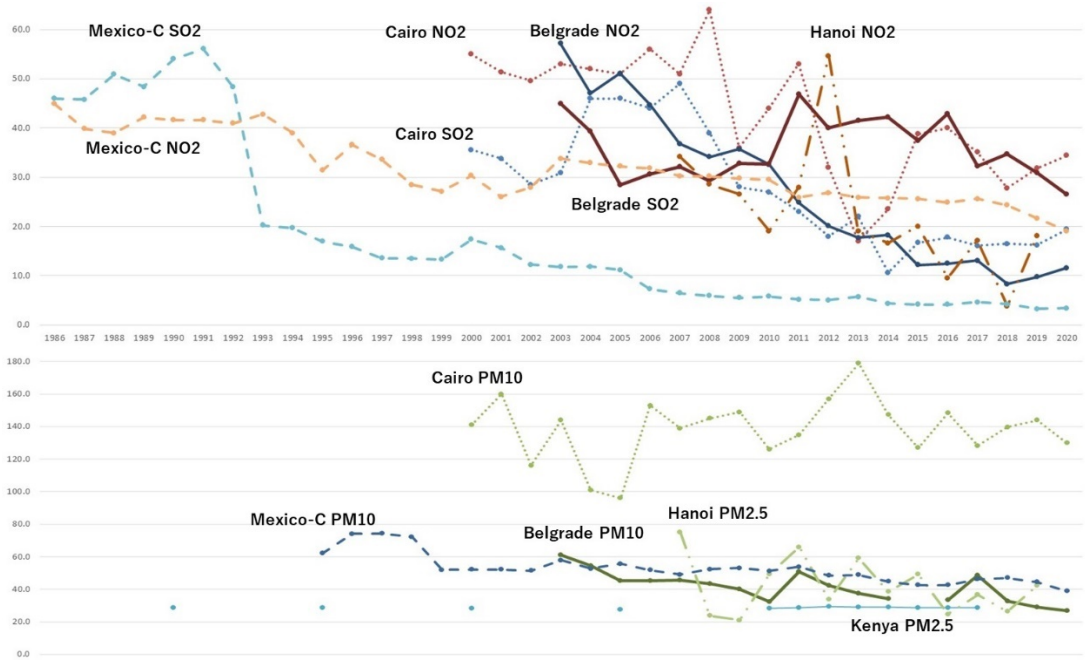
Figure 4-26 Progress of the Development of Air Quality Management by Each Sector



Source: JICA Survey team

Figure 4-27 Four Phases of Air Quality Management

In addition, Figure 4 28 shows the concentration of air pollutants in the five countries/cities. Mexico (Group G) has had a monitoring system in place since the early stages of the system formation period (1988), and the data also clearly shows the improvement in air quality due to the introduction of comprehensive air pollution control since the early 1990s.



Note: $PM_{2.5}$ is the annual average of $PM_{2.5}$ concentrations averaged by population-weighted averages for domestic urban areas, and the other is the average of the measured values at all measuring stations in the subject city.
Source: JICA Survey team

Figure 4-28 Changes in Air pollution in Five Taget Cities (Upeer: SO_2/NO_2, Lower: PM_{10}/$PM_{2.5}$)

Observations by air pollutant are as follows.

- ✓ For NO_2, there is a general downward trend in four cities (no data available for Kenya). However, it is still necessary to pay attention to pollution caused by the influx of used cars and the prevalence of unmaintained cars in these countries.
- ✓ On the other hand, with regard to SO_2, constant trend cannot be found in Egypt, Vietnam, and Serbia, and some countries have seen an increase in SO_2 concentration recent years. It is highly likely that emission controls and monitoring of factories are not working effectively, and there are issues with their implementation approach (3).
- ✓ Seasonal and localized deterioration that cannot be picked up by PM annual average data has been pointed out in Cairo, Hanoi, and Belgrade, and as previously mentioned, the collection and analysis of data through approach (1) is an issue. In addition, it is highly likely that measures taken to change residents' behavior are inadequate, such as burning agricultural residues and waste in the field, and heating for households. (approaches (2) and (3)).

Taking the above into consideration, we examined the background of institutional progress in terms of financial inputs in order to examine the conditions for establishing a more effective air quality management system.

In Mexico, where an effective air quality management system was successfully developed, the following two demands were the top political priorities in the 1980s and 1990s.

- Measures to deal with the political situation in the country (the deterioration of the economic situation of the middle class in Mexico City, and the dissatisfaction to the government against the bad living environment, including air pollution).
- Measures to control air pollution in Mexico City as a condition for concluding NAFTA, which was an important economic, diplomatic, and political issue at the time.

In Mexico, based on these political requests, Mexico proceeded with the development of an air quality management system by utilizing various donor support, including the massive WB support with a total project cost of US$1 billion [30], as shown in Table 4-21. The contents of the supports shows that every sectors of air quality management are included comprehensively, not only environmental monitoring, but also the development of emission inventories, and the planning and implementation of measures for vehicles and fixed sources.

Table 4-21 Example of Major Donor Support in Mexico

World Bank (WB): • 1993-1999. Transport Air Quality Management Project for the Mexico City Metropolitan Area **Total Project Cost: US$ 1086.70 million** (a) vehicles component (emission standard, registration system), (b) fuel component (vapor recovery, pilot program for fuel conversion), (c) transport policy and management, (d) scientific base component through an integrated research plan and expanding AQMS, (e) institutional strengthening
Japan International Cooperation Agency (JICA) • 1986. Support to fight against air pollution in Mexico City through the 1986-1988 Study on Air Pollution Control Plan in the Federal District (JICA, 1988). • 1990-1992. Study on the Air Pollution Control Plan of Stationary Sources in the MCMA. • 1993-1995. Study on the Combustion Technologies for the Air Pollution Control of Stationary Sources in the MCMA. • 1995-2002. Cenica's Project (National Center for Environmental Research and Training) • 2006-2008. Strengthening of the Air Monitoring Program in the United Mexican States. • 2011-2015. Joint research project on formation mechanism of ozone, VOCs, and $PM_{2.5}$ and proposal of countermeasure scenario.
German Agency for International Cooperation (GIZ): • Triangular Cooperation India – Mexico – Germany: Triangular cooperation project with the objective of strengthening mutual collaboration with other countries. (Deutsche Gesellschaft für Internationale Zusammenarbeit) • National Air Quality Strategy (ENCA): which serves as the planning instrument that guides actions to control, mitigate and prevent the emission and concentration of pollutants in the atmosphere, with a projection to the year 2030 • Sustainable Transportation Program: support for public and non-governmental actors in the implementation of measures to reduce greenhouse gas emissions and atmospheric pollutants in cargo transportation.
Swiss Agency for Development and Cooperation (SDC): • Climate and Clean Air Program in Cities of Latin America Plus - CALAC+: (The CALAC+ Programme Climate and Clean Air in Latin American Cities PLUS.) **Total Budget: CHF 5,900,000**

Source: JICA Survey Team, https://projects.worldbank.org/en/projects-operations/project-detail/P007694

[30] Total budget of WB and non-bank, including expected cost of pipeline project

With this massive support, Mexico proceeded to develop its domestic environmental management system. Although the budget and financial situation of Mexico's environmental management sector at that time was not available, Table 4 21 shows the budget and staffing for the environmental management sector in 2022. It should be noted that these figures are not only related to the air quality sector, but at least at this point, it can be confirmed that the budget and staffing of the environmental management sector are secured not only at the national level, but also in Mexico City and in the state of Mexico.

With this massive support, Mexico proceeded to develop its domestic environmental management system. Although the budget and financial situation of Mexico's environmental management sector at that time was not available, Table 4-22 shows the budget and staffs for the environmental management sector in 2022. It should be noted that these figures are not only related to the air quality sector, but at least at this point, it can be confirmed that the budget and staffing of the environmental management sector are secured not only at the national level, but also in Mexico City and in the state of Mexico.

Table 4-22 Budget and Staffs in Environmental Management Sector in Mexico

Institution	Annual Budget 2022 (USD)	Staff
FEDERAL – SEMARNAT		
SEMARNAT	1,300,000	3705
INECC	9,000,000	312
PROFEPA	39,000,000	2057
FEDERAL – SALUD		
INSP	26,000,000	777
COFEPRIS	38,000,000	1487
LOCAL		
Mexico City		
SEDEMA	62,000,000	200[3]
PAOT	6,000,000	194
State of Mexico[1]		
SMAGEM	60,000,000	327
PROPAEM	2,400,000	75
INTER-MINISTERIAL COORDINATION		
CAMe	2,500,000	40[3]

The success of the project can be attributed to; (i) the comprehensive support provided by multiple donors for the development of various sectors necessary for air quality management; (ii) the strong political motivation of Mexico to prepare organizations and personnel to promote air quality management, and (iii) the stable availability of financial resources to carry out these institutional improvements thanks to the massive funds.

A similar case can also be seen in Serbia, where donor support has led to the development of institutional arrangements, backed by political motivation. Serbia signed the EU Stabilization

and Association Agreement in 2008 and has been engaged in full-scale negotiations for EU accession. This was the impetus for the country's efforts to establish a system and build institutions in line with EU standards, which is assumed to be a situation common to all EU accession candidate countries in the region. The EC report on Serbia (2021[34]) also states that the implementation of the law and air quality plan remains as an issue. It can be inferred that identifying and supporting these underdeveloped sectors in stage (1) of Figure 4-26 will contribute to the future development of air quality management systems.

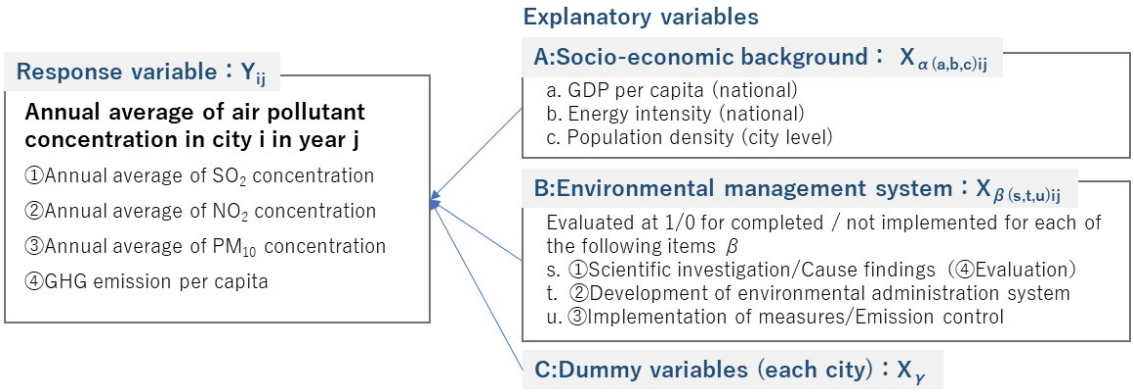
In addition, while both the Mexico and Serbia cases were motivated by external factors (NAFTA conclusion, EU accession), the following examples can be considered to motivate such air pollution control measures in the countries to be supported.

- Requests from citizens to the government: As in the Mexican case, complaints from citizens are the most basic motivation for air pollution control. From this perspective, public disclosure of air quality monitoring data can be effective as an educational activity.
- Coordination with climate change measures: Climate change measures and air pollution control measures are very closely related as they share the same sources, pollutants, etc. As the demand for climate change countermeasures is increasing not only in developed countries but also in developing countries, co-benefit measures that link the two can promote air pollution countermeasures at the same time.
- In particular, while many countries were found to have inadequate inventories of air pollutant emissions in this survey, many countries are working on GHG inventories under the IPCC framework, so there is a possibility that the government can develop inventories more efficiently by integrating the two.

4.4.2. Statistical Analysis

(a) Attempts on Multiple Regression Analysis

In addition to the qualitative analysis described above, quantitative considerations were planned in the analysis of the five priority cities when sufficient aging data on the air environment and socioeconomic indices could be obtained. In this survey, as shown in Figure 4-29, it was attempted to construct multiple regression models setting annual mean air pollution concentrations (NO_2, SO_2, PM) and GHG emissions as objective variables for five cities, and A. socioeconomic data, B. environmental management system ((1) scientific investigation and determination of cause and (4) evaluation, (2) technical support for promoting measures and (3) implementation of measures and emission control, as shown in Figure 4-25) and C. city dummies as explanatory variables. However, a significant result could not be obtained by judging from the P values and coefficient indicating the significance of each variable. The reasons why no significant results were obtained are considered to be as follows.



Source: JICA Survey team

Figure 4-29 Conceptual Diagram of the Regression Model Considered in the Study

<Reason why significant results were not obtained>

- ✓ Lack of reliable panel data set (air environment data): It was attempted to obtain long-term data of the air environment of each city, which is the objective variable, but long-term data could not be obtained for cities other than Mexico City. One of the factors is considered to be the difference in the number of data sets for each city. (For example, In Kenya, data of air quality at the city level were not available and therefore not included in the regression model; in Vietnam Hanoi, average daily data were obtained at three locations since 2007, but data had many missing values and no valid trends were found.)
- ✓ Lack of urban-level socioeconomic indicators that could serve as explanatory variables: In line with air environment data, it was difficult to obtain long-term data for each of the five cities, based on urban-level socioeconomic indicators that could serve as explanatory variables.
- ✓ Since the five cities extracted in the second stage of the study are not selected on the basis of statistical analysis, but rather, countries/cities with completely different social backgrounds and development processes are extracted, it is difficult to construct a regression model to explain the effect of measures on the air environment.

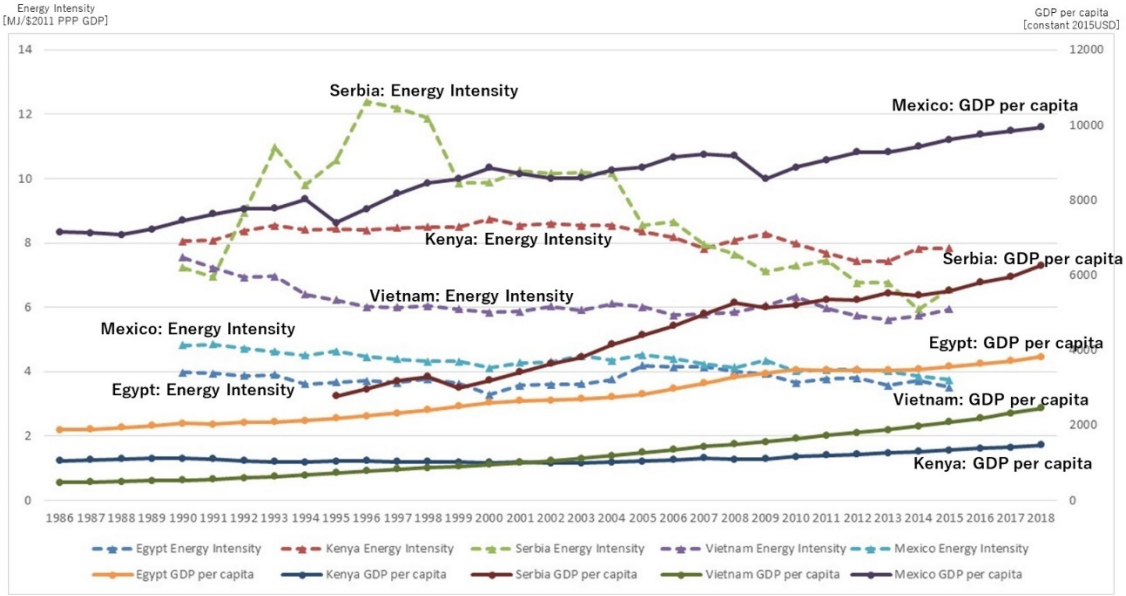
Considering the above points, it was judged that a significant regression analysis based on the air-related data collected in this survey was not possible.

(b) Summary Analysis of Relationships with Other Related Indicators

This paper analyzed the relationship between the aging change of air pollution concentration of five cities except Kenya and the economic indices, GDP per capita (country) [31] and energy intensity (country) [32] those of which show economic development. Energy intensity is calculated as units of energy use per unit of GDP, which is an index for measuring the degree of energy efficiency of an economy. In this survey, GDP per capita and energy intensity were

[31] Using GDP per capita (constant 2015 US$) published in World Development Indicators (World Bank)
[32] Using Energy intensity level of primary energy (MJ/$2011 PPP GDP) published in World Development Indicators (World Bank

selected as comparative indices in order to analyze the relationship between changes in economic activity volume and productivity due to changes in economic and urban structures in each country. Figure 4-30 shows the trends in the two indicators of five countries. The GDP per capita has been on an upward trend in all five countries, although the rate of change is different. On the other hand, the energy intensity of Mexico, Egypt, and Vietnam has generally been on a downward trend, while Serbia has been on a downward trend after one rise.



Source: JICA Survey team

Figure 4-30 Changes in GDP per capita and Energy Intensity

Figure 4-31 plots the relationship between air pollution concentration (SO_2, NO_2, PM_{10}) and GDP per capita or energy intensity. For those for which a tendency can be confirmed to some extent, the tendency is indicated by an arrow. (A plot of air pollution concentrations and two social indicators only for the year in which both of them were available. Therefore, for example for Serbia, data on air pollution concentrations during periods of increasing energy intensity were not available and therefore deviated from the analysis.)

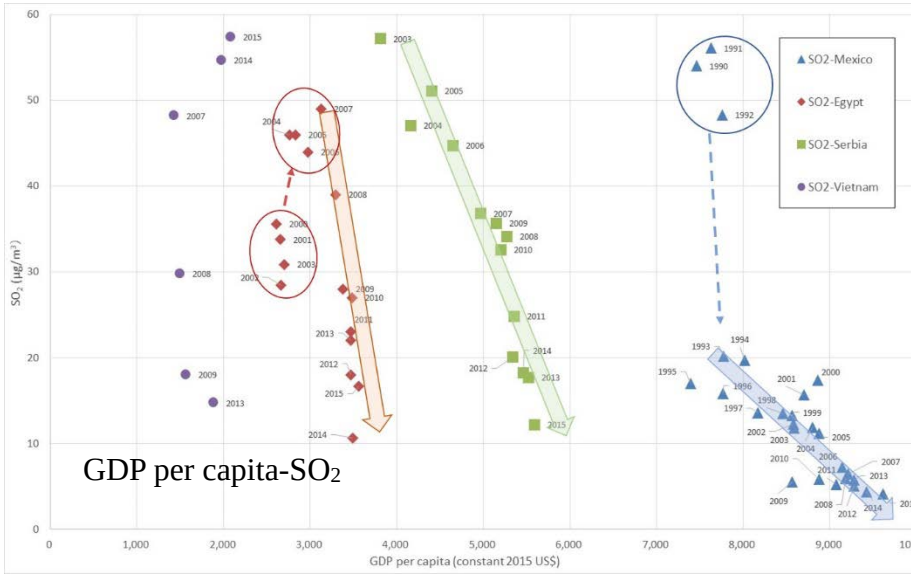
For SO_2, there was a reduction in SO_2 levels in Mexico and Serbia as GDP per capita increases or energy intensity decreases. This may be due to technological innovation and an increase in energy production efficiency as economic activities become more active. In addition, changes in the economic structure and the maturation of environmental administration in Mexico may be due to other effects. On the other hand, SO_2 concentrations in Egypt have started to decline after rising once as GDP per capita has increased. This trend could not be seen in NO_2 or PM_{10}.

For NO_2, the same relation as for SO_2 was confirmed only in Mexico. In Egypt and Vietnam, NO_2 decreased with increasing GDP per capita, but in Serbia, NO_2 density did not show a constant tendency between 2003 and 2015.

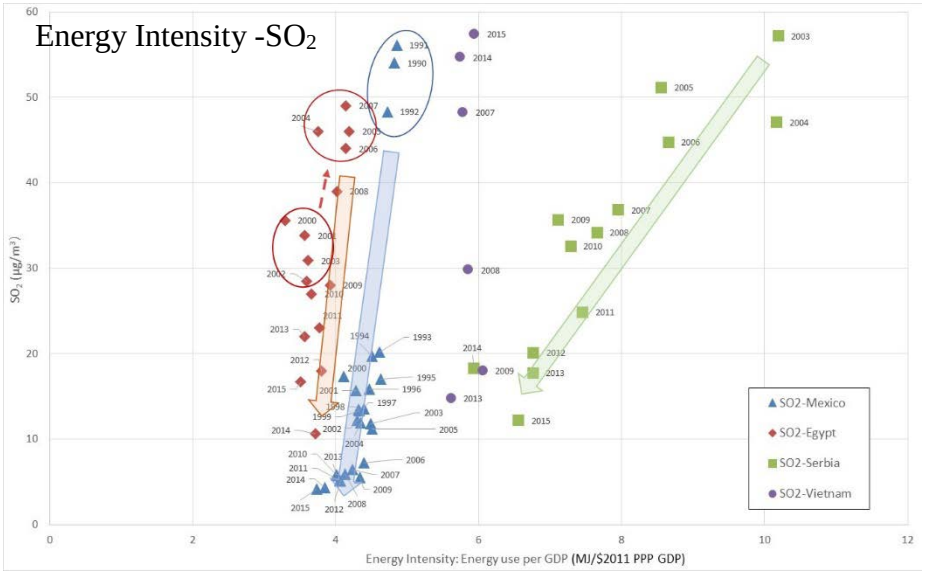
On the other hand, for PM_{10}, in Mexico and Serbia, as well as SO_2 concentrations, there was a decrease in PM_{10} with an increase in GDP per capita and a decrease in energy intensity. Looking at the plots of GDP per capita for the four countries as a whole, it was confirmed that it was close to an inverted U-shape, as was the case with the results of the first stage of the study.

From the above, it can be confirmed that Mexico is at the stage of the economic development with improving the city environment, because air pollutant concentration level of SO_2, NO_2, and PM_{10} have been decreasing while GDP per capita increases and energy intensity decreases. It suggests that the social system may be shifting from a tendency to prioritize economic growth to environmental considerations. The correlation between energy intensity and SO_2 was observed in Egypt and Serbia, suggesting that SO_2 measures may be influenced by the co-benefit effect of promoting energy conservation measures to industry, or by the fuel conversion associated with economic development. This is a point where effects can be expected separately from the progress in the effectiveness of air quality administration. As for Egypt and Vietnam, one of the factors that did not confirm the relationship between these social indicators and PM_{10} (the trend of high PM_{10}) may have been supported by the possibility that, apart from the economic structure and productivity gains associated with economic development, primary industries and non-industrial sources, such as open burning of agricultural residues and use of household heating fuel, may have a significant impact.

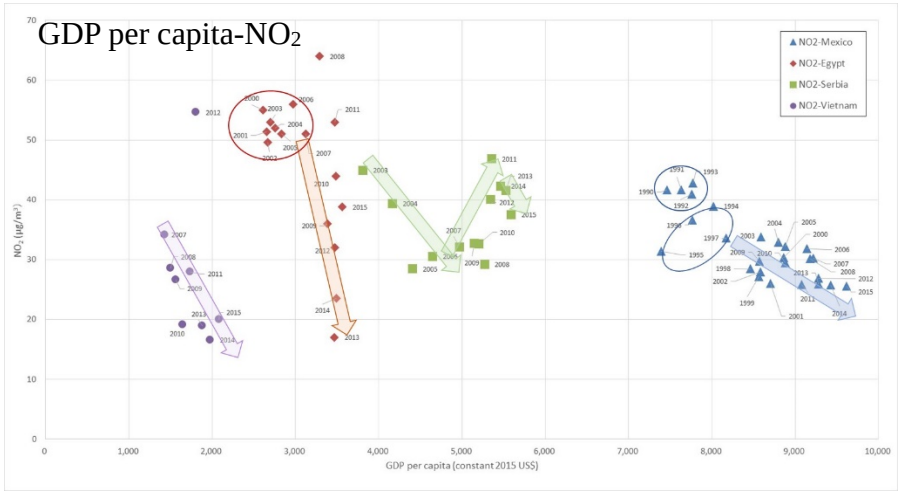
On the other hand in Vietnam, GDP per capita is on an upward trend, and energy intensity is on a decreasing trend, while the improvement of air pollution cannot be confirmed to a certain extent. As mentioned above, there are issues related to the reliability of air quality monitoring data and to the planning and implementation of effective countermeasures.



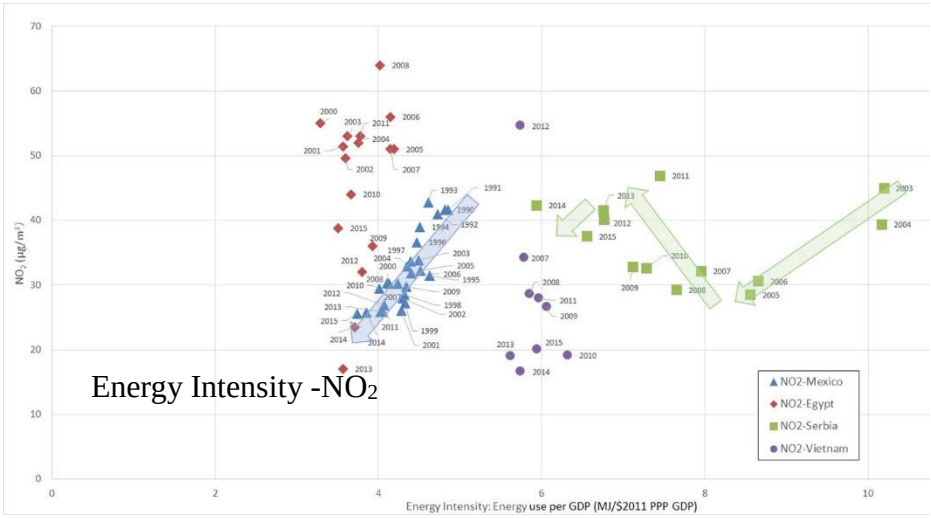
GDP per capita-SO_2



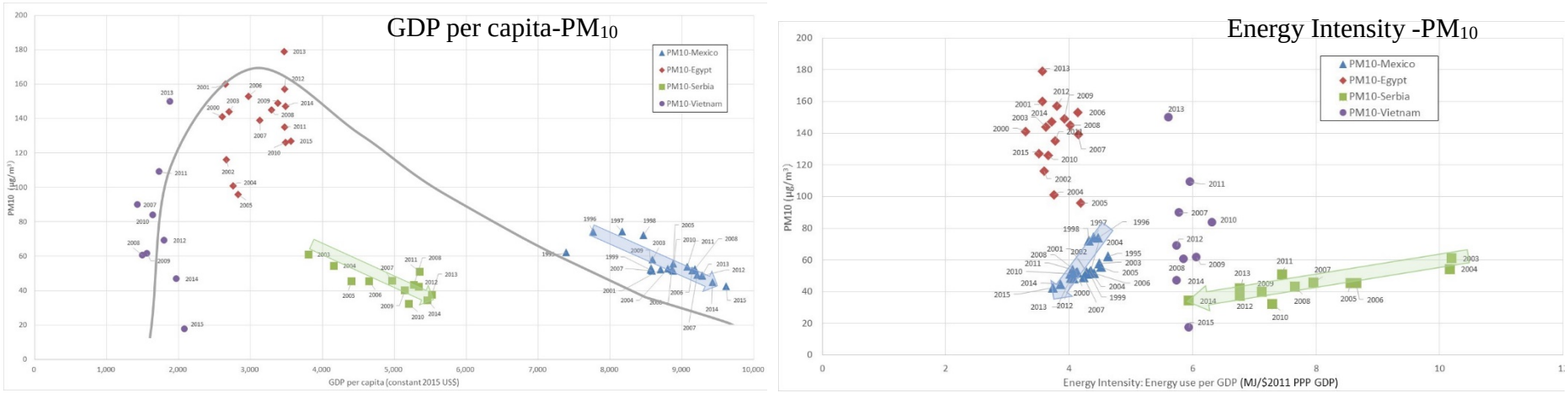
Energy Intensity -SO_2



GDP per capita-NO_2



Energy Intensity -NO_2



Source: JICA Survey team

Figure 4-31 Relation between Air Pollutant Concentration (SO_2, NO_2, PM_{10}) and GDP per capta/Energy Intensity

4.5. Summary of Findings from This Survey

Based on the results of the above analysis, the findings for analyzing and supporting the establishment of an air quality management system are summarized below.

4.5.1. Findings on air quality management issues in developing countries

The following issues were identified through the collection of information on the establishment of air quality management systems in various countries.

- After reviewing the history of development of air quality management in some countries, the following points were suggested to be particularly important for the establishment of effective institutions.
  - The strength of the motivation (including political imperatives) for air pollution control in the target countries
  - Comprehensive development of each process, from scientific research and investigation of the causes of air pollution to technical assistance for promoting countermeasures, implementation of countermeasures, and evaluation
  - Secure stable financial resources, including donor support
- In countries where air quality has not improved, emission from primary and non-industrial sources was found to be a problem, such as open burning of agricultural residues, waste incineration, and home heating. Since these emission require measures to change the behavior of the population, effective countermeasures have not been established despite their significant impact on the living environment.
- Although the direction of of environmental management systems and countermeasures are similar in all countries, the effects of implementing countermeasures does not always appear in ambient air concentrations, making it difficult to analyze the correlation between ambient air concentrations and the progress of management systems. The reasons for this may include differences in actual effectiveness of the systems and/or regulations, as well as the diversity of pollution mechanism due to various emission sources and natural conditions in different regions.
- Although screening and categorization were conducted based on $PM_{2.5}$ exposure values in this survey, it was concerned that the AQM system and its reliability may not be sufficient in some countries. Also, it was found and that pollution trends differ significantly for each pollutant. In particular, it is necessary to be more careful for the seasonal/local pollution, since these issue are difficult to be found on statistical data of annual averages.
- None of the countries has made progress in control of O_3, VOCs, toxic substances, etc., and a shift to these countermeasures is also an important issue for the future. These O_3, VOCs, and toxic substances are also highly related to $PM_{2.5}$ in terms of secondary production. In order to implement effective measures to reduce concentrations of these pollutants, it is important to take measures according to local conditions based on scientific findings.

- Regarding regulations and incentives for industry, few voluntary efforts of companies were observed, including the target countries of the 1st stage survey. This may be due to the tendency that economic growth is prioritized over environmental measures. Considering the low enforcement power of regulations by the authorities, it is possible that economic measures such as saving energy through Co-benefit measures and the introduction of Green Investment may be more effective than regulatory measures in developing countries.
- In many developing countries, where the administration with jurisdiction over air pollution control is weak, complaints and criticism from citizen and the media can be the most basic social incentive to promote air pollution control. In Mexico, complaints from citizens about the air quality, as well as the political imperative to conclude NAFTA, provided the initial motivation for improving the air quality management regime. In order to motivate such process, it is important to provide the public and decision makers with quantified and visualized information on the air quality, to educate the public, and to build consensus as a basis for discussion. Therefore, information disclosure and publicity of air quality monitoring data is the most fundamental activity to promote the development of air quality management, and it is important to disclose and accumulate reliable data.

4.5.2. Remaining issues from this survey and directions for additional research in the future

In analyzing the support needs and directions of the target countries, the following are findings regarding remaining issues in this survey and directions for additional research in the future.

- With regard to the analysis of the progress in air quality management in target countries, it was assumed that differences in the financial status of environmental management institutions and the amount of donor support may be a factor in the effectiveness of systems and regulations, but due to the limited information available, the analysis of financial status was limited to a few country cases. Further multifaceted analysis is needed in order to identify the factors to be supported and to provide effective assistance in the future.
- As shown in 2.1.1.2, the combustion of fossil fuels is major emission source of air pollutants and share common sources and pollutants with GHGs, including SLCPs. Air pollution are also closely related to the chemical substance management field under the PRTR system. Although this survey did not analyze the relationship between these climate change measures and the chemical substance management field, it is desirable to support the development of these closely-related fields at the same time, from the perspective of urban environmental management. Since it is assumed that many countries have not yet developed these systems, it would be effective to conduct a case study analysis of selected countries that have made successful progress in establishing such systems.

4.5.3. Findings for future identification of JICA's assistance needs and effective implementation of assistance

Based on 2.1.2.2 Current issues of JICA on air quality management sector, the following points should be considered for more efficient selection and consideration of countries for future JICA assistance.

- In many of the countries surveyed this time, legal systems and standards were formulated to some extent but lacked practicality. The case study of Mexico suggests that the reason for this is the insufficient monitoring and collection of basic information in phase (1) of Figure 4-25.To improve the effectiveness of JICA's future assistance, it is important to identify and provide technical assistance in the undeveloped sectors at the phase (1).
- In addition to the provision of equipment for air quality monitoring (air quality monitorng) and source monitoring (emission gas measurement, etc.) necessary for the development of basic information in the phase (1), the establishment of a sustainable operation system, including the establishment of a monitoring management system and securing a steady budget in the country, will be required after the phase (1). In addition to technical assistance, it is considered important to strongly encourage the target countries to have motivation for air pollution control (to secure budgets and personnel within the target countries).
- There were some examples of pollution which are characteristic in the regions, such as Balkan countries with winter pollution from house heating and Southeast Asian countries with PM pollution from open burnings. Common measures may be effective in these countries. Also, these countries share common international frameworks, such as the EU candidate countries and the Haze Agreement, and sharing their experiences and information through these frameworks may enable more practical and efficient assistance.
- Certain trends have been obtained in the correlation between GDP and energy intensity inFigure 4-30 and Figure 4-31. This may be useful to estimate the air pollution situation and future trends in selection of target countries for assistance, by applying these figures to the current status of candidate countries.
- Many of the countries surveyed in this study showed no improvement in PM concentrations in recent years. The experience in Japan can be an example of specific measures for this, which is, the removal of small incinerators and automobile regulations under the Automobile NOx/PM Law have been effective for decreasing PM pollution in Japan [33]. In addition to measures for traffic, the countermeasures against such localized, clustered small emissson sources within a city can also be referred to as a successful example of PM pollution improvement.

[33] Air Pollution Trends in Japan between 1970 and 2012 and Impact of Urban Air Pollution Countermeasures (Wakamatsu et al., 2013) https://doi.org/10.5572/ajae.2013.7.4.177

4.6. Findings from Interviews in the surveyed countries for cooperation at the city level

Based on the interviews in the surveyed countries, recommendations for identifying support needs at the city level have been issued as follows.

4.6.1. Egypt

The following points were raised as issues from the interviews with related authorities in Egypt.

- ✓ Increase the number of AQMSs in new administrative districts and other places where no measurement stations have been established.
- ✓ Mobile AQMS equipped with all monitoring equipment for air pollutants.
- ✓ Establishment of an integrated program for emission inventory, with the aim of creating a database of the emissions for all industries in the most polluted areas of Greater Cairo, such as El-Tabbin, Shubra El-Kheima, etc. To provide an integrated information system able of displaying emissions in the most polluted areas, both geographically and historically, with the aim of enhancing decision-making and planning.
- ✓ Improve QA & QC of air quality monitoring data, various methods of data analysis, and capacity building for staff in charge of air quality monitoring on the preparation of technical reports on the analysis of monitoring data.

4.6.2. Kenya

From the results of interviews and compilation of related information, the following issues are clarified.

- ✓ Kenya has a strong institutional framework for air quality management. However, there have been major gaps in their implementation. To bridge this implementation gap, the National Environmental Authority (NEMA) has established a department of Air Quality which is currently collaborating with various stakeholders especially UNEP to conduct strengthening of air quality management initiatives in Nairobi.
- ✓ · The country does not have a national air quality-monitoring programme. Current data generated is mostly through ad-hoc research initiatives, which are usually short-term and limited to $PM_{2.5}$.
- ✓ Nairobi City County is the only one among the 47 counties to adopt the National Air Quality Guidelines 2014. The county already has an established air quality plan (2019-2023) and Air Quality Act (2021). This presents an opportunity for partners to support air quality initiatives in the city.
- ✓ There is no budgetary allocation for air quality infrastructure in the counties and it is expected, the establishment of Nairobi Air quality Act 2021 will help bridge this gap.

4.6.3. Vietnam

From the results of interviews and compilation of related information, the following issues are clarified.

- ✓ In Hanoi City, while annual average of NO_2 is declining, annual average of PM_{10} and $PM_{2.5}$ was observed at all 10 monitoring stations under the jurisdiction of DONRE were exceeded the ambient air quality standard; air pollution caused by particulate matter is one of the problem in Hanoi. In Hanoi City, the use of honeycomb briquettes as household fuel and the burning of straw and agricultural by product in the open air are still big issue despite the prohibition, and the awareness rising of the residents and the strengthening of the controls are the issues that the government should tackle.
- ✓ In 2018, the Hanoi DONRE established 10 air monitoring stations in Hanoi and just started their operation. However, there are still shortage of monitoring stations and the reliability of data to be monitored. In addition, the emission inventory has not been developed. In order to accurately grasp the current state, thorough collection and management of this data is a challeneg in Hanoi City.
- ✓ Hanoi City will finalize the Hanoi City Five-Year Air Quality Management Plan by 2022. One of the urgent tasks is to improve the execution capacity of the governmental agencies (human resources development) in order to develop and implement a roadmap that should include reliable and appropriate solutions.

4.6.4. Serbia

Press coverage and complaints from the citizens in Belgrade

The following air quality-related news was obtained from the survey in Serbia.

1	The Air pollution reached extremely high levels for days at night time in February 2021. Residents of Belgrade complained about the smell of air that reminded them of arson, while there was a haze in the morning. On the app AirVisual, using index methodology US AQI, 25.02.2021, at some point, the values were above 300, when pollution is considered to be dangerous to health. Researchers who advertised in the media insisted that the biggest problem was windless weather. The main criticisms have been directed at the competent institutions, which are delaying measures to reduce emissions of pollutants from house heating, thermal power plants, smaller energy, transport and heavy industry. For detail: ekstremna-zagadenost-vazduha-u-beogradu-i-citavoj-srbiji
2	Concentrations of PM_{10} particles in Belgrade were up to three times the legally permitted value in January 2020. The concentrations of these particles were not exceeded for only few days in January 2020. The daily prescribed amounts of PM_{10} in Belgrade in the first three weeks of January were not exceeded by only three days. For detail: vazduh-u-srbiji-opasan-godinama
3	There is a Europe's largest landfill of untreated waste in Vinča, located near Belgrade, and frequently there have been fires. The most recent fires occurred in 2017 and August 2021, and the smell of smoke in the entire city caused concern among citizens. Experts emphasize that there are no measurements of toxic substances and carcinogens from plastic incineration, which are very hazardous to human health, and that this data needs to be made public.

Both these pollutants are related to particulate matter, and looking at the changes in concentration over time, there is no clear decrease in NO_2 and PM_{10} compared to SO_2. Recent cases such as JICA's Technical cooperation Project in Kosovo and the Survey in Moldova indicate that the combustion of solid fuels for household heating during the cold season causes PM pollution in winter season, which is a common problem in the Eastern Europe and Balkan countries.

Consistency with the EU directives

In the process of European Union (EU) integration, while presenting its Negotiation position for Chapter 27 (Environment and Climate Change) to the European Commission (EC) in 2019, the Republic of Serbia expressed its commitment to the transposition of the entire EU legislation into the national legislation, including the air quality directives.

Based on the "Serbia Report 2021[34]" by European Neighborhood Policy and Enlargement Negotiations, Serbia has a good level of alignment with the EU acquis in the field of air quality. However, the following points have been pointed out as remaining issues;

- *Implementation including the air quality plans, and further improvement of its air quality monitoring system should be accelerated.*
- *The EU air quality index should be adopted.*
- *Adequate staffing of the SEPA should be ensured.*
- *Pollution induced by the Kostolac B thermal power plant needs to be addressed as a priority*
- *Requirements of Directive 2016/2284/EU for national emission ceilings have not yet been transposed.*
- *Alignment with the EU legislation on volatile organic compound emissions needs to continue.*
- *In regards to industrial pollution and risk management, alignment with most of the EU acquis is at an early stage across the industrial sector, including on the industrial emissions Directive (IED). Serbia's national emission reduction plan is not implemented in practice for Sulphur dioxide and dust.*
- *The Serbian Kostolac B thermal power plant is Europe's biggest Sulphur dioxide polluter. A desulphurization unit built in 2017 was only put into operation in the fourth quarter of 2020. Inspection and law enforcement remain areas of concern.*
- *Serbia needs to increase capacities for managing the integrated permitting processes. Serbia should tackle industrial pollution by enforcing the polluters' pay-principle in order to encourage the industry to invest in green solutions.*

Re-designation of zones and agglomerations and AQMS

According to the analysis of air quality conducted by the Ministry of Environmental Protection, new commitments related to zones and agglomerations have to be taken in order to make them more relevant or appropriate for air quality assessment. After the re-designation of zones and agglomerations, AQ Monitoring system should be assessed anew. Also, necessity of data validation on air quality assessment data management has been emphasized.

4.6.5. Mexico

Photochemical Oxidants

In Mexico, countermeasures against so-called conventional air pollutants such as NOx and SOx have progressed, and atmospheric concentrations are decreasing, but pollution from photochemical oxidants has been raised as an issue. In Mexico City, almost all throughout the year there are favorable conditions for the formation of photochemical smog, but between March and June the frequency increases in the number of days in which its concentration exceeds the value of the NOM. It is common for the monitoring sites located to the south to be the ones that generally record the maximum ozone concentrations, exceeding more frequently the limit values.

[34] https://ec.europa.eu/neighbourhood-enlargement/serbia-report-2021_en

In 2016, 212 days were recorded with concentrations above the limit value for the average of one hour (95 ppb), accumulating a total of 856 hours in the entire metropolitan area, while the maximum value for the 8-hour average was 152 ppb (the standard establishes a limit of 70 ppb for the 8-hour average). The limit value for the 8-hour average was exceeded 202 days.

$PM_{2.5}$

After ozone, $PM_{2.5}$ is responsible for the largest number of days with unfavorable air quality in MCMA. The maximum 24-hour and annual average concentrations were 96 and 24 μg/m3, respectively, exceeding the NOM limit values in both cases.

○Annex

Annex 1: Overview Sheet of the 1st Stage Survey

Annex 2: Individual Sheet for Each Country of the 1st Stage Survey

Annex 3: Basic Checklist

Annex 4: Survey Reports of the Five Countries for the 2nd Stage Survey

Annex 5: Presentation for the Study Meeting