Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances

Updated at the 6th Meeting of the Task Force on Soil and Vegetation Monitoring and (to be) adopted by the Scientific Advisory Committee of the EANET at its 20th Session

Network Center for the EANET

Strategy Paper for
Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances
(Updated in 2020)

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I. Introduction

1. *The Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances* was adopted as the long-term directions of the EANET monitoring by the Scientific Advisory Committee at its 14th Session in 2014. Simultaneously, the specific activities for the period from 2015 to 2020 were set as the annex.

2. In the discussion for adopting the *Strategy Paper* above, importance of collaboration with relevant research projects and other international initiatives was suggested to accomplish the objectives, although the issues described in the *Strategy Paper* seemed to be too ambitious for the EANET. Moreover, importance of considering multiple air pollutant factors, such as ozone and particulate matters, was suggested to evaluate ecological changes.

3. The *Strategy Paper* had already described importance of air pollutants, such as ozone and particulate matters, as the long-term directions of the EANET monitoring. Therefore, the main text should not significantly be changed, while slight modifications may be necessary to adjust to the latest discussion in the EANET community and scientific knowledge.

4. Specific activities for the term from 2021 to 2025 are mainly updated as the annex. Selected activities taking account of their feasibilities are described there.

5. The updated Strategy Paper directly contributes to the "activity No. (4) *Development/update of strategy paper for guidance on future direction of EANET monitoring, as necessary"* in the *Medium Term Plan (MTP) for the EANET (2016-2020)*.

II. Objectives of soil and vegetation monitoring of EANET

II-1. Initial objectives

6. The initial objectives, "establishment of baseline data" and "early detection of possible impacts" described in the *Guidelines for Acid Deposition Monitoring in East Asia (2000)* and *Technical Manual for Soil and Vegetation Monitoring in East Asia (2nd ISAG, 2000)* can be interpreted as follows.

7. Establishment of baseline data is to describe the present status on plants and terrestrial ecosystems by the basic survey, which was described in chapter 2 of the *Technical Manual*. As the baseline data, the following data should be accumulated:
   - Chemical properties of soil
   - Growth of trees (by description of trees)
   - Species composition of understory vegetation

   The basic survey should consider climatic zones in the participating countries.

8. Early detection of possible impacts requires establishing the methodologies for detecting decline symptoms on plants in the early stage. To avoid serious damage on plants and terrestrial ecosystem and enable recovery from the problem, the symptoms should be detected in the early stage. In the EANET region, information on forest decline, plant sensitivities, and their implication with air pollution have not been sufficiently accumulated.

II-2. The long-term objective

9. The long-term objective is "To assess impact of acid deposition on terrestrial ecosystem in a comprehensive and systematic manner through development and maintenance of a good quality database", which is described in the Guideline for Acid Deposition Monitoring in East Asia (2000).

10. The long-term objective of soil and vegetation monitoring can be achieved by evaluating spatially and temporally the impacts of air pollution/acid deposition on terrestrial ecosystem in the EANET region with understanding the processes (mechanisms) in the ecosystems that are related to air pollution/acid deposition.

11. For quantitative evaluation of air pollution/acid deposition impacts, as the first step, the present status of ecosystem should be described by input-output budget analysis and ecosystem modeling in the respective monitoring sites (e.g. catchment areas). Taking account of the above budget analysis and also the present status of soil and vegetation by the basic survey, spatial and temporal evaluation should be promoted by appropriate methods for up scaling of monitoring data.

III. Issues to be implemented to achieve the objectives

III-1. Issues for the initial objectives

III-1-1. Issues for establishment of baseline data

Promotion of continuous monitoring:

12. Accumulation of the data on soil and forest vegetation is the first step for establishment of the baseline data, and the monitoring in the current sites should be carried out continuously at least every 3-5 years interval for soil chemical properties and general description of the forest. Protection/conservation of the monitoring site is important so that long-term data could be accumulated over several decades.

13. Financial and human resources in the respective countries are essential for continuous monitoring. Countries should make an effort to source funds from both national and international organizations. Networking and capacity building of relevant experts should also be promoted to accumulate human resources at both national and regional levels.

Improvement of monitoring system:

14. The number and location of monitoring sites should be reviewed considering climatic zones and the concept of the multi-stage sampling. Monitoring sites should be established systematically even though the numerous monitoring sites could not be established on small grids.

15. The EANET region is a latitudinally wide area and consists of varied climatic zones. It can be recommended that one area at least should be selected for representative climatic zones in the respective countries. For each area, two types of soil are selected if possible, and plots and subplots are established according to the multi-stage sampling system on soil monitoring.

16. Support by experts on soil and forest vegetation is essential for the monitoring, and such experts should be involved continuously. In most participating countries of EANET, one expert may not be able to complete all work involved in soil, forest vegetation and ecosystems monitoring, and therefore needs cooperation with other experts. The continuous involvement of these experts in the monitoring activities, and establishment of an appropriate system for regular reporting to a national committee involving relevant agencies involved in EANET activities should be considered.

III-1-2. Issues for early detection of possible impacts

17. The *Sub-Manual on Forest Vegetation Monitoring in EANET* was endorsed by SAC

at its 6th Session in 2006. The *Sub-Manual* proposed modified methods on observation of tree decline and some additional methodologies for early detection of possible impacts. Observation of tree decline should be conducted at least once a year according to the *Sub-Manual*. The methodologies described in the *Sub-Manual* should be utilized to collect the information on possible impacts.

General information of tree decline symptoms in the participating countries:

18. Prior to discussion of air pollution/acid deposition impacts, general information of tree decline symptoms should be accumulated; where, from when, which tree species, how decline, what cause, etc. Since impacts of air pollution and acid deposition may appear in combination with other factors, such as meteorological events and insect/fungus infections, the information should be obtained widely. Literature surveys for scientific publications should be adopted to collect reliable information.

Ozone concentration in agricultural and forest areas and its effects:

19. High concentrations of ozone have become one of the hot topics in the EANET region due to increase in concentrations of its precursors, such as NO_X. Effects of ozone on vegetation including agricultural crops should be discussed with those of acidic substances, since ozone formation in the troposphere is closely related to other air pollutants. To evaluate effects of acidic substances precisely, effects of ozone on vegetation should also be considered.

20. The data of ozone concentration in forest area is very limited due to accessibility and lack of power supply in the EANET countries. Similar situation exists in agricultural area where no power supply is available. Ozone concentration in those areas should be measured/estimated by utilizing various methods. Ozone concentrations could be measured in forest area by using less-expensive methods, such as passive samplers, since diurnal variation may relatively be limited in forest/mountainous area. However, hourly data is necessary to calculate indices of ozone concentrations, such as AOT40 and SUM06[1]. In the case that electrical supply is available near those areas, the automatic ozone monitor should be installed. Moreover, numerical modeling of ozone concentrations may be useful to discuss the spatial distribution and the regional risk on ecosystems.

21. Visible ozone injury should be assessed by field observation or microscopic

[1] AOT40, Accumulated dose Over a Threshold of 40 ppb; SUM06, a cumulative index of ozone concentrations over a specified threshold (0.06 ppm).

observation as a field evidence of ozone effects. The International Co-operative Programmes in Europe, such as ICP Forests and ICP Vegetation, have been accumulating a lot of information on the visible injury. Referring to the knowledge in Europe, information of the visible injury should be accumulated in the EANET region. A case study or trial campaign for measurement of ozone concentrations in forest area and assessment of visible ozone injury should be promoted. The areas where tree decline symptoms were reported may be likely candidates for the case study.

22. Further steps for assessment of ozone effects should be considered taking progress in other regions such as Europe and US into account. Effects on agricultural crops should also be discussed in the near future. Moreover, critical levels using AOT40 or POD_Y[2] should be discussed with relevant EANET bodies, such as Task Force on Monitoring for Dry Deposition.

Potential effects of particulate matters on ecosystems

23. Dry deposition of particulate matters is an important deposition process of sulfur and nitrogen, e.g. $(NH_4)_2SO_4$ and NH_4NO_3. In terms of acidification and eutrophication also, particulate matters should be taken into consideration. Moreover, dry deposition of particulate matters into forest area is a removal process of those from atmosphere, which may be considered as one of ecosystem services of forest, especially for urban trees. The information on concentration/flux of particulate matters in forest area, in particular those of fine particles, should be accumulated.

24. It has been reported that occlusion of stomata due to deposited particles may occur resulting in acceleration of water loss from leaf surface, although relatively coarse particles (> several μm) may mainly be related to this mechanism. Effects of fine particles (< 2.5 μm, so-called $PM_{2.5}$) on tree species are still not clear in the region, although both hygroscopic particles such as $(NH_4)_2SO_4$ and other particles such as black carbon (BC) and heavy metals may have the potential. The updated scientific information on laboratory/field studies should carefully be considered.

25. Atmospheric aerosols and regional haze may decrease yields of agricultural crop due to reduction of surface irradiance, while the aerosols may increase the diffuse fraction of solar radiation that enhances photosynthesis. Both negative (by reduction of direct radiation) and positive (by increase of diffuse radiation) effects should be

[2] POD_Y, Phytotoxic Ozone Dose above a threshold flux of Y nmol m^{-2} PLA s^{-1}, where PLA is projected leaf area.

considered to evaluate net effects of radiation changes on crop yields. The updated scientific information should be considered.

Compilation of information on early detection:

26. Procedures to collect information on plant sensitivities and dose-response relationship should be discussed. The information on ozone has been accumulated relatively in China and Japan. The dose-effect relationship for the air pollutants in other countries is necessary to discuss possible risks on plants on the regional scale. The information on epiphytic plant species, such as mosses and lichens, should also be collected since they have been used as indicators of air pollution including acid deposition. The *Sub-Manual* provides possible methodologies to collect the information on lichens. Practical solutions to utilize such methodologies should be discussed. It should also be discussed to collect basic information on fauna (e.g. forest insects).

Information on biomass burning:

27. Forest fire and/or burning of agricultural residues emit a large amount of greenhouse gases and gaseous/particulate air pollutants, resulting in significant increase in air concentrations of these pollutants. Simultaneously, air pollutants emitted from the fire affect remaining/surrounding forest trees and agricultural crops. People living in the area suffer from high concentrations of air pollutants. A large amount of the emissions may affect global climate and air pollution of neighboring countries. Information of biomass burning in the region should be compiled and shared in the EANET community. A precise data on biomass burning may contribute to air pollution modeling in the region, too.

III-2. Issues for the long-term objective

Promotion of regular catchment-scale monitoring

28. The case studies have been conducted in several reference catchment areas by the Network Center (NC) in cooperation with some participating countries. Elemental budget and biogeochemical processes have been discussed in the study catchments to evaluate effects of atmospheric deposition on the forest ecosystems. Based on the experience above, the *Guideline for Catchment-scale Monitoring* was developed by the Task Force and endorsed by the Scientific Advisory Committee of EANET at its 10th Session.

29. The regular catchment monitoring has started in Lake Ijira catchment in Japan according to the *Guideline for catchment-scale monitoring*. The Philippines has just started the regular catchment monitoring in La Mesa Watershed. The catchment-scale data may be informative for discussion of atmospheric deposition impacts quantitatively and qualitatively. It is expected that the regular catchment monitoring will be conducted in other countries.

Catchment analysis and simulation modeling on soil and inland water:

30. Based on the elemental budget and biogeochemical process in the study catchments, possible impacts of acid and nitrogen loads resulting from atmospheric deposition should be evaluated. Disturbance of biogeochemical processes due to atmospheric deposition, including "nitrogen saturation", is also one of issues to be evaluated.

31. Isotope ratios of some elements, such as sulfur, nitrogen/oxygen of NO_3^- and metals, are specific for their sources and/or changes through biological, geochemical or geophysical processes. Isotopic analysis of the elements from rainwater to stream water in a catchment may be informative for discussion of possible sources and biogeochemical processes in the ecosystems. Use of such techniques should also be considered for the catchment analysis.

32. Simulation model on soil and/or inland water acidification should be developed based on the catchment analysis above. Changes in chemical properties in the acidification process should be simulated in the model. Simulation modeling may help us evaluate the current situation of the ecosystems. A common simulation model applicable for the diverse ecosystems in the EANET region is highly desired. Trends of soil and/or inland water acidification should also be predicted in future.

33. Direct effects of air pollution on plants may also induce hydrological and biogeochemical effects in ecosystems. For example, it was suggested that ozone altered watershed hydrology due to its effects on leaf transpiration and water use of plants. Physiological changes of plants by air pollution may affect microbial community in soil. In the future simulation model, direct effects of air pollution/acid deposition on plants, and their relations to hydrological/ biogeochemical processes should also be taken into account.

34. The quality of inland waters is being measured at several sites under the inland aquatic environment monitoring (IAEM) program of EANET. In the revised *Technical Manual for IAEM - 2010*, importance of rivers/streams and their catchments is highlighted. The manual should be referred for catchment monitoring

in addition to the *Guideline*.

Identification of the areas susceptible to air pollution including acid deposition

35. Areas or regions susceptible to air pollution/acid deposition should be identified to conduct the monitoring effectively. As one of the previous activities in line with the *Strategy Paper*, a map of watershed sensitivity to acid deposition was developed by the NC in cooperation with the Task Force members, taking acid neutralizing capacity of soil and surface geology into consideration. The initial goal of the activity may be accomplished.

36. However, spatial distribution of air pollution/atmospheric depositions should also be taken into account to identify actual risks in the region. As a trial harmonized with this subject, one of the EANET countries developed the risk maps on acidification of soil and watershed and the maps of estimated growth reduction by ozone for representative species in their country. In the case of ozone, sensitivity of each tree species was also taken into consideration. In the trial above, outputs from numerical models on atmospheric depositions and ozone concentration were utilized to estimate the risks.

37. Possibility of utilizing numerical models for the spatial distribution should be considered to estimate actual risks at the national levels as well as regional levels. Moreover, spatial datasets on plant growth, such as NPP (net primary production) have recently been available for discussion on climate change. Such datasets may also be informative for discussion on possible risks on nitrogen deposition, since the growth rate must be related to nitrogen uptake in plants.

Up-scaling of the monitoring data and spatial evaluation

38. For spatial evaluation towards the long-term objective, up scaling of the monitoring data should be discussed as the next step. Use of the following methodologies should be discussed.

39. Based on the data in the basic survey and the catchment analysis, the condition of the region should be estimated by the appropriate spatial modeling, and then described on a map of the region. Regional data on atmospheric deposition may also be required for the evaluation.

40. Regional assessment of possible impacts on ecosystems requires spatial data on atmospheric deposition. Emission inventory and numerical model on transport and

chemical processes in the atmosphere are essential for this work. Further steps should be discussed in the EANET community.

41. Remote sensing technology may be helpful to describe the present condition on forest health decline based on the data from the basic survey. The *Sub-Manual* provides possible methodologies to utilize remote sensing technology. Satellite image analysis is one of the potential tools to detect changes in tree conditions, such as phonology, vitality of trees, etc. In particular for the susceptible areas to air pollution/acid deposition, which were identified by the previous work in the Task Force, applicability of the technique should be considered. Use of the existing datasets by the remote sensing technology should also be considered. Practical solutions to utilize such methodologies should be discussed in coming years.

IV. Collaboration with relevant networks/organizations

42. The progress of other initiatives in the Asian region related to air pollution/acid deposition may be useful to EANET soil and vegetation monitoring such as Long-range Transboundary Air Pollution in Northeast Asia (LTP) Project, Male Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia, etc. As for LTP Project, an expert meeting is held annually to share the information on the monitoring and modeling activities of the countries concerned. As for the Male Declaration, monitoring activities based on the action plan and establishment of the databases are promoted in each country.

43. In Europe and the North America, much experience has been accumulated. In particular, the Working Group on Effects (WGE) and its International Co-operative Programmes (e.g. ICP Forests, ICP Vegetation, ICP Waters, ICP Integrated Monitoring, etc.) under the CLRTAP (Convention on Long-range Transboundary Air Pollution) in Europe can provide much useful information for the East Asian activities, including its existing monitoring manual for UNECE region.

44. In the research field, the International Union of Forest Research Organization (IUFRO), International Long-Term Ecological Research Network (ILTER), and Asian Air Pollution Workshop (AAPW) may have the latest scientific information on terrestrial ecosystems. As for IUFRO, Unit 8.04.00, “Air pollution and climate change” may have relevant information. As for ILTER, collaboration with their national networks, such as Japan LTER network (JaLTER) and Philippines LTER network, can also be considered. As for AAPW, discussion sessions by scientists have been held annually to exchange the latest knowledge on air pollution impacts in

Asia.

45. Collaboration with these relevant networks/organizations should be promoted for future development of the EANET activities.

V. Overall strategy

46. The overall strategy to achieve the initial and long-term objectives described above can be described as shown in Figure 1.

47. The initial objective is to describe the present status on soil and vegetation in the EANET region, and it can also be one of steps toward the long-term objective.

48. For the long-term objective, another approach should also be promoted, especially for description of present status on ecosystem. To achieve these steps, some issues, such as promotion of catchment analysis and modeling, should be implemented.

49. Then, up scaling of these data should be discussed for spatial evaluation of impacts of acidifying species and related chemical substances in the EANET region.

VI. Acknowledgements

50. This *Strategy Paper* is a product of the scientific discussions of the members of the Task Force on Soil and Vegetation Monitoring. The brief history of the *Strategy Paper* is as follows:

- *Strategy Paper for Future Direction of Soil and Vegetation Monitoring of EANET*: adopted by SAC at its 2nd Session in Bangkok, Thailand in 2002
- *Strategy Paper for Future Direction of Soil, Vegetation and related Ecosystems Monitoring of EANET (2009-2014)*: adopted by SAC at its 8th Session in Hanoi, Vietnam in 2008
- *Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forests and Inland Water by Acidifying Species and Related Chemical Substances*: adopted by SAC at its 14th Session in Incheon, Korea in 2014
- *Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forests and Inland Water by Acidifying Species and Related Chemical Substances (update 2020)*: (to be) adopted by SAC at its 20th in 2020

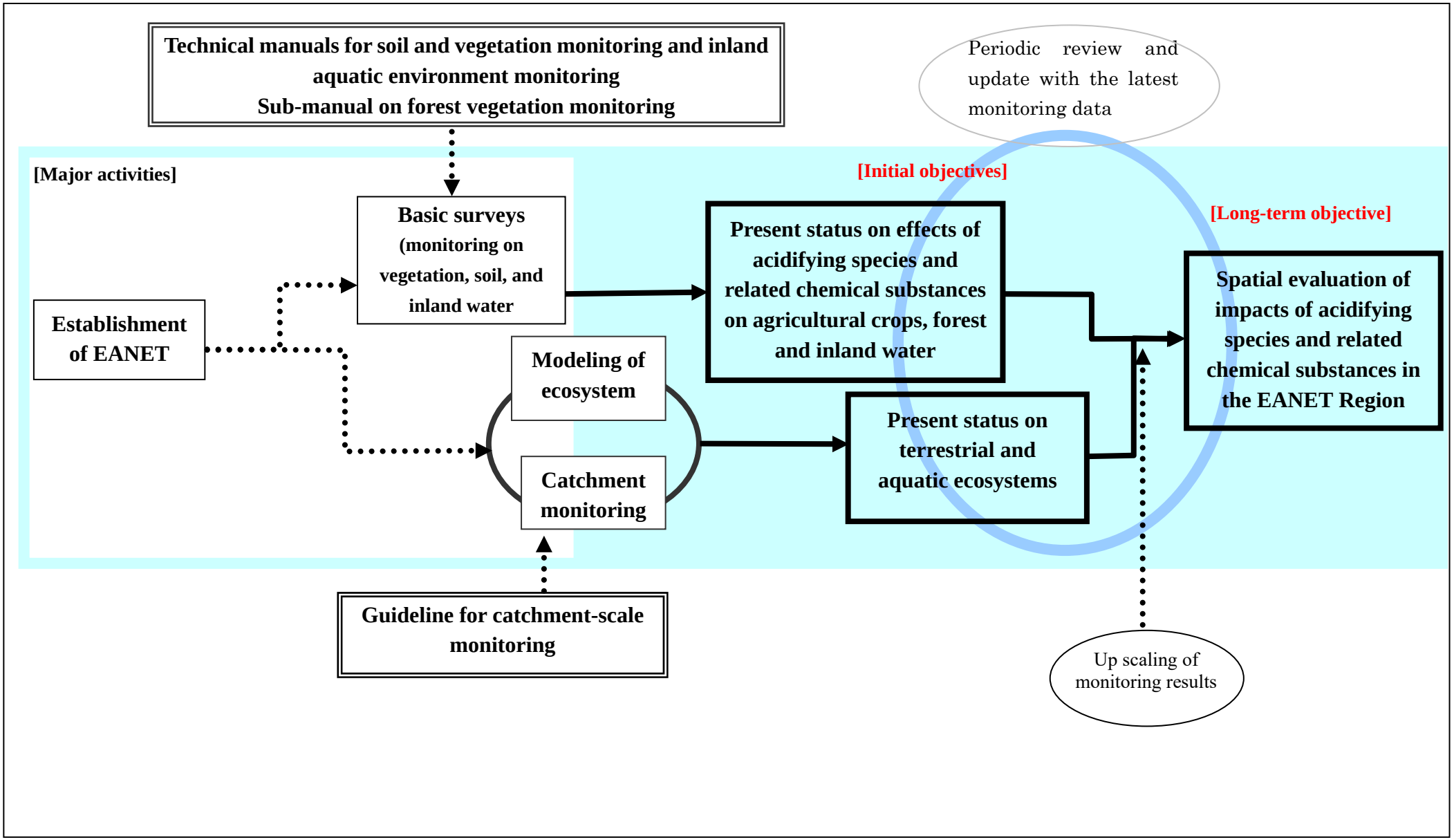

Figure 1. Overall strategy for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances

Annex

Specific activities for the term from 2021 to 2025

1. The following activities were selected as the specific works to be promoted for the period, taking account of priorities for the EANET and their feasibilities. Most of the activities may needs additional external funds to reach their milestones. The activities are expected to be implemented by forming sub-groups, if necessary.

2. To implement the specific activities effectively with assessment of the EANET data, clear subjects should be set for the term from 2021 to 2025. Taking account of the current situation of air pollution including acid deposition in the region, the following subjects can be considered:
   - Recovery of ecosystems from acidification: Phenomena suggesting the recovery and their relationship with air pollution/atmospheric deposition should be investigated. This is also important as validation of relevant measures/policies in the region and each country.
   - Loads of atmospheric nitrogen to ecosystems and its cycle: Nitrogen cycle is listed as one of the most important earth-system processes in the concept of "Planetary boundaries" and nitrogen cycle has already transgressed its boundary. Atmospheric nitrogen has the important role in nitrogen cycle.
   - Effects of ozone and PM on trees/crops: Ozone and PM are the current issue in the region. Ozone is the most important phytotoxic stressors.

   The interactions between air pollution and climate change should also be taken into consideration for the subjects above.

3. Part of outcomes from the specific activities will be included in the next periodic report of the EANET.

   i. Accumulation of information on air pollution effects in forest area and agricultural field

4. The latest scientific knowledge on air pollution effects in forest area and agricultural field will be exchanged/accumulated through the relevant scientific meetings, such as AAPW. The knowledge obtained will be shared among the EANET community as well as the Task Force members: annually

5. Because tropospheric ozone is still one of the most phytotoxic stressors, a project plan of the trial campaign for ozone effects in plants will be developed. External grants from competitive research funds should be obtained to implement the plan: in 2021-2022

6. The trial campaign is expected to be conducted by the collaboration among at least three or four countries, depending on grants obtained: in 2021-2023

7. Possibility of collaborating other regional networks, such as ICP Forests and ICP Vegetation, will also be considered to discuss ozone (or another air pollution) effects on the continental scale: in 2021-2023

ii. Promotion of catchment analysis

8. The regular catchment-scale monitoring in existing EANET sites will be continued by the respective countries. Technical/scientific cooperation among the relevant countries is effective for the continuous monitoring and assessment of the obtained data: annually/ periodically

9. The isotopic analysis has been applied to the EANET relevant catchment sites to clarify elemental dynamics in the forest ecosystems. The similar approach will be promoted at the national levels as well as the regional levels.

10. Effects of air pollution (such as ozone) on individual trees may also affect hydrological processes on the catchment scale, which is closely related to climate change. Multiple factors including climate change will be taken into consideration for assessment of air pollution impacts on forest catchments. New design/scheme on integrated assessment and monitoring will be discussed inside/outside the EANET community.

11. Efforts should be made to obtain competitive research grants for further promotion of the catchment analysis under changing environment..

iii. Promotion of regional impact assessment

12. The data on regional air pollution are expected to be complied and accumulated in the EANET region in the near future. Accordingly, air pollution modeling will be actively utilized in the EANET community. This will also contribute to regional assessment of air pollution impacts on forest ecosystems and crops. Referring to the outcomes from the “Workshop on regional impact assessment of atmospheric deposition and air pollution on forest ecosystems”, held on 21-22 November 2019, Niigata, Japan, possible design/ scheme on the regional impact assessment would be discussed within the term.

Appendix

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