Guidelines for Capacity Development of Air Pollution Prevention Measures Impacting Respiratory Health among the Thai Population in Eastern Thailand

Abstract:

This research aimed to: (1) examine and assess air pollution conditions and their impacts on respiratory health; (2) analyze the strengths and weaknesses of legal measures and operational practices; (3) investigate factors influencing the effectiveness of pollution prevention measures in the Eastern Region; and (4) develop capacity-building guidelines and propose policy recommendations. A mixed-methods research design was employed across seven Eastern provinces Rayong, Chonburi, Chanthaburi, Chachoengsao, Prachinburi, Trat, and Sa Kaeo implemented in four phases: (1) situational analysis through secondary data review and a survey of 400 participants; (2) policy measure analysis through 30 in-depth interviews and six focus group discussions; (3) participatory guideline development; and (4) data analysis and synthesis. The study was grounded in an integrative conceptual framework combining the DPSEEA model, capacity development theory, participatory concepts, and social-ecological perspectives.

The findings for the Eastern Region of Thailand revealed that PM2.5 concentrations averaged 35–45 micrograms per cubic meter, exceeding national standards, and were significantly and positively correlated with respiratory disease incidence rates ($r = 0.68$, $p < 0.01$). The highest-risk groups were children under five years of age (28.5%) and adults over sixty years of age (32.1%). Key weaknesses identified included insufficient inter-agency integration (78.3%), inadequate law enforcement capacity, and limited public participation.

The research produced a three-tiered capacity-building framework addressing individual, organizational, and systemic levels. Of the participants, 85.7% rated the proposed guidelines as beneficial and practically applicable. Novel contributions include an integrative conceptual framework previously absent from the Thai context, empirical evidence on pollution–health relationships, an interconnected three-tiered capacity development approach, effective stakeholder participation mechanisms, and a multilayered surveillance model. The authors conclude that capacity-building initiatives should simultaneously address all three levels through multi-sectoral collaboration, and that the developed framework for strengthening air pollution prevention measures as they relate to respiratory health among Eastern Thailand's population holds potential for broader application across other regions, with the capacity to sustainably reduce respiratory health impacts.

Key words: Air pollution, Respiratory health, Capacity development, Eastern region, Stakeholder participation

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Introduction:

Air pollution represents a major environmental and public health crisis of the twenty-first century. The World Health Organization has reported that air pollution caused approximately 6.7 million premature deaths globally in 2019, with the majority attributable to cardiovascular and respiratory diseases. In Thailand, this issue has escalated from a localized concern to a national crisis. The Pollution Control Department reported that between 2019 and 2023, more than 50 provinces experienced PM2.5 levels exceeding established standards, particularly during the dry season, resulting in significant public health impacts and substantial economic burdens.

Eastern Thailand encompasses seven provinces and plays a critical role in the national economy, contributing over 20% of the country's gross domestic product. The region is home to major industrial estates, most notably the Map Ta Phut Industrial Estatethe largest petrochemical industrial hub in Southeast Asia. Nevertheless, industrial development has led to the emission of pollutants from multiple sources, including factories, power plants, vehicular traffic, and construction activities. Available data indicate that air pollutant concentrations have periodically exceeded standard thresholds. The health consequences are clearly reflected in epidemiological data: the Department of Health has found that hospitalization rates for respiratory diseases in the Eastern Region exceed the national average, particularly for asthma, chronic obstructive pulmonary disease (COPD), and lower respiratory tract infections. High-risk populations include children under five years of age, adults over sixty years of age, individuals with chronic illnesses, and workers with high occupational exposure to pollutants. Beyond acute impacts, long-term exposure elevates the risk of serious chronic diseases such as lung cancer, stroke, and ischemic heart disease.

The government has sought to address these challenges through various mechanisms, including enforcement of the National Environmental Quality Promotion and Conservation Act B.E. 2535 (1992), establishment of emission standards, deployment of automated monitoring systems, and implementation of ad hoc measures. However, effectiveness remains constrained by several limitations: (1) insufficient inter-agency integration, leading to duplication or gaps in operations; (2) inadequate inspection and law enforcement capacity relative to the number and complexity of pollution sources; and (3) limited community participation due to insufficient knowledge and effective communication channels.

This research therefore aims to develop context-appropriate capacity-building guidelines for air pollution prevention measures in the Eastern Region. The specific objectives are to: (1) examine and assess current trends in air pollution and their impacts on respiratory health; (2) analyze the strengths and weaknesses of existing legal measures and operational practices; (3) investigate factors influencing the effectiveness of air pollution prevention measures as they relate to the respiratory health of the Thai population in the Eastern Region; and (4) develop capacity-building guidelines suited to the regional context, together with concrete policy and operational recommendations. The findings are expected to yield knowledge and practical guidance applicable at multiple levelspolicy, operational, and communityin order to support evidence-based decision-making, guide implementing agencies in improving operational mechanisms, and facilitate community participation in prevention and impact mitigation. Furthermore, the findings may be applied to other regions with similar characteristics, thereby contributing to the achievement of the Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-Being) and Goal 11 (Sustainable Cities and Communities).

Research Objectives

1. To examine and assess current trends in air pollution and their impacts on respiratory health.

2. To analyze the strengths and weaknesses of existing legal measures and current operational practices.

3. To investigate factors influencing the effectiveness of air pollution prevention measures as they relate to the respiratory health of the Thai population, with particular focus on the Eastern Region.

4. To develop context-appropriate capacity-building guidelines and propose concrete policy and operational recommendations.

Conceptual Framework

This research employs an integrative conceptual framework synthesizing multiple theories and concepts to provide a comprehensive basis for explaining and developing capacity-building guidelines for air pollution prevention measures, as appropriate to the context of Eastern Thailand. The framework is grounded in four core concepts:

1. The DPSEEA Framework (Driving Forces–Pressures–State–Exposure–Effect–Action) of the World Health Organization (Corvalán, Briggs, &Kjellström, 1996; WHO, 1999) constitutes a standard framework for the

systematic analysis of environmental health problems. This framework explains how Driving Forces—namely, industrial and economic development in the Eastern Region—generate Pressures in the form of air pollutant emissions from factories, vehicles, and various activities, which in turn affect the environmental State (i.e., atmospheric pollutant concentrations), resulting in human Exposure to pollutants, leading to adverse Effects on respiratory health, and necessitating Action for prevention and remediation. This framework facilitates an understanding of the causal mechanisms from upstream to downstream and enables the identification of appropriate intervention points at each stage.

2. Capacity Development Theory (UNDP, 2009; Eade, 1997) emphasizes that effective capacity development must encompass three levels: the Individual Level (e.g., developing the knowledge and skills of personnel in relevant agencies), the Organizational Level (e.g., improving organizational systems, structures, and resources), and the System Level (e.g., developing policies, legislation, and inter-agency coordination mechanisms). Effective capacity development must be implemented in an integrated manner across all three levels to achieve sustainable change (Baser & Morgan, 2008).

3. Multi-Stakeholder Engagement (Freeman, 1984; Ansell & Gash, 2008) holds that addressing air pollution requires collaboration across all relevant sectors, including the public sector (regulatory and law enforcement agencies), the private sector (industrial enterprises and business operators), civil society (non-governmental organizations and communities), and the academic sector (educational institutions and researchers). Each sector has distinct roles, responsibilities, and interests. Establishing effective participation mechanisms fosters shared understanding, acceptance, and collaborative commitment to prevention measures (Reed et al., 2009).

4. The Social-Ecological Model (Bronfenbrenner, 1979; McLeroy, Bibeau, Steckler, & Glanz, 1988) recognizes that health and environmental problems are shaped by multiple overlapping levels of influence, including the individual level (knowledge, attitudes, and behaviors), the community level (social norms, support networks), the organizational level (organizational policies and operational systems), and the public policy level (legislation, national and local policies). Effective prevention measures must account for factors operating at all levels, as well as the interrelationships among them (Stokols, 1996).

Drawing on the integration of these four core concepts, the research framework comprises four interrelated components. The first is Input Factors, encompassing the air pollution situation, health impacts, existing resources and capacities of relevant agencies, and the contextual characteristics of Eastern Thailand. The second is Process, covering the analysis of existing prevention measures, investigation of success factors and obstacles, stakeholder engagement, and development of capacity-building guidelines. The third is Output, comprising the guidelines and policy and operational recommendations developed through the research. The fourth is the anticipated Outcome, including more effective prevention measures, reduced respiratory health impacts on the population, and sustainable air pollution management.

This framework also takes into account the specific context of Eastern Thailand, which presents both opportunities and challenges. Key opportunities include a robust economic base, technological readiness, and the presence of strong academic institutions and research centers. Key challenges include the diversity and complexity of pollution sources, the tension between economic development and environmental conservation, and resource constraints in law enforcement. An appreciation of these contextual factors ensures that the developed guidelines are both contextually appropriate and practically implementable.

Materials and Methods

This study employs a Mixed Methods Research design integrating both quantitative and qualitative approaches, characterized as a Descriptive-Analytical Research study and a Development Research study, in order to obtain comprehensive data capable of fully addressing the research objectives.

The research was implemented in four sequential phases (Sequential Exploratory Design), with each phase interconnected and mutually reinforcing.

Study Area and Sample

The research was conducted in Eastern Thailand, with primary study sites selected across seven provinces: Chonburi, Rayong, Chanthaburi, Chachoengsao, Prachinburi, Trat, and Sa Kaeo—provinces characterized by high industrial density and persistent air pollution challenges. Site selection employed purposive sampling, with consideration given to the severity of pollution, diversity of industrial types, and demographic characteristics of communities. The study sample comprised four primary groups: (1) 60 personnel from government agencies involved in pollution control and public health; (2) 45 executives and officers from private enterprises and industrial facilities; (3) 50 community leaders and civil society representatives; and (4) 25 academics and specialists in environmental science and public health; totaling 180 participants.

Research Procedures

Phase 1 – Situational and Impact Analysis: Secondary data were collected and analyzed from databases of the Pollution Control Department, the Department of Health, and automated air quality monitoring stations in Eastern Thailand, to analyze trends in air pollutant concentrations and respiratory disease statistics over the preceding five years (2021–2026). Primary data were also collected through a questionnaire survey administered to 400 residents of at-risk areas, examining levels of awareness, attitudes, and self-protective behaviors against air pollution. Quantitative data analysis employed descriptive statistics, inferential statistics, and correlation analysis to examine the relationship between pollution levels and disease incidence.

Phase 2 – Policy Measure and Success Factor Analysis: Qualitative research methods were employed, including in-depth interviews with 30 executives and officials responsible for pollution prevention measures from various agencies, and six focus group discussions stratified by sector, to elicit views on the strengths, weaknesses, opportunities, and obstacles of current measures. Data analysis utilized content analysis and SWOT analysis to identify key issues and factors influencing the effectiveness of prevention measures.

Phase 3 – Capacity-Building Guideline Development: Participatory Action Research was employed through four stakeholder dialogue forums and workshops involving representatives from all sectors, to collaboratively develop context-appropriate capacity-building guidelines. Brainstorming, Mind Mapping, and the Nominal Group Technique (NGT) (Delbecq et al., 1975) were utilized to systematically elicit and integrate stakeholder input into the guideline development process.

Phase 4 – Data Analysis, Synthesis, and Report Preparation: Drawing on findings from the preceding phasesincluding document review, qualitative research, in-depth interviews with industrial stakeholders, and engagement with relevant government officials in pollution control and public healthdata were recorded, analyzed, and synthesized to produce research reports, academic articles, and policy recommendations for relevant government and private sector agencies. These outputs are intended to raise awareness of environmental pollution and to advance capacity-building guidelines for air pollution prevention measures among communities residing in Eastern Thailand.

Results

This research examined guidelines for the capacity development of air pollution prevention measures affecting the respiratory health of the Thai population in Eastern Thailand, using purposive sampling across all seven provinces: Chonburi, Rayong, Chanthaburi, Chachoengsao, Prachinburi, Trat, and Sa Kaeo. The findings are summarized by thematic area as follows.

1. Air Pollution Situation and Health Impacts

Secondary data analysis from the Pollution Control Department for the period 2021–2026 revealed that PM2.5 concentrations in the Eastern Region averaged 35–45 micrograms per cubic meter, exceeding the national ambient air quality standard of 25 micrograms per cubic meter (Pollution Control Department, 2023). During the dry season months of January through April, PM2.5 levels frequently exceeded 50 micrograms per cubic meter for several consecutive weeks. Additionally, concentrations of PM10, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds (VOCs) in certain areasparticularly within a 5-kilometer radius of industrial estatesexceeded standards during periods of intensive production activity.

Data from the Ministry of Public Health indicate that the hospitalization rate for respiratory diseases in the Eastern Region stood at 156.8 per 1,000 population, surpassing the national average of 128.3 per 1,000 population (Ministry of Public Health, 2023). The most prevalent diseases were asthma (23.4%), COPD (18.7%), and lower respiratory tract infections (31.2%). Correlation analysis revealed a statistically significant positive association ($r = 0.68$, $p < 0.01$) between PM2.5 concentrations and respiratory disease case counts. The most severely affected groups were children under five years of age (28.5% of all cases) and adults over sixty years of age (32.1%).

The population survey of 400 respondents found that 67.3% had low to moderate knowledge of air pollution's health impacts, and only 42.8% demonstrated appropriate self-protective behaviors, such as wearing face masks on high-pollution days, avoiding outdoor activities, and regularly monitoring air quality information.

2. Analysis of Current Prevention Measures

In-depth interviews and focus group discussions identified four main categories of existing air pollution prevention measures: (1) source control measures, including factory emission standards and vehicle emission inspections; (2) monitoring and surveillance measures, including installation of automated air quality monitoring stations and alert systems; (3) risk communication measures, including dissemination of air quality data via applications and websites and public health campaigns; and (4) emergency measures, such as mandated reductions in production activities during severe pollution events.

SWOT analysis revealed that the strengths of existing measures include clear laws and standards, advanced monitoring technology, and comprehensive data systems. However, key weaknesses include: (1) lack of inter-agency integration, with 78.3% of informants identifying duplication or gaps in operations; (2) insufficient law enforcement capacity, particularly concerning small-scale and mobile emission sources; (3) limited resources and budgets, especially at the local administrative organization level; and (4) inadequate engagement from the private sector and the general public.

3. Factors Influencing the Effectiveness of Air Pollution Prevention Measures

Content analysis of interviews and focus group discussions identified five key factors affecting the success of prevention measures: (1) political commitment and support from senior management; (2) effective inter-agency coordination mechanisms; (3) personnel capacity and competency in implementing measures; (4) participation and cooperation from the private sector and the public; and (5) adequacy of resources and technology.

The four stakeholder groups held distinct expectations and needs. Government agencies sought more effective tools and guidelines for law enforcement. The private sector required clarity on standards and technical support for emission reduction. Communities needed accessible information and meaningful participation channels. The academic sector emphasized the need for data and research to develop locally appropriate measures.

4. Capacity-Building Guidelines for Air Pollution Prevention Measures

Drawing on Participatory Action Research workshops, the study developed capacity-building guidelines across three levels:

Individual Level: (1) Development of practical training curricula for personnel in relevant agencies, covering measurement techniques, data analysis, and law enforcement; (2) preparation of standardized operational manuals for each type of prevention measure; (3) establishment of knowledge-exchange networks among personnel across regions; and (4) development of appropriate communication media and channels for public education.

Organizational Level: (1) Establishment of provincial air pollution management coordination centers to link the operations of various agencies; (2) development of a centralized, shared database accessible to all relevant agencies; (3) adequate and sustained allocation of budgets and resources; (4) development of systematic monitoring and evaluation systems with clear performance indicators; and (5) creation of mechanisms for private sector and community participation in planning and implementation.

System Level: (1) Revision of laws and regulations to be appropriate and up-to-date; (2) development of an integrated regional air pollution management policy; (3) establishment of formal inter-agency coordination mechanisms at the policy level; (4) promotion of technology and innovation to reduce and control pollution; and (5) development of incentive systems and support measures for the private sector to reduce emissions.

The research demonstrates that capacity development for air pollution prevention measures must be implemented in an integrated manner across all three levels simultaneously and requires collaboration from all relevant sectors. The developed framework can be adapted for application in regions with similar contextual characteristics and holds potential to sustainably reduce respiratory health impacts among the Eastern Thai population.

Discussion

This research has generated eight principal contributions of theoretical and practical value:

1. Integrative Conceptual Framework for Pollution Prevention Capacity Development: The study developed an integrative framework synthesizing four theoriesthe DPSEEA framework, Capacity Development Theory, Multi-Stakeholder Engagement concepts, and the Social-Ecological Model. This represents a novel integration within the context of air pollution management in Thailand, demonstrating that capacity development must proceed systematically and comprehensively across all dimensions simultaneously to achieve sustainable outcomes.

2. Empirical Evidence on Pollution–Health Relationships: The research presents clear evidence of associations between air pollutant levels (PM2.5, PM10, SO2, NO2, VOCs) and respiratory disease incidence rates in Eastern Thailand, reporting a high correlation coefficient ($r = 0.68$, $p < 0.01$) and identifying children under five and adults over sixty as the highest-risk groups. These findings provide an essential foundation for designing effective targeted protective measures.

3. A Three-Tiered Capacity-Building Approach Suited to the Local Context: The study developed concrete and operationally viable guidelines encompassing all three levelsindividual, organizational, and systemic. It was found that development at each level is interrelated and mutually reinforcing; development at any single level alone is insufficient to produce sustainable change.

4. Effective Stakeholder Participation Mechanisms: The research developed and tested stakeholder participation mechanisms, identifying three essential components: (1) a clear and formalized structure; (2) an open and transparent process, such as the NGT technique; and (3) continuous information-exchange mechanisms. The study also found that the roles and expectations of different sectorsgovernment, private sector, community, and

academiadiffer significantly, making the creation of an inclusive space responsive to all groups a critical success factor.

5. Success Factors and Barriers in Industrial Area Contexts: The research identified the five most influential factors: political commitment, coordination mechanisms, personnel capacity, private sector participation, and resource adequacy. In high-density industrial areas, the greatest challenge was found not to be lack of technology or technical expertise, but rather lack of integration and trust among sectors.

6. A Multi-Tier Monitoring Model: The study developed a surveillance concept integrating three components: (1) permanent automated monitoring stations; (2) mobile monitoring units; and (3) community participation in incident reporting. This was motivated by the finding that conventional monitoring systems may be inadequate to reflect actual conditions in areas with diverse and complex pollution sources.

7. Effective Risk Communication Approaches: The research developed insights into the importance of tailoring communication to the varying levels of knowledge, attitudes, and behaviors of target groups, finding that information provision alone is insufficient. Concrete motivational and supporting measures are also required, such as distributing high-quality face masks, establishing pollution-free spaces, and developing real-time air quality applications with actionable guidance.

8. Resource-Constrained Management Strategies: The research identified effective strategies including Prioritization, Resource Sharing, and collaborative networking. Specifically, investing in community and private sector capacity development as partners in pollution surveillance and control was found capable of substantially reducing the burden on government and improving overall system efficiency without requiring significantly increased public expenditure.

In the researchers' assessment, these eight novel contributions represent an interdisciplinary synthesis that offers concrete and actionable guidance for developing air pollution prevention capacity in complex, high-density industrial contexts. These contributions are applicable to other regions with similar characteristics, provide a foundation for future research, and serve as important evidence to support the formulation of local and national policies and action plans for sustainable air pollution management.

Conclusion

The research on Guidelines for Capacity Development of Air Pollution Prevention Measures Impacting Respiratory Health among the Thai Population in Eastern Thailand yielded several key findings that merit discussion in relation to relevant theory and prior research, as follows.

1. Relationship between Air Pollution and Respiratory Health: The high correlation ($r = 0.68$, $p < 0.01$) found between PM2.5 levels and respiratory disease incidence is consistent with the WHO (2021) finding that air pollution is a major risk factor for respiratory disease globally. However, the correlation observed in this study is higher than that reported in other urban areas of Thailand, where values typically range from 0.45 to 0.55 (Thepnuan et al., 2019). This may reflect the distinctive characteristics of Eastern Thailand, where high industrial density and the simultaneous emission of multiple pollutants generate cumulative effects and complex atmospheric chemical reactions. Furthermore, the identification of specific high-risk groups (children under five and adults over sixty) is consistent with Bronfenbrenner's (1979) Social-Ecological Model, which emphasizes that individual-level factors such as age and immune status significantly influence health risk.

2. Effectiveness of an Integrated Capacity-Building Approach: The finding that simultaneous development across all three levels (individual, organizational, and systemic) is more effective than single-level development

supports the capacity development theories of UNDP (2009) and Baser and Morgan (2008), which hold that sustainable development must occur across all levels of a system. This finding is particularly significant because previous research in Thailand has predominantly focused on single-level capacity developmentsuch as personnel training (individual level) or policy development (system level)without accounting for the interconnections among levels. The pilot finding that 85.7% of participants rated the guidelines as beneficial and practically applicable demonstrates both the appropriateness and feasibility of the developed approach.

3. Importance of Multi-Stakeholder Participation: The finding that participation from all sectors is a critical success factor for prevention measures is consistent with the frameworks of Freeman (1984) and Ansell and Gash (2008). The discovery that the greatest challenge is not lack of technology but rather lack of trust among sectors underscores that addressing pollution in industrial areas requires social and political dimensions beyond purely technical solutions. The use of the NGT technique to build consensus, consistent with the principles of Delbecq et al. (1975), enabled all sectors to express views equitably and mitigated dominance by any single group.

4. Application of the DPSEEA Framework in a Local Context: The application of the DPSEEA framework (Corvalán et al., 1996; WHO, 1999) to analyze air pollution in Eastern Thailand demonstrated its suitability for explaining causal pathways from driving forces to health impacts and remedial action, particularly in identifying appropriate intervention points at each stage. However, this research found that in areas with complex pollution sources, Action must occur simultaneously at multiple points in the DPSEEA chain, not merely at the endpoint. This represents an extension of understanding regarding the application of this framework in complex contexts.

Acknowledgments

Based on the research findings and novel contributions presented above, the following policy recommendations are proposed:

1. Policy Level: Government agencies should establish a regional air pollution management coordination center to link the operations of various agencies in Eastern Thailand, with clearly defined legal structures and mandates. Furthermore, laws and regulations should be revised to be appropriate for high-density industrial contexts, particularly by setting emission standards for small-scale and mobile pollution sources not currently subject to stringent controls. An integrated interprovincial air pollution management policy for Eastern Thailand is also necessary, given that pollution does not respect administrative boundaries. Critically, sufficient and sustained budgetary allocations are required for personnel capacity development, monitoring equipment procurement, and prevention measure implementation.

2. Operational Level: Government agencies should develop a centralized, shared database encompassing air quality data, health data, and pollution source information, which will improve analytical capacity and decision-making. Practical training programs for personnel on measurement techniques, data analysis, and law enforcement should be conducted continuously, two to three times per year. A multi-tier surveillance system integrating automated monitoring stations, mobile monitoring units, and community participation should be developed, accompanied by a rapid response unit for deployment during severe pollution events. A systematic monitoring and evaluation system with clear performance indicators and regular quarterly reporting should also be established.

3. Private Sector and Industry: Investment in technologies and management systems to reduce emissions is essential, particularly clean technologies and renewable energy. The private sector should establish real-time emission monitoring and reporting centers with publicly disclosed data to foster community trust and transparency. Development and regular rehearsal of emergency pollution management plans, coordinated with local authorities and surrounding communities, are necessary. The private sector should support research and development to identify emission reduction approaches suited to their production processes, in collaboration with academic and research

institutions, and should contribute to health and environmental activities in surrounding communities, such as supporting green spaces, distributing face masks, and providing free health screenings.

4. Communities and Civil Society: Establishing community-based air pollution surveillance networks with trained volunteers to observe and report incidents would substantially enhance monitoring effectiveness. Communities should develop skills in accessing and using air quality information, as well as appropriate self-protection practices—particularly among high-risk groups. Participation in policy formulation and prevention measure development through formal channels, such as public hearings and committee membership, will help ensure that measures respond to community needs. Communities should also establish internal communication mechanisms to share information and experience, and promote behavioral changes that reduce pollution generation, such as using public transportation, reducing open burning, and planting trees.

5. Academic Institutions and the Research Sector: Development of air pollution management curricula linking theory with practice and emphasizing interdisciplinary learning is important. Establishing a Center of Excellence for Air Pollution Management in Eastern Thailand would serve as a valuable resource for data, research, and advisory services. Academic institutions should develop research tools and approaches appropriate to the local context, emphasizing applied research with real-world utility. Supporting collaborative research with government and private sector partners will ensure that research addresses genuine needs, and disseminating knowledge and research findings to the public in accessible formats will enhance the utilization of research outcomes.

The integrated and sustained implementation of these recommendations will strengthen air pollution prevention measures for greater effectiveness and sustainability, thereby improving air quality and long-term population health in Eastern Thailand and providing a valuable model for other regions facing similar challenges.

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