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Chapter

Guidelines for Environmental Noise Management in Developing Countries

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Abstract

This chapter describes the challenges of environmental noise policies and governance, noise emissions, noise transmission modeling, and those of health and economic risk assessment in developing countries. It bases on an analysis of current legislation regarding noise pollution in major developing countries in Asia, Africa, and Latin America. Although legislators are engaged in promulgating laws and regulations explicit procedures for noise measurement, noise mapping, development of a healthy and comfortable soundscape, and the implementation and enforcement of legislation are rarely developed. A strategic framework approach is needed to overcome these challenges and enable countries to achieve sustainable environmental noise management. Guidelines are provided to resolve these tasks to better protect the population of urban areas against the health end economic impacts of environmental noise.

Keywords: guiding principles, noise policies, governance, information challenges, health and economic risk assessments

1. Introduction

The World Health Organization (WHO) has considered environmental noise (also called community noise, domestic noise, or residential noise) in its environmental health criteria and guideline documents an important problem since the 1970s [1–4]. In the earliest document of 1980 noise is explicitly ‘considered to be any unwanted sound that may adversely affect the health and well-being of individuals or populations,’ and the later documents do not redefine the term. This definition is often incorrectly quoted as ‘noise is unwanted sound’, see for example [5, 6]. The WHO Guidelines for Community Noise define environmental noise as noise emitted from all sources, except noise at the industrial workplace [2].

Exposure to environmental noise has several impacts on human health and the environment, which have social and economic implications. These include [4, 7]:

• Cardiovascular diseases

• Increases in cardiovascular symptoms (e.g. blood pressure)
• Hearing impairment
• Cognitive effects
• Speech interference
• Sleep disturbance
• Performance deficits
• Annoyance
• Tinnitus
• Mental health effects.

The extent of the environmental noise problem is large [8]. In the European Union (EU) an estimated 113 million people are exposed to long-term day-evening-night traffic noise levels of at least 55 dB(A). 22 million people are exposed to high levels of railway noise, and 4 million to high levels of aircraft noise. Long-term exposure to environmental noise is estimated to cause 12,000 premature deaths and contribute to 48,000 new cases of ischaemic heart disease per year. 22 million people are estimated to suffer chronic high annoyance, and 6.5 million people suffer chronic high sleep disturbance. In 2011, the WHO estimated that the disability-adjusted lost life years (DALYs) due to environmental noise exposure in EU countries amounted to 60,000 years for ischaemic heart disease, 45,000 years for cognitive impairment of children, 903,000 years for sleep disturbance, 21,000 years for tinnitus, and 654,000 years for annoyance [9].

In developing countries, urbanization, industrialization, and vehicle fleet growth have increased noise emissions and immissions1 in densely populated areas. Exposure to environmental noise significantly threatens human health and the quality of life of millions of people. Cities such as Bangkok [10], Cairo [11], Jakarta [12] and many others [13] are now having to take action to enhance their institutional and technical capabilities to estimate and control noise exposure and implement preventive actions to reduce the risks that noise poses to their citizens [14]. Data reported from 28 cities of low-and middle-income countries were found to have equivalent sound pressure levels for daytime hours of 55–91 dB(A) [13]. Night-time equivalent sound pressure levels ranged between 42 and 80 dB(A). Corresponding noise-induced impacts included high annoyance, sleep disturbance, and persistent hearing loss [13].

The degree of environmental noise exposure of urban populations is directly related to the level of society’s development in a country. Societal development results in an increase in the levels of urbanization, industrialization, and transportation systems. Without appropriate intervention, environmental noise and the noise impact on communities will increase. Governments are responsible to promulgate, implement and enforce strong environmental noise strategies, policies, laws, and regulations, which are suitable to control environmental noise. Failure to do this will make it

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1 The term ‘imission’ is used here instead of the term ‘immission’ (used in the literature and pronounced ‘aimission’) because its pronunciation is more logical to distinguish it from the term ‘emission’.

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impossible to prevent a continuous increase in environmental noise pollution, and
governments will be ineffective in combating it.

Mandatory noise emission and noise immission standards at the national, regional,
and municipal levels are the usual instruments of a governmental ‘Command and
Control’ approach. Regulatory standards strongly depend on a country’s risk manage-
ment strategy, its socio-political situation, its technical and instrumental capacities
and capabilities, costs of compliance, and the existence of international agreements
and guidance documents such as those of the WHO. While countries’ mandatory
noise emission and immission standards usually are country-specific, in general, the
following issues are to be considered [2]:

• Identification of the adverse public health impacts and the population to be
  protected.

• The indicators for noise immission and their ranges.

• Applicable methodologies for noise monitoring, noise mapping, and noise
  transmission modeling.

• Procedures for testing compliance of sound pressure level indicators with noise
  mandatory standards.

• Standard operating procedures for control of emissions.

• Mandatory emission standards.

• Identification and implementation of responsible authorities tasked with the
  enforcement of regulations.

• Procurement of sufficient funding.

The Command-and-Control approach for emission and immission control at the
national, regional or municipal levels strongly influences the implementation and
enforcement of noise control policies. If regulatory standards are exceeded action
plans to mitigate noise exposure, which address all relevant sources of noise pollution,
must be drafted, implemented and enforced.

In principle, there is a need for a strategic approach (SA) on Environmental Noise
Management (ENM) in developing countries to assist decision-makers and stake-
holders to formulate and implement effective ENM strategies [15].

The Inter-Noise 2007 Workshop on Environmental Noise Management in Devel-
oping Countries observed [15]:

• The importance of an overall strategy. Although a step-by-step programme of
  implementation of environmental noise policies is probably the realistic way
  forward it should be done in the context of a clear, strategic approach. Most
developing countries lack this.

• The importance of the implementation and enforcement of environmental
  noise policies. Quite a few developing countries have promulgated noise policies,
  but the implementation and enforcement of them are poor. This is partly the
result of a lack of political will and partly because of the cost. Because it is unrealistic to expect implementation and enforcement to rapidly improve a step-by-step approach would be more realistic.

- **The importance of active citizens’ groups.** Due to poor understanding of the impacts of environmental noise among both politicians and the public the effect on stress levels, health, quality of life etc. — there is little pressure on governments from citizen groups for action to be taken. Only when these impacts are better understood will governments be motivated to tackle environmental noise and will citizens demand that noise be taken seriously. There are citizen groups in a few developing countries, however, protesting about aircraft noise and about increasing noise from traffic on existing roads.

- **The importance of low-cost solutions.** At present tackling environmental noise is not a political priority for most developing countries. Therefore, it is going to be particularly difficult to persuade them to put an effective environmental noise strategy in place if they believe it is going to cost a lot of money. Therefore, low-cost solutions are important. It also is important to highlight the cost–benefit advantages of tackling environmental noise, for example, money spent on noise reduction could result in savings on health costs.

- **The importance of not re-inventing research, policy and practice.** Developing countries can use the research that has already been done by some countries such as the United Kingdom and, more importantly, international organizations such as the WHO and the International Civil Aviation Organization (ICAO), even though many of these bodies are basing their recommendations on experience from developed countries. In fact, developing nations should get involved as they may bring a new fresh perspective to their deliberations.

The aim of ENM is to enable government authorities to design policies and strategies to achieve and maintain a low-noise soundscape and reduce environmental noise impacts on human health and protect animals against noise exposure. To implement a low-noise soundscape, governmental authorities, in collaboration with other stakeholders, must consider the local circumstances with respect to background noise levels and the available technological and instrumental capacities and capabilities. In addition, responsible authorities must also account for extant cultural and social conditions and the financial and human resources available.

Several factors determine an effective ENM strategy. These include the knowledge of relevant environmental noise sources, the application of models for noise transmission and noise mapping, and procedures for the assessment of noise exposure and its related health and environmental impacts. The promulgation, implementation, and enforcement of emission standards and health-based emission standards are also needed as well as a range of cost-effective noise exposure control measures. Responsible authorities must be empowered to implement and enforce control measures. A simplified cycle of ENM is depicted in Figure 1 [16, 17].

There are a lot of different stakeholders involved in ENM. These include politicians, political advisors, technology officials, policy analysts, communities, researchers, interest groups, and acoustic professionals. The interaction of these players with the policy stages involved in ENM is shown in Figure 2.
A SA on ENM in developing countries systematically encompasses the most important components of comprehensive ENM. It is a flexible, rational, and broad high-level approach that is adaptable to the needs of different countries and cities. It
helps guide national and local governmental authorities and other stakeholders who have a role to play in ENM. Governmental authorities in collaboration with relevant stakeholders can formulate and implement ENM strategies and programmes to prevent further deterioration of sound pressure levels. Stakeholders include the judiciary, the private sector, civil society including non-governmental organizations, the media, academia, development agencies and financial institutions.

This chapter does not develop such a SA but outlines guidelines to develop a SA and, by its realization, implementation and enforcement help reduce the health impacts of different types of environmental noise such as noise from road traffic, railways, airports and low-flying aircraft, industries, residences, leisure facilities, shooting ranges, outdoor appliances and ships in or close to ports.

2. Problem description

Guiding principles related to ENM aim to ensure the protection of human health from environmental noise. ENM should first be based on the polluter pays principle, the precautionary principle, the prevention principle, and the principle of

| Access to Environmental Information: | all stakeholders should have access to information regarding Noise |
| Awareness: | Provision of information to all stakeholders |
| Best practice: | application of state of the technology |
| Co-benefits: | consideration of the benefits of integrated ENM, air pollution management including greenhouse gas reduction |
| Coherence: | orientation of the efforts of all stakeholders including different neighboring jurisdictions towards a common objective. |
| Concerted effort: | discussion and cooperation among all stakeholders involved |
| Continual Improvement: | to promote the continual improvement of ENM as well as the reduction of noise itself |
| Cost-effectiveness: | ENM measured at least cost and highest effectiveness |
| Decentralization: | implementation of decentralized ENM with regional, national and local components |
| Equity: | fair and equal protection of all people from noise exposure and consideration of individual vulnerability |
| Integrated approach: | development of integrated ENM (prevention, monitoring of adverse impacts, control of sources and education) |
| Opportunity: | sound solutions to noise problems at the suitable moment |
| Participation: | active participation of the population in the development and implementation of the plans to minimize noise pollution and prevent the increase of noise levels |
| Polluter Pays Principle: | individuals responsible for noise pollution should bear the cost of its consequential impacts |
| Precautionary Principle: | where there are threats of serious or irreversible health damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent higher noise levels |
| Prevention principle: | action should be taken where possible to reduce noise at the source |
| Stakeholder: | Commitment of all stakeholders to noise management |
| Sustainability: | development of economically and socially compatible ENM which is sustainable over the long term and future generations |
| Stepwise approach: | ENM follows a target and milestone approach |
| Universality: | comprehensive ENM including human health |

Box 1.
The guiding principles of ENM.
participation of all stakeholders, including the population [2, 19]. The principle of participation requires the commitment of all stakeholders to ENM, their access to information regarding environmental noise, the raising of stakeholder awareness, equity with respect to the protection of the public against noise exposure, and the orientation of all stakeholders towards a common objective (coherence) in a concerted effort. Secondly, any ENM approach should be integrated with the more general efforts of environmental protection against all kinds of pollution to fully exploit the benefits of integrated solutions. Thirdly, an ENM approach should develop sound solutions that are compatible with national, regional, and local needs and, consequently, can be implemented in a decentralized way with due consideration of local capacities at least costs and highest efficiency. Fourthly, as developing countries always suffer from lack of appropriate funds, ENM is to follow a stepwise approach by setting achievable targets and milestones. Finally, ENM should be sustainable in the sense used by the WSSD report [20] and comprehensive with respect to public health protection.

However, in developing countries economic, institutional, and political constraints may hamper the full implementation of these principles.

The guiding principles are defined and summarized in Box 1 [19].

3. Challenges in developing countries and guidelines for overcoming them

Challenges with respect to ENM exist in the fields of [13, 15–17, 21–24].

• Environmental noise policies.
• Environmental noise governance.
• Information on environmental noise emissions.
• Environmental noise modeling.
• Environmental noise monitoring.
• Health and economic risk assessments.
• Financing environmental noise management.

The following procedures to help governmental authorities in collaboration with other stakeholders to overcome these types of challenges are specified in Sections 3.1–3.6 [17, 20]:

• Identify:
  ◦ Appropriate policies on environmental noise.
  ◦ Relevant legislative and regulatory requirements.
  ◦ Important sources of environmental noise caused by human activities.
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- **Set:**
  - Appropriate objectives and targets for human (and animal) health.
  - Priorities and milestones for achieving objectives and targets.

- **Establish:**
  - Policies, strategies, laws, and regulations on environmental noise.
  - A structure and programmes to implement policies and achieve objectives and targets.

- **Facilitate:**
  - The modeling of environmental noise.
  - The estimation of effects on human health (and animals).
  - Urban planning, corrective action, and the prevention of adverse effects.

- **Ensure compliance with emission and noise standards.**

- **Account for changing circumstances.**

In addition, the barriers stated above can be overcome by:

- **Gaining:**
  - Ministerial support in developing countries for a rational ENM.
  - Support from international agencies, especially regarding technical and financial means needed.

- **Undertaking cost–benefit analyses and health impact studies.**

### 3.1 Challenges in developing countries in the field of environmental noise policies and guidelines to overcome them

Environmental noise policies aim at including and/or strengthening the concept of environmental noise, human (and animal) health in policies, legislation and its harmonization, implementation, and enforcement in the development of developing countries and countries in transition. As Figure 1 and the discussion above show, several factors determine an effective and rational ENM strategy. These include noise monitoring networks, models for the transmission of sound pressure levels, noise mapping, assessments of human exposure and impacts, and the promulgation of emission standards and imission health-based standards. In addition, several cost-effective noise exposure control measures are necessary, together with the legislative powers and human and financial resources to implement and enforce them.
The following ‘challenges’ to achieve this aim have been reported in the context of environmental laws and politics which also analogously apply to noise legislation [17, 25, 26]:

• Low government commitment to ENM policies, their implementation and enforcement. A recent report from Kenya states that the Environmental Management and Coordination Act ‘has been unable to ensure that the country fully addresses present-day environmental challenges’ [27]. Similarly, a report on Nigeria’s environmental governance framework has identified that it is ‘ineffective in dealing with the country's environmental challenges’ [28].

• Limited
  
  ○ coordination and integration of ENM policies with other sectoral policies and plans [29, 30].
  
  ○ collaboration of different responsible agencies [25].
  
  ○ institutional capacity to implement and enforce ENM legislation and policies [31].
  
  ○ control of corruption [32].

• Absence of risk-based approaches, which form a part of ENM policies and legislation [33].

• Limited appropriate review mechanisms to evaluate policies for noise mitigation measures [34].

• Absence of soundscape policies to judge exposure to a combination of noises from different sources [35].

• Lack of:
  
  ○ Criteria for guidelines/standards for compliance testing [31, 36].
  
  ○ Stakeholder participation (particularly of industry, manufacturers, urban planners, transport planners, transport associations, the informal sector, health communities, enforcement institutions and financial institutions) to formulate and implement ENM policies [25, 27].
  
  ○ A detailed cost–benefit analysis of policy measures [2].
  
  ○ Monitoring and modeling environmental noise levels [30].
  
  ○ Assessment of impact on human health and environment due to noise exposure [30].
  
  ○ Reports on sound pressure levels and their impacts in a transparent way [30].
Information sharing to the public on the effects of environmental noise, raising awareness and promoting participation and engagement [30, 37].

• Use of obsolete emission and imission standards [30].

‘Guidelines’ for overcoming the main challenges of environmental noise policies include [16, 19]:

• The adverse impacts of environmental noise pollution on health and the environment can be mitigated, once ENM is acknowledged as an objective for sustainable development and made an integral part of the overall policy framework and is considered in specific policies such as land use planning, energy, transport, and industrial development.

• In emission and imission standard setting, social equity and fairness to all stakeholders involved (e.g. industry, local authorities, non-governmental organizations, media and the public) can be ensured if a participatory approach is followed – as far as possible and meaningful.

• In setting exposure standards and averaging times, the globally applicable WHO Guidelines for Community Noise [2], the WHO Night Noise Guidelines for Europe [3] and the WHO Environmental Noise Guidelines for the European Region [4] may be used.

• For the assessment of adverse health impacts due to environmental noise exposure in developing countries the WHO/EURO Burden of Disease from Environmental Noise [9] may give useful advice.

• Promote the inclusion of environmental noise in Environmental Impact Assessments for planned projects.

3.2 Challenges in developing countries in the field of environmental noise governance and guidelines to overcome them

The objective of environmental noise governance is to facilitate law implementation and enforcement and inform, educate, train and strengthen stakeholder participation in all aspects related to environmental noise and the prevention and reduction of environmental noise exposures and the corresponding health and environmental impacts. To achieve this objective, governmental authorities can implement the individual issues of this process in collaboration with other stakeholders. As indicated above, local circumstances with respect to background noise levels and cultural and social conditions must be considered. The estimation of the costs and benefits of ENM as well as the provision of human and financial resources are indispensable ingredients of good governance.

In developing countries ‘challenges’ to achieve this include:

• Conflicts through duplicated responsibilities [17].

• Introduction of inappropriate technical equipment and ignorance of its usability [38].
• Prevalence of ad hoc awareness raising with a focus on raising alarm [39].

• Poor information on how the public can contribute towards effective ENM [34].

• High cost of awareness-raising programmes [33].

• Design and implementation of sustainable ENM strategies are often based on incomplete knowledge [28, 40].

• Insufficiency of adequate communication strategies among stakeholders [33].

• Inadequate regulatory, planning, technical, social, institutional, and financial capacity for ENM [30].

‘Guidelines’ for overcoming the main challenges of environmental noise governance include [16, 19]:

• A rapid assessment of the most important sources.

• Estimation of environmental noise exposure for all the noise-sensitive areas.

• Comparison of estimated environmental noise levels with environmental noise standards.

• Identify training and capacity-enhancing needs for all stakeholders and encourage, support and promote capacity-enhancement programmes

• If capacity for public information exists it can be used to inform the public and other stakeholders on a regular basis of the importance of noise and ENM strategies and the role that the public can play in reducing emissions. If capacity for communication among stakeholders does not exist, it needs to be developed.

• A focus on ‘Champions in ENM’ (e.g., well-known identities and celebrities) to convey noise information, increases awareness in different public groups, and keep ENM issues high on the interest list is a very useful way to disseminate ENM information.

3.3 Challenges in developing countries in the field of information on environmental noise emissions and guidelines for overcoming them

At-source measures that reduce overall emissions are preferable to noise exposure measures. For example, for road transport reduction of sound pressure levels of the engines and tyres, traffic management and transport demand management measures are options for reducing emissions at source. For aircraft transport reducing emissions at sources is a major pillar of the Balanced Approach of the International Civil Aviation Organization [41].

This section aims to include and/or strengthen enforceable, affordable, sustainable, and highly effective measures to assess and find solutions to reduce sound emissions and, consequently reduce public exposure to adverse sound pressure levels. The ‘challenges’ to achieving this objective include [17]:
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• Lack of [42, 43]:
  ◦ Emission inventories and quality-assured emission data.
  ◦ Periodical update of emissions standards.
  ◦ Regional harmonization of emissions standards.
  ◦ Low-cost and effective alternative technologies.

• Short-term and ad hoc measures to reduce noise emissions usually fail to adequately address the overall challenge.

• The use of end-of-pipe solutions is not in accord with the ‘precautionary’ and ‘prevention’ principles.

• Best available control technologies are not or not consequently applied.

• Use of ineffective measures to reduce noise pollution.

• Insufficient application of the ‘polluters pay’ principle.

• Poor dissemination and exchange of good practices and lessons learnt (positive and negative).

‘Guidelines’ for overcoming main challenges of environmental noise emissions include [16, 19]:

• Replacement of short-term ad-hoc actions by medium- and long-term strategies for emission prevention and reductions will define a better way to address noise problems in developing countries and further development of these countries.

• Prevention of pollution by alternative technologies is always less expensive than a posteriori reduction of sound emissions, including the costs of health effects.

• Positive and negative lessons learnt from experiences in other countries/cities may help to rapidly find best practices and optimal solutions.

• Compilation of a (rapid) inventory of noise sources and their sound emissions is a good starting point for sound propagation estimations. A noise source inventory includes sound emissions from:
  ◦ On-road and off-road motor vehicles.
  ◦ Railways.
  ◦ Airports and low-flying aircraft (i.e. close to airports).
  ◦ Ships in or close to ports.
• Industries.
• Leisure facilities.
• Shooting ranges.
• Outdoor appliances.
• Residences.
• A periodical update (numerical reduction) of emissions standards for emitting sources and the implementation of the new standards warrants reduction in noise emissions and noise exposures. However, an emissions reduction can be traded off for an increase in the number of emitting sources (e.g. vehicles).
• Emissions standards should be regionally harmonized. Regional harmonization will support equity and help avoid the import of noisy and obsolete technology.
• Low-cost and low-noise technologies will accelerate the development of countries.
• Sound emissions from mobile sources can be reduced through a combination of measures:
  • Tighter emission standards and their enforcement.
  • Low-sound vehicle technology.
  • Inspection programmes.
  • Establishment of maintenance programmes.
    • Improved integrated land use, traffic planning and demand management on a regional scale.
    • Public transport and non-motorized transport.
    • Economic incentives/taxation.
• Emissions from stationary sources can be reduced through a combination of measures:
  • Tighter emission standards.
  • Emission control technologies and low-noise production.
  • Land use planning, zoning, and economic restructuring.
  • Enhancing enforcement.
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- Find innovative alternatives to further reduce emissions.
- Economic incentives/taxation.

3.4 Challenges in developing countries in the field of environmental noise modeling, mapping, and monitoring and guidelines to overcome them

Environmental noise modeling has the objective to estimate national and local equivalent noise sound pressure levels in terms of $L_{90}$, $L_{10}$, $L_{\text{max}}$, $L_{\text{min}}$, and $L_{\text{eq}}$. The result of noise modeling may be used for the development of two-dimensional (2D) and three-dimensional (3D) noise maps which provide information on noise exposure of people [44, 45]. Noise monitoring is used to assess critical sound pressure levels in residential, commercial, and industrial areas under different environmental conditions. In addition, noise monitoring can serve to validate and/or verify noise modeling predictions, and to establish and/or strengthen national and local sound pressure level monitoring programmes [46–51].

In developing countries, the ‘challenges’ for noise modeling and mapping are the lack of [13, 52, 53]:

- Quality-assured emission data.
- Suitable sound propagation models.
- Regional harmonization of propagation models.
- Quality-assured topographical and meteorological input data for more advanced models.

For noise monitoring, the challenges for developing countries include:

- Absence of [54]:
  - Coverage and/or limited coverage of outdoor sound pressure level monitoring systems.
  - Periodic review of sound pressure level monitoring issues.
- Limited existence of baseline data; poor quality data; lack of standard operating procedures for monitoring; poor quality control and assurance; deficiencies in the maintenance of monitoring systems; lack of monitoring of sound pressure levels in urban and peri-urban areas [55, 56].
- Insufficient representativity of monitoring sites for actual exposure of humans [57].

‘Guidelines’ for overcoming main challenges of environmental noise modeling, mapping, and monitoring include [16, 19]:

- Sound propagation models are useful to determine the extent and spatial coverage of noise from different sources. Propagation models can provide
estimates of sound pressure levels from transportation, ports and airports, railways, and industrial plants.

- Sound pressure level monitoring mainly serves to validate the results of models and may be useful to test compliance with noise emission standards. The results of monitoring can provide feedback for continuous process of decreasing noise levels by lowering the standard values. Monitoring can also serve to better establish associations between environmental noise exposure and health impacts.

- Monitoring is usually performed at those places where people live. Hotspot monitoring may be useful for assessing exposure at locations of high noise exposure, near sources.

- Quality assurance and quality control (QA/QC) are necessary conditions to obtain reliable data (i.e. data of at least ‘known quality’) from a sound pressure level monitoring programme. The development of QA/QC programmes and implementation and strict obeyance of QA/QC plans to ensure that information from sound pressure level monitoring data provides a reliable basis for policy making.

- Publications on QA/QC in noise monitoring exist, which could be helpful to set up QA/QC plans and obtain data of known quality [58–60].

### 3.5 Challenges in developing countries in the field of health and economic risk assessments and guidelines for overcoming them

Little data exist on the human health impacts of urban noise pollution in developing countries [61]. Communities have little knowledge of impacts of noise exposure on human health, which is demonstrated by their ignorance of this threat [62]. The objective of this section is to establish and/or strengthen national and local programmes which monitor the health and economic impacts of environmental noise exposure in a harmonized way. ‘Challenges’ to achieving this objective include [63–67]:

- Lack of long-term studies on health due to environmental noise exposure.

- Scarcity of studies on economic impacts due to environmental noise exposure [68, 69].

- Scarcity of short-term studies on health due to environmental noise exposure [13, 35].

- Low public awareness [70–72].

- Poor information and assessment of health and economic impacts of environmental noise exposure [73].

- Low quality of evidence on noise exposure impacts [74].

- Insufficient institutional capability [75].
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‘Guidelines’ for overcoming main challenges of health and economic risk assessments include [16, 19]:

• To protect public health and minimize the economic risk of environmental noise exposure, national and local institutions such as information and training centres should be established or strengthened, which can evaluate the health and economic impacts of environmental noise exposure.

• Cost–benefit analysis is based on reliable information on the health and environmental impacts due to environmental noise exposure. A standardized calculation of the social costs of noise exposure on human health is needed to achieve this goal. The assessment of economic and financial impacts of environmental noise exposure on human health will determine the economic costs of environmental noise exposure on society and different stakeholders. A cost–benefit analysis demonstrates the advantages of mitigating environmental noise exposure.

• It is advantageous to train and educate administrative staff and general professionals on the topic of environmental noise-induced health effects.

3.6 Challenges in developing countries in the field of financing of ENM and guidelines for overcoming them

Funds are required to:

• Update and upgrade existing laws and regulations.

• Strengthen governmental institutions to implement and enforce mandatory emission and imission standards.

• Enhance capacities and capabilities for assessing source sound pressure emissions.

• Raise awareness of all relevant stakeholders.

• Promote participation and engagement of stakeholders including the public.

• Assess data of known quality of noise exposure by means of monitoring and modeling sound pressure levels.

• Produce noise maps.

• Test compliance with imission standards.

• Assess noise impacts on health and economic costs.

• If imission standards are not met, develop emission control measures, implement, and enforce them.
This section discusses challenges and provides guidelines to establish mechanisms for financial sustainability in regional, national, and local noise, health programmes including financing from the private sector and other sectors.

Challenges in developing countries include [17]:

- Environmental noise pollution currently is considered an issue of low priority and, therefore, underfunded.
- Eventually, existing resources are inefficiently used.
- There is a lack of:
  - Good governance regarding financing with a high level of accountability and transparency.
  - Sufficient funding for institutional capacity enhancement.
  - Knowledge of opportunities in applying existing market mechanisms.
  - Co-operation and coordination among funding agencies.
  - Implementation and enforcement of the ‘polluter pays principle’.

‘Guidelines’ for overcoming main challenges of financing of ENM include [16, 19]:

- Raising awareness among decision-makers on the need for financing ENM and the monitoring of noise-induced impact on health is crucial.
- Governments could share information on ENM and give incentives to the private sector to participate in ENM according to the polluter pays principle.
- Economic, financial, and cost efficiency/benefit analyses for ENM including health programmes would constitute a clear procedure to limit expenditures for public health impacts.
- International aid agencies could be helpful in capacity enhancement to reduce noise exposure as an impediment to development. These agencies and regional and national funding institutions could provide incentives for ENM.
- To maximize synergies, it would be useful to coordinate funding among governmental agencies.

4. Conclusions

Environmental noise pollution is growing in developing countries because of an increase in the levels of urbanization, industrialization, and transportation systems. The degree of environmental noise exposure of urban populations is directly related to the level of society’s development. Environmental noise and the noise impact on communities will increase if appropriate interventions are not considered. It is the
responsibility of Governments to promulgate, implement and enforce strong envi-
ronmental noise strategies, policies, laws, and regulations, which are suitable to con-
trol of environmental noise. If Governments fail to do so, it will be impossible to
prevent a continuous increase in environmental noise pollution, and they will be
ineffective to develop an environmental noise management system. The aim of envi-
ronmental noise management is to maintain low-noise soundscapes that protect
human and animal health.

This chapter reviews the challenges in developing countries with respect to envi-
ronmental noise policies, governance, noise emission, noise modeling, mapping, and
monitoring, the assessment of health and economic risks, and the mechanisms for
financing environmental noise management. Guidelines are presented to create a
strategic approach for environmental noise management suitable for developing
countries that will help overcome these challenges.

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Conflict of interest

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