



# HHS Public Access

Author manuscript

*Ethiop J Health Dev.* Author manuscript; available in PMC 2017 August 31.

Published in final edited form as:

*Ethiop J Health Dev.* 2016 ; 30(1 Spec Iss): 50–56.

## Health Effects of Environmental Exposures, Occupational Hazards and Climate Change in Ethiopia: Synthesis of Situational Analysis, Needs Assessment and the Way Forward

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### Abstract

**Background**—The burden of diseases caused by environmental and occupational health hazards and the effects of global climate change are of growing concerns in Ethiopia. However, no adequate information seems to be available on the current situation. This means there is a critical gap in research, policy framework and implementation in the country.

**Objective**—The purpose of this paper was to synthesize evidence from a systematic situational analysis and needs assessment to help establish a hub for research and training on three major themes and their related policy frameworks: air pollution and health, occupational health and safety and climate change and health.

**Methods**—The methods used in this work include a systematic review of secondary data from peer-reviewed literature, thesis reports from academia, government and national statistical reports. Limited primary data based on key informant interviews held with major stakeholders were also used as sources of data.

**Findings**—Exposures to high levels of indoor and outdoor air pollutants were found to be major sources of public health challenges. Lack of occupational safety and health due to agricultural activities and exposure to industries was found to be substantial. Worse is the growing fear that climate change will pose increasingly significant multidimensional challenges to the environment and public health. Across all three areas of focus, there was a paucity of information on local scientific evidence. There is also very limited trained skilled manpower and physical infrastructure to monitor the environment and enforce regulatory guidelines. Research, policy frameworks and regulatory mechanisms were among the cross-cutting issues that needed urgent attention.

**Conclusions**—Critical gaps were observed in research and training across the three themes. Also, there is a limitation in implementing the link between policy and related regulations in the environment and health.

### Introduction

The significant burden of diseases due to environmental and occupational health hazards and the emerging effects of global climate change have become a growing concern. Such newly emerging challenges have further aggravated the other ‘older and more commonly faced’

challenges caused by communicable diseases, malnutrition, poverty, poor maternal/child health, and infectious diseases. Globally, there is a significant burden of diseases from outdoor air pollution (AP) in urban areas (1). Developing countries face additional burden from personal exposure to indoor biomass burning (2). Recent evidence from studies in some large African cities (3, 4) shows an increasing burden of non-communicable diseases (NCDs), such as asthma and cardiovascular diseases. These are in addition to the long-standing communicable diseases. An increase in urbanization, changing lifestyle and a growing population size are thought to be the immediate causes of these new challenges (5). Evidence is available to show that the challenges are shared among most countries in sub-Saharan Africa (6–8).

Apparently, the growing threat posed by the complex and multi-faceted climate change-related health challenges in the region was among what initiated the need to establish global environmental and occupational health (GEOHealth) hubs. In response, the School of Public Health, Addis Ababa University, and the Department of Preventive Medicine and the Institute for Global Health, University of Southern California, USA, undertook a three-year planning project to establish a GEOHealth Hub for East Africa. There were also partners from Kenya, Rwanda and Uganda. The project period was from September 2012 to August 2015. The project focused on three main areas based on identified needs and available expertise: air pollution and health, occupational health and safety, and climate change and health.

As part of the planning process, a country-wide situational analysis and needs assessment (SANA) has now been completed for Ethiopia. The country's current profile has been assessed, needs and critical gaps identified.

The primary purposes of the SANA were to

- a.** assess the existing country situational profile around four themes:
  - i.** air pollution and health
  - ii.** occupational safety and health
  - iii.** climate change and health, and
  - iv.** policy, regulatory, and organizational frameworks that manage environmental threats;
- b.** identify gaps and needs related to tracking data, research evidence, and capacity, based on the situational analysis; and
- c.** determine possible interventions that meet the identified needs and chart the direction for the full GEO Health hub, in conjunction with companion SANAs for the three partner countries: Kenya, Rwanda and Uganda.

In the assessment, national priority areas in research, in the management and capacity building in associated areas have been identified. The assessment also identified key stakeholders and studied the existing policy frameworks to address environmental and occupational health problems (9). A summary of the findings of the four themes considered

in SANA have been reported in this article. In the summary, emphasis was given to cross-cutting issues and lessons to be learned to inform research and training for the full realization of the regional hub that is just getting started.

## Methods

The SANA for Ethiopia was conducted using a structured data collection guideline that arose from the goals of the assessment and the overall purpose of the GEO Health hub. These implementation guidelines were prepared after a series of consultative meetings that took into consideration current practices in environmental and occupational health in Ethiopia. The guide explicitly indicated the purpose of the GEO Health, deliverables, operational definitions, and the tools of primary and secondary data collection. The content of the literature to be searched in the four themes was identified and approved for subsequent data gathering and review. Data collectors were carefully selected from academia and practicing experts from government and non-government stakeholders. Data collectors were selected from the Federal Ministry of Health, the Federal Ministry of Environment and Forestry (i.e., the former Ethiopian Environmental Protection Authority), the Federal Ministry of Labor and Social Affairs, the National Meteorological Services Agency, and non-government environmental agencies such as Pesticide Action Network (PAN) Nexus, Ethiopia (PAN-Ethiopia).

The data collectors were given orientation about the data to be collected and the synthesis to be made. The orientation continued until the SANA report drafting process was completed. The progress of data collection and management was monitored through weekly meetings of the technical teams in the months of January to March 2013.

Two general approaches were followed in gathering data for the needs assessment. One approach identified possible gaps based on the synthesis of the findings from the situational analysis. The other approach used the primary data collected from stakeholders using semi-structured discussion guidelines. This means that both secondary and primary sources were used in the SANA.

The secondary data were collected via comprehensive review of peer-reviewed and “grey” literature from published articles identified via the most popular search engines. In addition, related academic theses/ dissertations, government reports, as well as statistical reports and bulletins were read and appropriate notes were taken. Primary data collection was conducted using checklists or question guidelines, as appropriate, for use in each of the four themes. Interviews were held with relevant stakeholders on policy, implementation, and resource issues. Carefully constructed question guides were used to carry out the needs assessment. The needs assessment focused on officials and experts from relevant stakeholder ministries and academic units. Progress of each team was carefully monitored on a weekly basis throughout the data collection period.

## Data Management and Analysis

Related literature was reviewed using appropriate key words in databases (e.g., PUBMED, Google Search, etc.) and local journals(9). The relevance of the information in both the peer-

reviewed literature and the unpublished reports from stakeholders' archives was categorized on the basis of key topic area.

Summary information was transferred to a spreadsheet that was organized according to key assessment questions. Key questions and responses were entered into a common GEO Health database that could quickly provide information and storage for future use. Data were identified and then keyed, with source and method of statistical analysis included. Descriptive analysis was mainly used for the write-up of selected sub-themes of each of the four main themes.

During the data collection, first, situational analysis, followed by needs assessment, was conducted. Then, data were collected using SANA implementation guidelines. This procedure appears to have enhanced the consistency of the data collection and the processes of the writing-up of the report. Also, the involvement of experts from the stakeholder government and non-government agencies in collecting the data enhanced access to the appropriate data sources. Clearly, this contributed to the success of the SANA. Similarly, there was a proper supervision of activities of the research teams through weekly and biweekly held meetings with the principal investigators of the GEO Health Hub.

An inception meeting with stakeholders was held in January 2013, prior to the start of the data collection. This eliminated communication gaps that could have occurred. There were weekly Skype meetings between the core teams at AAU and USC to discuss challenges faced in data collection and the preliminary findings of the assessment.

The complete draft of the SANA report was discussed at a national workshop held in Addis Ababa in July, 2013. At the workshop, findings of the assessment were presented. This was followed by panel discussions. The final report that incorporates inputs obtained from the workshop was disseminated at a national meeting held in Addis Ababa in July, 2014. Present at the national meetings were officials and experts from key national and regional stakeholders including the Ministry of Health, Ministry of Labor and Social Affairs, the Ministry of Environment and Forestry and the National Meteorological Services Agency. There were also representatives from universities such as Mekelle University, Gondar University, Jimma University, Hawassa University and Haromaya University (9).

## Results

### Air Pollution and Health

The limited currently available evidence shows that air pollution is a very pressing problem in the country. The relative contribution of indoor air pollution, which is mainly caused by biomass fuel use in poorly ventilated households, was judged to be greater compared to that of the outdoor air pollution caused by industries and vehicles (10). However, the relative contributions of outdoor air pollution are on the rise. This reflects the growing intensity of industrialization and urbanization. Biomass fuels emit harmful gases, vapors, and smoke that are known to affect the respiratory organs and cause acute and chronic respiratory diseases, including lung cancer.

The levels and health effects of both indoor and outdoor air pollution have not been comprehensively studied in Ethiopia. Results are available from a few small studies that used NO<sub>2</sub>, CO, and particulate matter as indicators of indoor air pollution in households and refugee camps (11–13). These studies were geographically limited to Addis Ababa, Tigray, Oromia, and the Southern regions. These studies noted that the levels of indoor air pollution exceeded regulatory limits recommended by regulatory agencies such as the US EPA and the WHO guidelines (e.g., recommended limit of 120µg/m<sup>3</sup> set by WHO for TSP (14).

However, such limited studies do not appear to have either adequate spatial coverage or enough temporal resolution to fully characterize the actual burden of air pollution on human health and its potential impact on the ecosystem in the country.

The monitoring and management of air pollution were found to be critical areas of concern. The policy structure for management and control of air pollution appears to be adequate. The management and controlling activity was mandated to the Ethiopian Environmental Protection Authority and the Ministry of Environment and Forestry. There are federal proclamations and regulations that deal with the management of air pollution. However, the capacity to evaluate and monitor the levels of urban air pollution is inadequate still. Resources are also limited. A similar shortage is also noted in technical and training capacity. Such inadequacies act as bottlenecks to the progress of air pollution management.

Vehicle-caused problem of air pollution is likely to be a major concern, especially in large urban centers such as Addis Ababa. Although the level of traffic air pollution has not been extensively evaluated in Addis Ababa, the growing on-road vehicular density and the limited road infrastructure are the likely indicators of potential health hazards.

On the other hand, there is insufficient information on the levels of air pollution and associated health impacts in Ethiopia. In this regard, there is a need to improve the national capacity to conduct effective monitoring and evaluation of indoor and outdoor air pollution and assess associated health effects.

The legal and policy frameworks that are currently in place in the country are favorable to the environment. They are also potentially helpful to prevent environmental pollution. But, the policy frameworks are solely based on a limited number of local small-scale studies. There is a fear that sufficient scientific evidence is lacking. This happens to be so mainly due to the inadequacy of relevant scientific evidence in the area in this country. The framework for the enforcement of the laws is mainly intended for ambient air quality management and is assigned to the MEF.

However, proper implementation of the laws is held back due to the inadequacy observed in trained manpower and infrastructural capacity in critical areas. Laboratory facilities needed to measure and characterize air pollution exposures is one area in which such a lack is observed.

The SANA has revealed that air pollution and its health impacts have not been given sufficient priority by the relevant stakeholders. As a result, very little action has been taken

by in the area. In addition, there is very little co-ordination among the various government stakeholders regarding taking the needed action.

### **Occupational Safety and Health (OSH)**

In addition to the assessment of health effects of exposure to agricultural activities, the SANA also focused on exploring the growing level of industrialization in the country and its impact on the health and safety of the workforce.

Ethiopia is a primarily agrarian country with only about 5% of the total employed workforce engaged in the manufacturing, construction, and mining sectors (15). Males predominate as workers in all sectors. The occupational hazards in the work place depend on the nature of the industry and the production process. The predominant safety issues included accidents that result in injuries, and a wide variety of health hazards of major concern involving chemicals and physical agents. Workplace hazards were found to be closely linked with the growth of industries and increasing urbanization that have led to a rapid expansion of the construction industry.

The organization and availability of health services in work places varies widely depending on the scale of the enterprises, making the majority of the workforce engaged in small-scale enterprises vulnerable to health effects and injuries associated with occupational exposures. Stand-alone health facilities and contract-based public health services are the two modes of provision for health services. In most cases, the provisions of health services do not appear to have a strong link with the monitoring and prevention of hazards.

The theoretical concept of hazard management through avoidance, reduction, or isolation appears to be currently ineffective in Ethiopia due to the widespread use of obsolete machines, poor accountability by employers, poor knowledge of and awareness by workers of work-place risks, and a lack of training in safety issues. Risk management at the individual level, through the provision of personal protective devices, is a common practice, but of little efficacy. Due to lack of training, employees do not properly identify signs of hazard signs.

There is a severe shortage of properly trained OSH inspectors in Ethiopia, especially outside Addis Ababa and in a few major regional cities. Close to 95% of all available OSH inspectors are found in four regions; namely, Addis Ababa, Tigray, Oromia, and Amhara. (Source: MOLSA, by July 2013, a questionnaire based response, personal communication). Many of the OSH inspectors lack basic professional training. The Addis Ababa Bureau of Occupational Safety and Health is a pioneer, by Ethiopian standards, in the organization and use of OSH instrumentation for monitoring known occupational hazards. This Bureau itself badly needs assistance and further development in basic professional training- i.e., handling the existing monitoring instruments and enhancing the quality of monitoring instrumentation.

There are only a handful of studies in Ethiopia that assessed the type and magnitude of relevant health outcomes and respective occupational risk factors (16–19). Exposure measurements in the work place were only available in some studies. The studies focused on

cotton dust, noise, and cement dust. Work place exposure was characterized subjectively in many studies through the use of operational definitions in the research questions. Not many studies involved direct exposure assessment. The few available studies appear to be neither comprehensive nor nationally representative.

The current organization of hazard surveillance and of monitoring of accident/injury does not appear to be systematic. There is a shortage of monitoring instruments. The quality of even these limited instruments is much below the level desired. There is therefore an urgent need for basic training in the operation of the instruments used in monitoring and evaluation activities. Capacity-building efforts in areas of research, training, policy development, regulation, and organization are greatly needed.

The current labor proclamation is the basis for all activities and practices on the delivery of OSH services. An operational guideline (OSH directive) outlines detailed procedures, and provides standards or cut-offs for hazard prevention. There is a concern that the existing regulatory documents do not address emerging issues related to new industries due to the recent economic development, such as those in the construction industry and floriculture. It is worth noting, however, that a national OSH policy envisaging new economic developments has been submitted to the Council of Ministers for consideration and approval.

### **Climate Change and Health**

Data obtained from both the situational analysis and needs assessment revealed an increasing recognition that climate change currently represents one of the greatest developmental and public health challenges in Ethiopia. Sensitive systems such as agriculture, health, and water have been affected. The increase in the effect is feared to continue still. The assessment also revealed that there were only a few spatially detailed, methodologically consistent related studies of the impacts of climate on health matters.

This lack of evidence reflects the current low level state of research on climate change and health in Ethiopia

Climate change is of critical importance to Ethiopia. Certainly, Ethiopia is among the world's most vulnerable countries to the health effect of climate change (20). Human-induced climate change is expected to bring a significantly further warming over the next century. Climate models suggest that Ethiopia will see further warming that is estimated to be 0.7°C and 2.3°C by the 2020s and between 1.4°C and 2.9°C by the 2050s in all seasons (21).

Some impacts of climate change occur as a result of anomalies in temperature and rainfall that have been demonstrated through the analysis of climate data for 1961–1990. Ethiopia has experienced repeated droughts, floods and agricultural failings followed by malnutrition, extreme temperature events (extreme heat and cold), and re-emergence of climate-sensitive diseases (22).

Increased environmental survival of pathogens and creation of new ecological niches for vectors to propagate diseases are also observed. The major health effects include under-nutrition due to variability in agricultural production and food security. There is also



increasing incidence of climate-sensitive diseases such as malaria, meningitis, and diarrhea. Other adverse health impacts due to scarcity of water and natural disasters such as floods and droughts are also observed. Malaria is likely to occur in the highlands in the country in the very near future. Soil-transmitted helminthic infections such as hookworm may also increase because of warming. Diarrhea is expected to be a rising health risk due to the rainfall and flooding that contaminates drinking water. Zoonotic infections will emerge because of the changes in parasites or pathogens to host relationships favored by climate change. Malnutrition among children under five, and even among the adult population, may be a significant concern. All these are the result of food shortages posed by the anomalies of climate change.

The impact of climate change on health and other related issues appears to be well recognized among the various governmental stakeholders. This is one thing that is encouraging. What is discouraging, however, is the fact that much less attention than is expected appears to be given to the specific actions needed in response to the rising recognition of the effect.

A lack of sufficient collaboration has been observed among organizations on the planning and execution of climate change and health activities. Similarly, there is a lack of trained professionals who can independently carry out climate change and health-related research and activities at various levels. The SANA also revealed the absence of a well-organized structure in the various organizations. The inter-sectoral collaboration is noted to be poor. There is also inadequate coordination and communication among different stakeholders.

In addition, no policies seem to be in place to connect together those who independently target climate change and health. The existing policies also appear to fail considering the gender and community-related dimensions of climate change. Equally important may be the existence of weak monitoring and evaluation efforts among the various organizations in the area.

### **Policy, Regulatory and Organizational Framework**

Many policies and regulatory provisions are already in place to play roles in the management and control of health impacts of air pollution, exposure, occupational safety, and climate change. However, there seems to be a lack of commitment to implement the policies/strategies. The assessment has clearly noted that there are a number of major constraints in addressing the public health challenges that arise from exposure to air pollution, occupational safety, and climate change.

The results of the situational analysis indicated that there are cross-cutting gaps in the different sectors. Among these, the shortage of skilled personnel is an urgent priority. Most stakeholder organizations appear to be grappling with an acute shortage of professionals and poor retention mechanisms.

Research activities on the health impacts of air pollution exposure, occupational safety, and climate change currently appear to be at a minimal level. This has hampered evidence-based decision making and monitoring and evaluation. A widespread lack of linkage and co-



ordination between universities and relevant stakeholder governmental agencies was revealed. This is a manifestation of a mismatch between what the training institutions are producing and the specific skills required by the ministries.

The SANA shows that the level of awareness of the challenges posed by environmental, occupational, and climate change related issues is currently quite low. Furthermore, the outcomes of the minimal monitoring and evaluation activities in progress are made worse by poor documentation.

There is a need to build training and research capacity and develop clear implementation guidelines, and the need to build effective inter-ministerial coordination mechanisms should be highlighted as some of the most important findings of the SANA. There is a rapid pace of urbanization and industrialization in the country. This is an expression of the move being made towards industrialization and the civil reform to advance productivity (23). In this context, the growing challenges of climate change on public health and economic development calls for concerted efforts to put in place relevant policies and appropriate mechanisms to enforce the policies and protect the environment and public health.

## Discussion

The findings of the SANA on all of the four themes discussed so far are characterized by the complexity of the challenges and their multi-sectorial nature. However, despite the need to pool meager resources and co-ordinate efforts in a multi-disciplinary and multi-dimensional fashion, mechanisms for coordination and integration are just “‘on the books’ still. They are not functional. No mechanism that facilitates the engagement of the different stakeholders in protecting the environment and its associated health effects appears to be available.

The assessment shows that each of the four core themes had distinct characteristics in their current situation and identified gaps. Yet, there are cross-cutting commonalities. Across the board, there seems to be a scarcity of scientific evidence that arises from any local research. There is also a severe shortage of skilled man-power and a lack of well-developed physical infrastructure to enable the enforcement of the available limited policies and regulations.

The sectorial areas of the GEO Health, which included the health effects of air pollution, occupational exposures and climate change, face the following common gaps and challenges:

1. Organizational gaps: The capacity to accommodate an adequate number and type of professionals is lacking.
2. Research capacity: The ability to generate scientific evidence that can inform regulatory policy making through well designed scientific studies is inadequate
3. Training gaps: A lack of programs to produce health professionals and experts to manage environmental exposure assessment and monitor associated health effects is observable.

4. Limited capacity: Monitoring equipment and laboratory settings, including the skill needed to assess the health risk of environmental exposure, are not available.
5. Policy and regulatory gaps: There is a need to have an updated policy on several fronts. The need for this is particularly pressing in areas where economic developments are necessitating the development of new regulatory and monitoring mechanisms. Examples of such areas include occupational health and safety in emerging industries and monitoring the adverse effects of climate change.
6. Monitoring and evaluation gaps: There is a limited institutionalized monitoring of key indicators in the GEO Health themes. Such key issues include ambient air monitoring and monitoring the level of hazards in occupational settings such as work place injury. Forecasting and planning for major changes in pollution patterns and in the patterns of the distribution of diseases caused by climate change is another area where improvement is desirable.

While the challenges revealed by the SANA appear to be daunting, there has been significant progress during the planning process for the GEO Health hub towards multi-disciplinary and multi-sectoral co-ordination within and between academic institutions, governmental stakeholders and non-governmental environmental agencies. There are already indications of co-operation between various units of Addis Ababa University to tackle environmental and occupational health issues. Experts from government ministries such as the MOH, MEF, MOLSA and NMSA have started to collaborate with AAU researchers to initiate air quality monitoring and the training of experts.

The lessons and experiences gained from this assessment for Ethiopia have been used to conduct similarly designed SANAs in each of the other three partner countries (Kenya, Rwanda, Uganda). This may eventually lead to the establishment of a regional GEO Health Hub for eastern Africa. There is increasing momentum for regional co-operation and co-ordination between Ethiopia and the three other eastern African partner countries (Kenya, Rwanda and Uganda) as a result of the planning process for the regional hub. All the three countries have now completed similar SANAs using the Ethiopia SANA as a model. While synthesis of evidence across countries is still ongoing, preliminary indications are that all the four partner countries face very similar challenges in the health impacts of air pollution, occupational exposure and climate change. In addition, the collaboration with the US partners (especially with USC) has now reached a level of maturity that will enable effective collaboration to take place. The network has now been expanded to include University of Wisconsin Madison (with a focus on climate change and exposure assessment) and the South Coast Air Quality Management District (SC-AQMD) to enable more effective training and technology transfer on air quality monitoring and regulatory enforcement capacity building.

Based on the evidence from the country-specific SANA reports and extensive consultations among all relevant partners and stakeholders, a successful application has been submitted for funding to establish a full GEO Health hub for eastern Africa, setting the training and

research agenda for the next five years and beyond. Based on the available evidence on common environmental challenges of all the four partner countries and the expertise of US and east African partners, the hub will mainly focus on training and research activities around the health effects of indoor and outdoor air pollution. To a limited extent, pilot studies will also be conducted on the heat stress related climate change factors associated with the occupational setting of emerging industries such as flower growing commercial farming.

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